Student Launch Proposal
Carbon Dioxide Analysis in Troposphere with Autonomous Air Brakes

Mailing Address:
15 Wyoming
Irvine, CA 92606

AIAA OC Section
9/30/2016

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1. Organization Information

1.1. AIAA Information

The American Institute of Aeronautics and Astronautics (AIAA) is the professional society for the field of Aerospace Engineering. Our Student Launch (SL) team is sponsored by the AIAA OC Section in California. The board meets every Sunday. In their educational outreach, they provide professional guidance and assistance to youth at Lucerne Valley who wish to pursue projects related to aerospace. The name of this project is “Carbon Dioxide Analysis in Troposphere with Autonomous Air Brakes.”

We qualified for Student Launch under the name "Voting Involvement Association," but we will change our name to AIAA OC Section.

The team's mailing address is:

15 Wyoming
Irvine, CA 92606

1.2. Name, Title, and Contact Information for Two Adult Educators

1.2.1. Robert Koepke (Mentor, Electrical Engineer, Programmer, Level 2 NAR)

Robert has been co-leading TARC teams for eight years and a part of the STEM outreach for AIAA for seven years. He has a BS degree in Electrical Engineering from USC and has worked as an electronics designer, programmer, and now the manager of the software department for Honeywell. Robert worked on the F-20 Tigershark while at Northrop. Robert launched his first rockets shortly after Sputnik in 1957 and has continued in rocketry with his own children and grandchildren and Indian Princesses and Indian Guides.

He can be contacted at (714)-288-0321.

1.2.2. Jann Koepke (Artist, Mom, Level 1 NAR)

Jann has been co-leading TARC teams for eight years. She has a bachelor’s degree in Fine Arts from Cal State University Los Angeles in 1979. She has worked in electronic business as an assembler and in the accounting office. Now she is retired. She has been doing Rocketry for 25 years with her husband children and grandchildren. Jann is the AIAA OC Section Council member in charge of education. She has also led 4H projects in livestock including lambs, goats, and beef.

She can be contacted at (714)-288-0321.

1.3. Name and Title of Safety Officer

Sahil, Range Safety Officer (RSO).

1.4. Name, Title, and Contact Information for Student Leader

Albert, Team Leader, verticalprojectile.rocket@gmail.com.

1.5. Student Information and Responsibilities

All seven student members in the team are listed below. These members will be responsible for completing all of the work (e.g. written documents, presentations, design, construction, and launching) using mentors and advisors only for guidance. Team members represent four high schools in Orange County, California.

1.5.1. Albert (Student Team Leader)

Albert is a junior at Irvine High School in Irvine. He has been in the Team America Rocketry Challenge (TARC) for three years and is interested in chemistry and aerospace engineering. He will be enrolled in AP Environmental Science, AP US History, AP Calculus BC, and AP Language and Composition this year.

He can be contacted at verticalprojectile.rocket@gmail.com.

1.5.2. Norman

Norman is a junior at Arnold O. Beckman High School in Tustin. He has been doing model rocketry for two years now and is interested in biology and the field of medicine. He is enrolling in AP Statistics, AP Chemistry, AP U.S. History, AP Physics, Spanish 4H, and English 3H this year. His favorite hobbies include drawing, playing the piano, and hanging out with his friends.

1.5.3. Sahil (Range Safety Officer)

Sahil Patne has been working in the field of rocketry for three years. As a junior at Irvine High School, he will be enrolled in classes such as AP Calculus, AP Biology, and AP Computer Science, AP US History, AP Language and Composition. He enjoys spending time in nature, playing basketball, and drawing various art forms.

1.5.4. David

David Chang is in the eleventh grade at Northwood High School in Irvine, California. As one of the two lead programmers in the team he is learning to program the airbrake and parachute control using the Teensy. He also assists in the design and mechanical engineering of the main circuit board, which is controlled by the Teensy. His favorite subjects in school are math, science, and engineering.

1.5.5. Kushagra

Kushagra is a junior at Northwood High School in Irvine. He has been in TARC for three years and is interested in computer science, math, and engineering. As one of the two lead programmers in the team he is learning to program the airbrake control using the Arduino Uno IDE. He is also in charge of perfecting the airbrake to Pnut communication, ensuring their connection in all possible circumstances. He will be enrolled in AP Chemistry, AP Physics, AP Statistics, and AP Calculus BC this year.

1.5.6. Claire

Claire is attending Crean Lutheran High School and will be a junior this coming fall. This is her first year in TARC. Some classes she will be taking include AP Calculus AB, AP Chemistry, and Honors Physics. She is also involved with her school's business cohort program. Claire's hobbies are playing piano, hanging out with friends, and going on hikes.

1.5.7. Allison

Allison is a junior at Corona del Mar High School. This is her second year on a TARC team. She is interested in visual arts and sciences and is enrolled AP Chemistry, AP Psychology, and AP Calculus AB. In her free time, she likes to hang out with friends and draw.

1.6. NAR/TRA Section for launch assistance, mentoring, reviewing

The AIAA OC Section rocketry is NAR Section #718. Launches will be held at Lucerne Dry Lake in the Mojave Desert near Lucerne Valley, California. NAR section #538, the Rocketry Organization of California (ROC) holds launches on the weekends around the second Saturday of each month. Mentors Robert and Jann Koepke have been members of ROC for several years and team members have attended many ROC launches over the past 5 years. Many ROC members hold level 1 – 3 certifications and have always provided mentoring and review assistance to anyone asking. ROC currently has an FAA waiver allowing flights to 7,000 AGL, with call-in windows available to 19,000' AGL (http://www.rocstock.org) at their monthly launches.

1.7 AIAA Orange County Section

Since we are attached to the American Institute of Aeronautics and Astronautics (AIAA), we can reach out to the hundreds of aerospace professionals in Southern California for help in designing airplanes and rockets and constructing with composite materials.

1.7.1. Dr. James Martin

Dr. Martin holds degrees from West Virginia University, Massachusetts Institute of Technology, and George Washington University. He has worked at the NASA Langley Research Center, The University of Alabama, and Boeing. His work has mostly involved the design and evaluation of reusable launch vehicles. Some recent work has been on crew escape for the Shuttle, the Space Launch Initiative, and a robotic lander on the moon. Dr. Martin retired from Boeing when the Launch vehicle business was sold. He continues to be active in aerospace doing consulting, as an Associate Editor for AIAA J. Spacecraft and Rockets, and as Chair of the local AIAA Orange County Section.

1.7.2 Jonathan Mack (Electrical Engineer and Programmer)

Jonathan graduated with a Bachelor of Science from Long Beach State. Currently he is a Field Applications Engineer (FAE) for Intersil. He has led a 4H project in mechanical, electrical and software design areas in robotics. At home his hobbies mainly focus on improving DIY (Do It Yourself) knowledge, including everything from mad science projects to more mundane things like welding and cooking (usually not at the same time.)

1.7.3 Guy Heaton (Mechanical Engineer)

Guy graduated with a Bachelor of Science from Pepperdine University. Currently he is a Senior Mechanical Engineer and has been working on printing solutions for 12 years. Responsibilities include designing for injection and blow molding and extrusions. He also does mechanical systems, drive trains, cabling, durability testing, and sheet metal design. When not designing new printers he does manufacturing time analysis, line balancing, and documentation.

1.7.4 Mike Stoop (Software Engineer, Level 3 NAR, California Pyro 3)

Mike Stoop is currently the CTO of PriceDoc, Inc, a healthcare related web services company. Mike has been in the software industry for 30 years and an avid rocketeer for 40 years. Mike achieved his level 3 certification in 2002 and has participated in many individual and team 'M" class and above rocket projects. He has launched K and larger engines with electronic dual deploy many more than 15 times. Mike is also the owner of Madcow Rocketry, a mid/high power rocket kit manufacturer.

1.7.5 Drew , SpaceX (Aerospace Engineer)

Mr. Drew Beckett holds BS and MS degrees in aerospace engineering from the Dwight Look College of Engineering at Texas A&M University at College Station. Mr. Beckett developed and operated unmanned aircraft technology demonstrators for the Texas A&M Flight Mechanics Laboratory (later Unmanned Flight Laboratory) while employed by the Texas Engineering Experiment Station. More recently, Mr. Beckett has been in the employ of Space Exploration Technologies where he is responsible for the inertial guidance, navigation, and control sensors for the Falcon 9 launch vehicle and Dragon spacecraft as well as navigating Dragon on-orbit as a mission operator.

2. Facilities and Equipment

2.1. Description of facilities

The two facilities we had for building our rockets and do research was at the Koepke's home and IvyMax , where we have also built all of our TARC rockets. IvyMax provided classrooms and whiteboards for us to plan our designs and efficiently make our rockets. Using the prize money from TARC Nationals, our team has bought a toolbox along with all the necessary equipment for building our rocket. The list of equipment is an aggregate of both locations and is shown below.

- Tape measure
- Smart weigh scale
- Superior Mini Digital Platform Scale
- Drill
- Band Saw
- Angled Ruler
- Epoxy Bag
- Drill Bit Box
- Adjustable Crescent Wrench
- Curvy Spring Pliers
- Assorted Screws Box
- Screwdriver
- Bent Tweezers
- Exact-o Knife
- Monkey Wrench
- Scissors
- Pliers
- Electrical Hinge Tape
- Hack Saw
- Blue Masking Tape
- Epoxy Clay
- Washers
- Benchtop Sanders and Grinders
- Table Saw
- Vacuum pump
- Vacuum Bagging Supplies

2.2. Necessary personnel

Our mentors Bob and Jann Koepke are also present at IvyMax and the Koepke's workshop to offer advice and answer any of the team members' questions.

2.3. Computer equipment

2.3.1. Hardware

Two PC laptops to take to launches to check design and calculations and to record flight data
Each team member has at least one laptop computer.
Webcam and speakers as required for the WebEx sessions

2.3.2. Software

2.3.2.1. Microsoft Office
A suite of applications that we will use to write proposals as well as the design reviews. The suite includes Word, a word processor used to create written documents, PowerPoint, a software used to create presentations, and Excel, a software used to track budgets and schedules/timelines.

2.3.2.2. Adobe Acrobat
A program used to create .pdf files which is a universal method to distribute documents since a .pdf reader is free and on most PCs.

2.3.2.3. Adobe Photoshop
A program used to manipulate and edit photographs and drawings

2.3.2.4. Apogee Rockets RockSim 9
A CAD program used to help design the rocket. This program also calculates the center of pressure and center of gravity to determine the stability of the vehicle. It allows flight simulation for tracking the stability and safety of the rocket.

2.3.3 Web Presence
The Vertical Projectile website verticalprojectile.org has a "SL 2016-2017" tab under “NASA SL.” “Documents” will be in the "SL 2016-2017" tab.

Our personal information will be under “About Us.”

2.3.4. WebEx Facilities
We will use the Honeywell Executive Conference Room in Irvine. Several of the mentors work at this location. Conferences and WebEx’s are held frequently there and it is permanently equipped with:

- PC computer
- 80 inch large screen TV
- 2 T1 lines connected to the Internet
- Audio system with speakers
- Conference phone

We provide a Logitech C910 webcam. In case of problems, all mentors from Honeywell are familiar with the WebEx and network.

3. Safety Plan

The SL team has developed a series of risk mitigation plans to reduce the risk of this project.

Vehicle Risk Mitigation

1. Risk - The engine does not ignite while conducting the launch of the rocket. Mitigation - Prior to launch, multiple team members will check to make sure the igniter is properly inserted in the engine to its full length, ensuring ignition of the motor.	4. Risk - The rocket body caves in, or collapses on itself. Mitigation - The team will use fiberglass for the body tube, a material capable of withstanding outside forces. Inside, flight boards, bulkheads, and centering rings will help to maintain the circular frame of the body tube.	7. Risk - The electronic matches fall out of their designated place. Mitigation - Before placing the shear pins, the matches will be checked to ensure that they have been tightened down to remain in place. This task will be placed on a checklist that members will go through while preparing the rocket for launch.
2. Risk - The engine does not fit (too loose or tight) in the motor casing. Mitigation - The team will make sure the engine is inserted in the proper motor casing, and cannot be shaken or pulled out with ease. The team will also check when the motor casing is inserted into the motor mount.	5. Risk - The quick links are not attached properly. Mitigation - The team will double check all connections to ensure that the rocket is assembled completely before preparing the rocket for launch. These tasks will be written on a checklist, which members who checked the task will sign off to take responsibility.	8. Risk: Motor explodes Mitigation: Detailed instructions will be followed step by step when building the motor. Team members will be required to maintain focus and detail while putting together the motor.
3. Risk: Airbrakes do not function while in flight. Mitigation: When electronics, are activated at ground level, a test for airbrake function will be performed. The airbrake motors will checked prior to assembling the whole rocket.	6. Risk - The shear pins do not shear due the ejection charge. Mitigation - When purchasing the pins, the team will note the force required to shear them. The team will perform black powder ground tests to make sure the ejection charges exert more force than the pins can withstand. To ensure shearing, the backup charge will have a greater amount	9. Parachute was not packed correctly and does not deploy Mitigation: The team will check to make sure the parachuted is fitted correctly into the body of the rocket prior to launch. However, if the primary ejection charge does not separate the rocket, backup ejection charges with greater amounts of black

	of black powder.	powder will allow the parachute to deploy.

Payload Risks and Mitigations

1. Risk: SD card is defective Mitigation: Test run before the actual flight.	4. Risk: SD card is not plugged in Mitigation: Double check that the SD card is properly placed in its socket.	7. Risk: Arduino fails to start. Mitigation: Program an LED light to blink when the Arduino is connected to the power supply.
2. Risk: Batteries are not fully charged Mitigation: Charge the batteries to max before the flight.	5. Risk: Wires detach from the Teensy Mitigation: Securely strap the wires to the circuit board using Velcro or other adhesives.	8. Risk: Defective CO2 Sensor Mitigation: Test run before the actual flight.
3. Risk: The VCC is not connected to the sensor, so the sensor does not work Mitigation: Check if the supply wire is securely attached from the 5 volt pin of the teensy to the Sensor.	6. Risk: Batteries fail Mitigation: Use Voltmeter to check if the battery is fully charged before the flight.	9. Risk: The supply and ground wires are switched. Mitigation: Have two other people keep an eye on the wire connections.

Recovery Risks and Mitigations

1. Risk: Backup ejection charges do not ignite. Mitigation: Check to make sure the RRC3 is beeping in the specific sequence as denoted in the manual.	4. Risk: Drogue chute flies at wrong altitude Mitigation: Double check that the Stratologger and RRC3 both are beeping in their specific sequences.	7. Risk: Main chute doesn't deploy Mitigation: Backup Flight Computer and ejection charges should take care of this.
2. Risk: The Batteries of Backup Electronics Fall out Mitigation: Use battery holders and zip ties to ensure that the batteries do not fall out, and double check the sturdiness of these before every launch.	5. Risk: Airbrakes fail to close, interfering with recovery Mitigation: Double check that the LED light is blinking on the Arduino. Also, make sure the most recent code is uploaded in the Arduino.	8. Risk: Stratologger CF Flight Computer is not turned on Mitigation: The team will have three members check the Stratologger to see if it is beeping in its specific sequence, and they will affirm its status by signing their name in the checklist.

3. Risk: The Backup RRC3 Flight Computer is not turned on Mitigation: The team will have three members check the Flight Computer to see if it's beeping and affirm its status by signing their name in the checklist.	6. Risk: Drogue doesn't deploy Mitigation: Double check that the electronics are turned on and beeping, and have three people sign the checklist to affirm. Also, back up ejection charges will take care of this.	9. Risk: Main batteries fail Mitigation: Use fresh batteries and make sure the electronics will power up first in a test second before flight.

More information on shop safety can be found in Appendix B: Shop Safety.

More information on launch safety can be found in Appendix C: Launch Safety.

More information on materials can be found in Appendix D: Material Safety Data Sheet (MSDS).

The designated RSO is Sahil. Per SL requirements, he will monitor the following team activities with an emphasis on safety during:

- execution of the safety plan
- design of the vehicle and launcher
- construction of the vehicle and launcher
- assembly of the vehicle and launcher
- ground testing of vehicle and launcher
- sub-scale launch test(s)
- full-scale launch test(s)
- launch day
- recovery activities
- educational engagement activities

He will also:

- Implement procedures developed by the team for construction, assembly, launch, and recovery activities
- Manage and contain current revisions of the team's hazard analyses, failure modes analyses, procedures, and MSDS/chemical inventory data
- Assist in the writing and development of the team's hazard analyses, failure modes analyses, and procedures

3.1 NAR and TRA Safety Rule Summary and Compliance

A brief summary of the NAR safety rules is listed below; these rules are the ones that apply to SL and SL only and have been reworded. The actual NAR rules can be found here. The actual TRA rules can be found here.

Rule	AIAA SL Team Compliance
NAR: Person(s) will posses and fly only high power motors in their range of certification and required licensing TRA: The person who is a certified flyer shall operate and fly a high power rocket.	Only the team mentor with a minimum of Level 2 certification will purchase, possess, and load the high power motors (K).
NAR: Materials that are lightweight such as; paper, wood, rubber, plastic, and fiberglass will be used to construct the rocket. Only when required will ductile metal be used for the construction of the rocket. TRA: The high power rocket vehicle is intended to be propelled by one or more high power solid propellant rocket motor(s) shall be constructed using lightweight materials such as paper, wood, plastic, fiberglass, or when necessary ductile metal.	The vehicle will be made primarily of fiberglass, with some wood, paper, and plastic as required in the payload and recovery areas. Metals will be those commonly used in payload and recovery sections, and not present on on the exterior of the rocket.
NAR: The rocket motors that will be used will be certified and commercially made. They will not be tampered with or be used for anything except what is recommended by the manufacture. No smoking, open flame, or any heat source will be allowed within twenty five feet of these motors. TRA: The motors that are used will be certified commercially made rocket motors. They will not be dismantled, reloaded, or altered disposable or expendable high power rocket motors. Only use the rocket motor for only the purpose stated by the manufacturer.	A rocket motor manufactured by Aerotech has been chosen for use; Aerotech is a company that produces motors for recreational rocketry use. The motor will be K560. Team members will prevent unauthorized people to reach the loading area, restricting the ignition of an open flame. Team members will be looking for the possibility of an open flame or smoke at all times.
NAR: Rockets will be launched with an electrical launch system and with electrical motor igniters than will be installed in the motor after the rocket is at the launch pad or in the designated prepping area. The launch system that is used will have a safety interlock that works with the launch switch that is not installed until the rocket is ready for launch and the launch switch will return to the off position after the launch. If the rocket contains an onboard ignition systems for the motors or recovery devices,they will have safety	In the design process of the rocket, a locking mechanism that keeps all power off in the electronics will be included. This ensures a fail-safe for the rocket and keeps it inactive until the rocket is secured and ready on the loading area.

interlocks that will interrupt the current path until the rocket reaches the launch pad. TRA: The ignition system that is used is remotely controlled, electrically operated, and contains a launching switch that will return to “off” when released. The ignition system must contain a removable safety interlock device in series with the launch switch. The launch system and igniter combination must be designed, installed and operated so the liftoff of the rocket must occur within three seconds of actuation of the launch system. Ignition device must be installed in a high power rocket motor only at the launch site and at the last practical moment before the rocket is placed on the launcher.	
NAR: If the rocket doesn’t launch after the button on the electrical launch system has been pressed, the launcher’s safety interlock will be removed or the battery will be disconnected. Sixty seconds will be waited before anyone will be allowed to approach the rocket. TRA: You can launch the high power rocket if you have the immediate knowledge, permission and attention of the safety monitor. Everyone should be standing and facing the launcher during a countdown and launch. The countdown should be audible by everyone. Don’t approach the high power rocket that has had a misfire until the safety interlock has been removed or the batter has been disconnected from the ignition system, one minute had passed and the safety monitor has given permission for a single person to approach the misfired rocket to inspect it.	While the rocket is on the launch pad, team members will be sure to get the public’s attention and not beginning the launch sequence without it. Team members will make sure the range and sky is clear before proceeding with the countdown. With every misfire, team members will wait at least a minute before approaching the rocket. The rocket will first be deactivated, and the problem will be inspected.
NAR: Before a rocket is launched, there will be a five second countdown. No one will be any closer to the launch pad than allowed by the minimum distance table. In case of a problem, a means of communication will be there to warn participants and spectators.	Once the rocket is secured on the launch pad, the Range Safety Officer will go through his checklist to make sure the rocket and its surroundings are ready for its flight. This includes warning the spectators and making sure the rocket fits under the safe conditions

Before the rocket is launched, it will not fly if stability cannot be determined. TRA: The person who fly's a high power rocket must first have it inspected and approved for flight by Safety Monitor for compliance with the applicable provisions of this code.	described by these rules, which the Range Safety Officer will be aware of.
NAR: The rocket will be launched from stable device that provides rigid guidance until the rocket reaches the speed that guarantees a stable flight and is pointed within twenty degrees of vertical position. If wind exceeds five miles per hour, the launcher will be adjusted to the length that permits the rocket to attain a safe speed before leaving the launcher. A blast deflector will be in place to prevent the motors exhaust from hitting the ground. No dry grass will be around the launch pad, the minimum distance table will be referred to when determining this, and will increase the distance by a factor of one point five if the rocket motor being launched uses titanium sponge in the propellant. TRA: The high power rocket should be launched from a stable device that provides rigid guidance until the rocket has reached adequate speed to ensure a safe flight path. A jet deflector should be in place to prevent rocket motor exhaust from impinging directly on flammable materials. The launch pad should be at an angle less than twenty degrees off vertical. Make sure the end of the launch rail or rod is capped to prevent eye injury.	Stability of the launch pad will be guaranteed, as we are using a launch rail, which is more stable than a launch rod. This launch rail is established on a tripod-like metal base. In windy conditions, the Range Safety Officer will make sure what length the rail needs to be adjusted to. Team members might possibly tilt the rail in certain windy conditions a certain number of degrees to launch as straight as possible, but this tilt will be kept well below the max of 20 degrees. At our launch site, Lucerne Dry Lake, the lake bed has no burnable materials in its vicinity, so there is no chance of burning an item like dry grass.
NAR: The rocket will not contain a combination of motors that totals more than 40,960 N-sec of total impulse. The rocket will not weigh more at liftoff than one-third of the certified average thrust of the high power motors intended to be ignited at launch. TRA: Make sure the rocket weighs less than	The rocket will contain a K motor that has the maximum force of 2,560 N-sec of thrust and has the mass of 1,408.1 grams. Inside the rocket, black powder charges are placed inside the rocket for separation, and are well below the total impulse limit.

the rocket motor manufacturer's recommended maximum liftoff weight for the rocket motor(s) used for the flight. During the preflight inspection the safety monitory may or may not request documentary proof of compliance. Do not install a rocket motor or combination of rocket motors that will exceed 40,960 N-Seconds of total impulse.	The rocket is approximated to weigh 21.7 lbs and will be less than one-third of the average thrust of the K motor.
NAR: The rocket will not be launched at targets, clouds, near airplanes, or on trajectories over the heads of spectators or beyond boundaries of the launch site. The rocket will not have a flammable or explosive payload. The rocket will not be launched if the wind speeds exceed over twenty miles per hour. The people launching the rocket will comply with Federal Aviation Administration airspace regulations when flying and will ensure the rocket does not exceed any applicable altitude limited in effect at the launch site. TRA: The person(s) flying the rocket must comply with the "Airspace Control and Facilities", Federal Activation Act of 1958 and other applicable federal, state, and local laws, rules, regulations, statutes, and ordinances TRA: Do not launch the high power rocket at a target, clouds or beyond the boundaries of the launch site. Do not launch a high power rocket if the wind exceeds twenty miles per hour. Do not launch the high power rocket if there is an aircraft in the window.	The rocket will not be tilted more than twenty degrees. Prior to launching, the team members will make sure the range and sky is clear to avoid airplanes or any other objects. Wind speed is noted every launch preparation, and if the speed is above twenty miles per hour, the team will not launch until conditions subside. ROC Association has obtained all permissions with state laws to launch at Lucerne Dry Lake.
NAR: The rocket will be launched outdoors, in an open area where trees, power lines, buildings, and people not involved in the launch do not present as a hazard. The area is at least as large as the smallest dimensions as one-half of the maximum altitude to which rockets are allowed to be flown at the site or	Lucerne Dry Lake is the designated launch site and is located in the Mojave Desert in Southern California. As a dry lake bed, there is no structure within miles of the radius of the lakebed, such as trees, power lines, or buildings.

1500 feet, whichever is greater. TRA: The launch sight of high power rocketry should only be outdoor area, power lines, and building will not present a hazard to the safe flight operation of a high power rocket in the opinion of the safety monitor. Do not locate a launcher closer to the edge of the launch site than one-half the radius of the minimum launch site dimension. The launch site must be at least as large as the stated in the launch site dimension table.	
NAR: The launcher will be 1500 feet away from an inhabited building or from any public highway on which traffic flow exceed ten vehicles per hour, not including traffic flow related to the launch. It also won’t be closer than the appropriate Minimum Personnel Distance from the accompanying table from any boundary of the launch site. TRA: The launcher location must be more than 1,500 feet from any occupied building. Make sure that the ground for a radius of ten feet around the launcher is clear of brown grass, dry weeds, or other flammable substances. TRA: No person(s) can be closer to the launch pad of a high power rocket than the person actually launching the rocket and those with the title of safety monitor. All spectators must remain within the area determined by the safety monitor and behind the safety monitor and the person who Is launching the rocket.	The team members will make sure prior to launch that spectators are in the designated area and away a certain distance from the launch area. Occupied buildings are more than two miles away and the dry lake bed is clear of any flammable substances. The team members will make sure no one else is within the radius of the members and the rocket prior to launching.
NAR: The recovery system in the rocket will return all parts of the rocket safely and undamaged and can be flown again. The rocket will use only a flame-resistant or fireproof recovery system wadding in the rocket. TRA: The rocket must contain a recovery system that will return all parts of the rocket safely to the ground, and so the rocket may be flown again. Flame resistant recovery wadding should be	A drogue parachute and normal parachutes will safely bring down the rocket in multiple sections that will be tethered together. Inside the rocket, blast cloth will shield the parachutes from heat or damage by the motor or ejection charges.

installed if wadding is required by the design for the rocket.	
NAR: The people recovering the rocket will not attempt to recover the rocket from any power lines, tall trees, or other dangerous places. Therefore it will be flown under conditions where it is likely to recover in spectator areas or outside the launch site; no person(s) will attempt to catch the rocket as it approaches the ground. TRA: No person(s) should attempt to catch a high power rocket as it approaches the ground. No person(s) should retrieve a high power rocket from a place that is hazardous to people.	If the rocket happens to get stuck in a dangerous place, the team will not attempt to recover the device on their own, despite there being no trees or power lines within miles of the Lucerne Dry Lake launch site. All members are aware of the rule of not recovering the rocket in bad situations or catching the rocket prior to landing.
TRA: The high power rocket should be constructed to withstand the operating stresses and retain structural integrity under conditions expected or known to be encountered during the flight.	Fiberglass tubes will maintain the rigidity of the rocket during its flight. Flight boards that slide into the rocket will also maintain the circular structure of the tubing.
TRA: The person intending to operate the high power rocket will determine its stability before flight, providing documentation of the location of the center of pressure and center of gravity of the high power rocket to the safety monitor, if requested.	While designing the rocket on the software Rocksim, members were able to determine the stability margin and keep center of gravity one caliper ahead of center of pressure for the best flight possible.
TRA: The payload in the high power rocket should not be flammable, explosive, or cause harm. Don't fly vertebrate animal in a high power rocket.	The scientific payload involves the detection of carbon dioxide at various altitudes, comprising of electronic components and not anything alive. These components are not flammable.

3.2 Preparation and Launch:

Our team will create a checklist for launch preparation. The checklist will guide the team through safe and complete preparations for launch and include the necessary details.

3.2.1 Checklist

- preparation for launch and assurance that all safety interlock switches are off and batteries uninstalled.

    - The safety interlock switches will be verified as "OFF" and batteries for the recovery electronics will be installed.
- The battery for the GPS's and payload will be installed but will remain off.
    - The Whistle GPS will be placed in a foam cutout and secured to the shock cord. The parachutes will both be located above and below the flight computers, with the drogue parachute packed below and the main parachute packed above in a deployment bag. The payload will be turned on throughout the entire flight, and since there is no telemetry but rather an SD card to store the payload data, the SD card will start recording the moment the Arduino's battery is turned on in the ground.
- Four ejection charges will be prepared and installed (1 for the drogue and 1 for the main for each of the redundant and backup electronics).
    - The two ejection charges for the main will be in two separate compartments, and will be in series. The shear pins can be put into place holding the vehicle sections above and below the avionics bay. The GPS device for the upper section will also be encased in a foam cut out and secured to the shock cord. The rocket can then be placed on the pad (standard launch rail), electronics armed, igniter installed and connected to the electronics launch system. It is necessary only to apply power to the igniter for the launch. The total time should take less than 2 hours.
- Removable shear pins shall be used for both the main parachute compartment and the drogue parachute compartment.
    - There will be shear pins (2mm nylon screws) at all separation points. The shear pins will keep all points of separation attached while the rocket is moving upwards, and this is mainly to make sure that the rocket does not separate before necessary. The primary and backup ejection charges will have enough force to break through the shear pins, ensuring that the main and drogue parachutes deploy.

3.3 Hazardous Materials Safety

In an emergency, dial : 911

California Poison Control Center: 1-800-222-1222

While completing the launch vehicle, team members will frequently come into contact with hazardous materials. These substances will not be dangerous to the team members as long as these rules are followed when handling. Concerning materials include adhesives, paints, and the actual materials used to build the vehicle. The manufacturer of those materials knows best about the posed hazards. Each manufacturer and safety organizations publish MSDS for each product.

Handling these materials will require the use of Personal Protective Equipment (PPE).

An MSDS (Material Safety Data Sheet) is available to provide an overview explaining how to work safely with and handle specific chemicals or materials. It is compiled by the manufacturer of the particular chemical. Although MSDS do not have a particular format, they are required to have certain information per OSHA (Occupational Safety and Health Administration) 29 CFR 1910.1200. A list of the required information can be found here on this website;

<http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=10099>.

Listed are some threats to team members' safety that must be accounted for (see details below the table):

Risk	Mitigation
Impact to the body	Gloves, apron, goggles
Cut or puncture	Gloves and Apron
Chemicals – fumes and/or direct contact	Gloves, respirator, goggles
Heat/cold	Gloves
Harmful Dust and small particles	Mask and Goggles
Loud noises	Earplugs

The team will keep a copy of the MSDS for all materials used in the making of the vehicle when an MSDS exists for a certain material. The following items will be present and available for team member use whenever they are working, constructing the vehicle or payload, or launching.

- Safety goggles
- Rubber gloves
- Protective aprons
- Ear Plugs
- Leather gloves
- Respirators / Dust Masks

Eye protection must be worn whenever there is a danger of:

- Dust, dirt, metal, or wood chips entering the eye. This can happen when sawing, grinding, hammering, or using power tools.

- Strong winds during a launch (common at Lucerne Dry Lake)
- Chemical splashes when using paints, solvents, or adhesives
- Objects thrown (intentionally or inadvertently) or swinging into a team member

These types of gloves must be worn to protect the team member's hands whenever there is danger of contact with a hazardous material:

- Latex or rubber gloves for possible contact with hazardous chemicals such as adhesive, paint, or thinners, or dangerous solid materials.
- Leather gloves to protect against impact, cuts, or abrasions (e.g. in the use of some power tools such as grinders)

Team members will always work in a clean, well-ventilated area. Protection for a team member's lungs (dust mask or respirator) must be used when:

- Working with chemicals emitting fumes (e.g. paints and solvents). In this case, the team member must wear a respirator.
- Working in an environment where there is dust (e.g. sanding and working with power tools). The team member must wear a dust mask.

Body protection, such as an apron must be worn whenever there is danger of:

- Splashes or spills from chemicals
- Possible impact from tools

Ear protection (plugs or ear muffs) must be worn whenever there are loud noises present, which include:

- Using loud power tools or hammers
- Launching larger rocket motors at launches

When creating documents that require work with potentially hazardous materials including chemicals, that section will be marked with the following:

"HAZARDOUS MATERIAL - SEE MSDS"

A sample MSDS is included in Appendix E to show what is included. As materials are identified during the research and design phases of this project, suitable MSDS for those materials used will be gathered and made available to all team members in hard copy form at the work area as well as on the web site.

3.4 Compliance with Laws

The Student Launch team will comply with certain federal, state, and local laws to ensure the legality of this project.

3.4.1 Federal Aviation Regulations 14 CFR

The team will comply with Federal Aviation Regulations 14 CFR by launch our rocket be unmanned, not launched across into the territory of another foreign country, and does not create a hazard to persons, property, or other aircraft. The motor our rocket will be using will be the Aerotech K560 which has a propellant mass of 1408.1g.
Our team launches in Lucerne Dry Lake in California, which is 72.5 kilometers away from the nearest airport and typically without clouds, and will launch at acute angles of attack. The rocket will also utilize a drogue and main parachute so that it will not pose a significant threat to people upon landing.

Our team will also notify the Federal Aviation Association (FAA) in the event that we are going to test a high power rocket. This will help avoid complications in air traffic.

Mr. Koepke, our mentor, will be present at these launches to observe the safety of them. He is 69 years old.

3.4.2 Amateur Rockets, Code of Federal Regulation 27 Part 55: Commerce in Explosives

The team will comply with these rules by keeping our pyrotechnic compositions and pyrotechnic devices in a locked magazine. All magazine storages will have fire apparatus posted with a weather-resistant, reflective warning sign with lettering at least two inches high.

All flame producing devices will be kept outside of a range of 50 feet. Our black powder charges and other flammables, will be kept in a airtight metal magazine to prevent the distribution of an explosion if there happens to be any in the box. All loaded indoor storage magazines will not be located in a residence or dwelling

3.4.3 Fire Prevention, NFPA 1127 "Code for High Power Rocket Motors.

Our team will comply with NFPA 1127 "Code for High Power Rocket Motors. Our rocket will be propelled by a rocket motor with a total impulse of more than 160 N-sec but no more than 40,960 N-sec. Our rocket motor will have more than 125g of propellant weight and weigh more than 1500g with the motor installed. The rocket motor that we will be using is the Aerotech K560 which has a propellant mass of 1408.1g.

3.5 NAR/TRA Rocket Motor and Energetic Device Usage

The rocket motors will not be stored by the SL team, so the motors the rocket uses will be purchased and used on site.

If a motor is not usable, Mr. Koepke can store them in an explosives box and receive the necessary certification from the local fire department.

3.6 Written Statement from Team Members Regarding Safety

We, the team members of the Student Launch team of the AIAA OC Section will understand and abide by the following safety regulations:

- Range safety inspections of each rocket before it is flown. Each team shall comply with the determination of the safety inspection or be removed from the program.
- The Range Safety Officer has the final say on all rocket safety issues. Therefore, the Range Safety Officer has the right to deny the launch of any rocket for safety reasons.

- Any team that does not comply with the safety requirements will not be allowed to launch their rocket.

No.	Date	Name	Signature
1	8/20/16	Albert Wen	AlbertW
2	8/20/16	Norman Chu	Norman Chu
3	8/20/16	David Chang	
4	8/20/16	Kushagra Pandey	Kushagra P.
5	8/20/16	Claire Chang	
6	8/20/16	Sahil Patne	SPatne
7	8/20/16	Allison Chen	

4. Technical Design

4.1 Vehicle Overview

The launch vehicle, which is a recoverable, reusable, and single-stage rocket, will be 91.75” long, have a 4” diameter, weigh 9.845 kg, or 21.70 lbs, and will be made of fiberglass body tubes.

The fins are 83.50” from the nose cone.

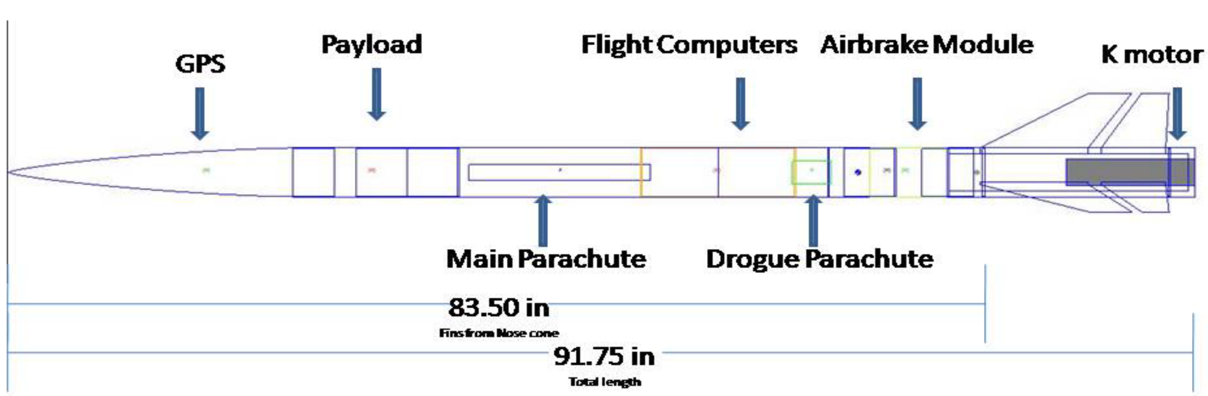
The diameter will be 4” to provide ample space for the payload and other electronics without adding too much drag to the overall design. Fiberglass will be the material of choice because has the necessary strength and affordability for this project.

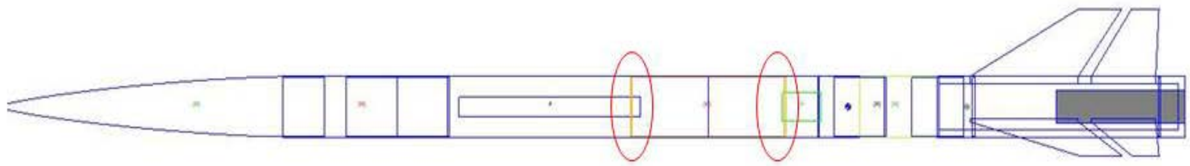
This launch vehicle will be a single stage modified Frenzy XL kit designed by Michael Stoop and purchased from Mad Cow Rocketry. Modifying a kit instead of designing an original flight vehicle would be a more efficient use of time and be less difficult.

The launch vehicle will also utilize an air brake system to meet the height requirement of exactly one mile. The air brake system will be in Section 4.8.

Based on past experience, this rocket will be composed of different modules, which allow the rocket to be customizable and a more cost-effective vehicle. If a module is damaged or lost, we can easily make another module and continue using the same rocket.

There are three independent sections, satisfying the requirement of a maximum of four. According to the 2017 NASA SL Handbook, “An independent section is defined as a section that is either tethered to the main vehicle or is recovered separately from the main vehicle using its own parachute.”





The red circles indicate where the rocket separates into independent sections.

The static stability margin is 1.95 calibers, according to what RockSim has calculated. However, when viewing the rocket in-flight in the software's 2D flight profile, we found that the rocket started with a static stability margin of 2.6 calibers, which is something we did not expect. We suspect that either the software has a bug (it often does not accept some mass values unless we press "enter" upon input) or the rocket's static stability margin is truly what it states in the 2D flight profile. If the latter case is true, then we will need to continue improvements on the rocket to a rocket with a 2.0 static stability margin at the point of rail exit.

Please note that the rocket does not have forward canards or forward-firing motors.

4.2 Construction Methods

4.2.1 Fiberglass Cutting

24-hour epoxy will be used to seal the fiberglass, and airbrakes will be included in this design to control the vehicle's altitude. If necessary, additional fiberglass can be layered onto the body tubes and vacuum-bagged to provide additional strength.

A hacksaw with a fine pitch blade will be used to cut the fiberglass body tubes. To cut the tube, we will gently cut a groove at the desired length of the body tube and rotate the tube as we cut. Fiberglass can dull the blade, so we may need to switch blades. After multiple rotations, we will be able to receive a fairly clean cut body tube. Alcohol will be used to remove fiberglass dust

Fiberglass is a hazardous material. The MSDS for the material is in Appendix E

4.2.2 Epoxy

The epoxy we will use for the launch vehicle will be used to assemble the rocket. We will use alcohol to clean the tubes after cutting and sandpaper to increase the surface area of the tube when gluing.

Epoxy is a hazardous material. The safety procedures for handling epoxy can be found in Appendix E.

4.2 Projected Altitude

The projected altitude is 5661.68 feet, or 1.07229 miles AGL. This was calculated using RockSim 9, a simulation software by Apogee Rockets. We must purposefully go over the target altitude so that the air brakes are able to perform and at the same time remain within a reasonable range for the air brakes to be effective. The current design can be modified by adding more mass to bring the rocket closer to 5280 feet, or 1.000 mile AGL. We obtained this data using an Aerotech K560.

4.3 Projected Parachute System

The rocket is required to have a main and drogue parachute. We will employ two, which will be ejected by 4F black powder charges. Flight computers will provide autonomous ejection.

4.3.1 Parachute Selection

According to RockSim simulations, post-apogee, our rocket is projected to have a mass of 8437.7 g, or 18.60 lbs. The projected altitude is 5661.68 feet.
If the rocket did not have a parachute, the velocity upon impact would be 450.763 ft/s.

Using the equation for kinetic energy,

$$K = \frac{1}{2}mv^2$$

$$= \frac{1(8437.7\ g)}{2} \times \frac{1\ kg}{1000g} \times (450.763\ ft/s)^2 \times \frac{(0.3048\ m)^2}{1\ ft^2}$$

$$= 7.9368 \times 10^4\ N \cdot m$$

$$= 583737\ ft - lbf$$

The final result shown here was verified using unitconversion.org.

To insure a safe and recoverable flight, we will use the listed recovery electronics to eject two parachutes, one main and one drogue.

Our drogue parachute will be a 2 ft parachute from Fruity Chutes. This will deploy at apogee.

Our main parachute is an 108” parachute from Fruity Chutes. It will deploy at 900 ft.

According to RockSim simulations, our rocket will have a velocity of 119.15 ft/s at 900 ft, post-apogee. The drogue chute will slow down the rocket before the main parachute is deployed. The final velocity of the rocket is 14.21 ft/s, after the rocket deploys the main parachute.

Using the equation from before,

$$K = \frac{1}{2}mv^2$$

$$= \frac{1(8437.7\ g)}{2} \times \frac{1\ kg}{1000g} \times (14.21\ ft/s)^2 \times \frac{(0.3048\ m)^2}{1\ ft^2}$$

$$= 98.94\ N \cdot m$$

$$= 72.97\ ft - lbf$$

The final result shown here was verified using unitconversion.org.

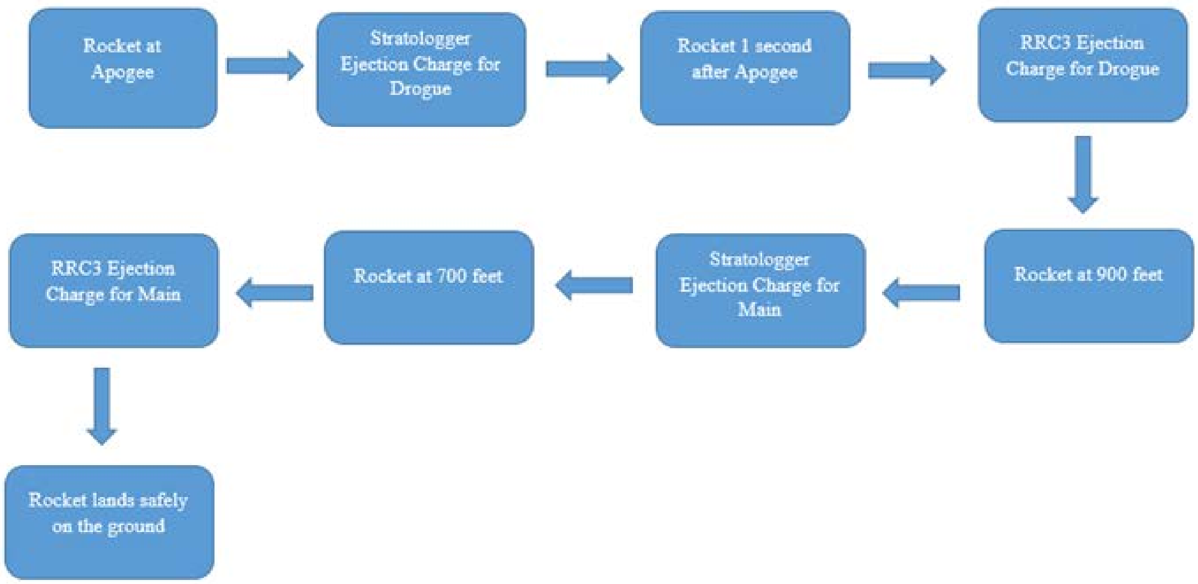
The kinetic energy of the rocket is under the maximum 75 ft-lbf.

4.3.2 Recovery Electronics

The vehicle will use redundant dual deployment for recovery. The top section will be connected to the parachutes via a nylon shock cord, and the avionics bay will also be connected via a nylon shock cord. Recovery will occur in two phases – near apogee a small drogue parachute will be deployed that is designed to slow the rocket for initial descent. Much later, at an altitude of 900 feet, the ejection charge will deploy the main, which is designated to drastically slow down ascent for the purpose of safety.

The primary set of recovery electronics will use a Stratologger CF Flight Computer, and the backup set will use an RRC3 Flight computer. In this way, if there is a bug in the design of either flight computer that would affect the recovery during our flight it will not be replicated in the other set of electronics. Each of the two recovery electronics has its own separate commercially available battery capable of powering the electronics for a minimum of 1 hour dwell time plus flight time. That battery is disconnected through an interlock key switch accessible on the outside of the rocket near the nose cone, and this is to ensure that the electronics are not powered on until it is safe to do so on the launch pad. They key can be removed only when the switch is locked ON. The recovery electronics will ignite a measured portion of gunpowder using an electric match. Recovery electronics are totally independent of the payload electronics and power. To assure that the radio frequency signals of other electronics do not interfere with recovery, use a MG Chemicals SuperShield. One to two mil coating provides 40dB - 50dB shielding across a frequency range of 5 to 1800MHz.

4.3.2.1. Recovery Flowchart



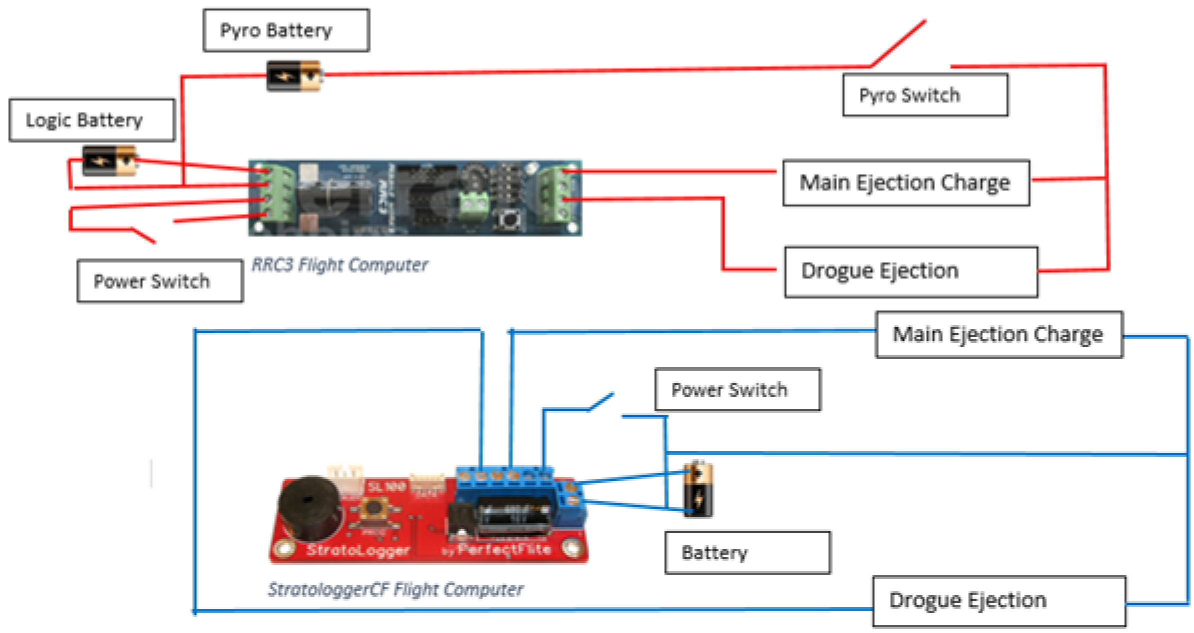
4.3.2.2 Recovery Electronics "A"

The main set of electronics will use a Stratologger CF Flight Computer, an altimeter and dual deploy mechanism with a range of 100,000 feet. It can store 31 flights of 9 minutes each (altitude, temperature, and battery voltage at 20 samples per second) and is capable of deploying drogue and main chutes with audible ematch continuity check. The altitude is sensed via barometric pressure and accelerometer; this provides an additional level of security in the event there are barometric pressure anomalies during the flight causing a false trigger.

4.3.2.3 Recovery Electronics "B"

The backup electronics will use an RRC3 Flight Computer, a dual deploy mechanism and altimeter. In addition to basic dual-deploy capability, the RRC3 Sport is a multi-flight recording unit, allowing you to fly all day, without the need to stop and download data in between flights. It can also support real-time data streaming capabilities in flight for telemetry or for interface with other custom control systems. The altitude is sensed via barometric pressure and accelerometer; this provides an additional level of security in the event there are barometric pressure anomalies during the flight causing a false trigger.

4.3.2.4 Recovery Schematics



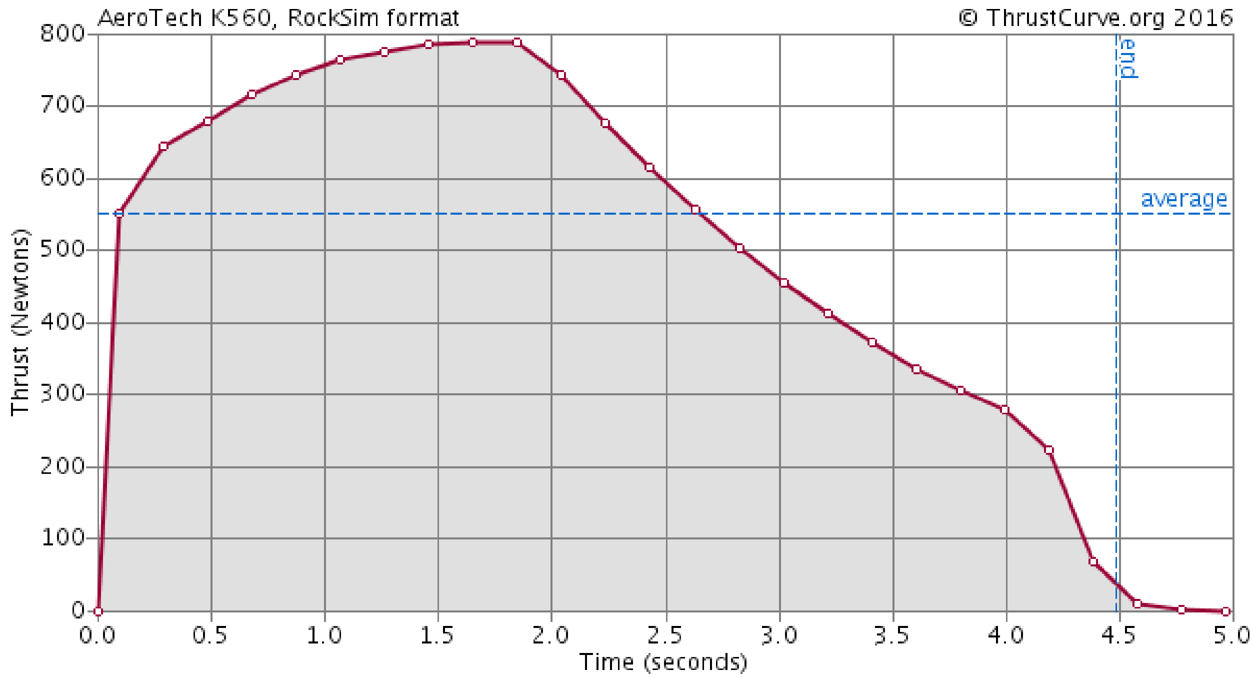
4.4 Projected Motor

The table below contains data taken from both thrustcurve.org and our RockSim simulations.

Aerotech Engines	Total Impulse (Ns)	Total Mass (g)	Max Altitude (ft)	Max Velocity (ft/s)	Max Accel (ft/s^2)
K560 (75 mm)	2417.0	2744.0	5597.15	645.60	625.85
K1050W* (54 mm)	2522.0	2259.0	6171.78	804.28	639.94
K780R (75 mm)	2,361.1	2934.4	5286.35	674.52	640.38
K1000T (75 mm)	2496.6	2575.0	5903.15	392.925	745.308
Cesaroni Engines	**Total Impulse (Ns)**	**Total Mass (g)**	**Max Altitude (ft)**	**Max Velocity (ft/s)**	**Max Accel (ft/s^2)**
K570 (75 mm)	2070.3	1685.0	4972.4	626.67	314.485
K90 (75 mm)	2415.3	1994.0	6053.31	680.92	639.93

*The average thrust on this RockSim engine file differed from the data given by thrustcurve.org. The average thrust that thrustcurve.org gave was 1062.3 N. The average thrust given by the RockSim engine file is 1025.218 N. The burn time also differed: 2.46 sec on the file, 2.4 sec on thrustcurve.org

Based on the given data, we project that we will use the Aerotech K560 for this project. Its total impulse does not exceed the



We would have preferred a motor with a higher initial impulse, or a spike, in the graph above, to increase the velocity of the rocket. Increasing the velocity of the rocket would have increased the normal force exerted by the center of pressure of our rocket and resulted in an overall straighter flight ("Calculating the Center of Pressure of the Model Rocket" by James Barrowman).

Unfortunately, other motors we simulated either did not have a high enough impulse or had too much impulse to place the rocket within a reasonable range above the target altitude.

4.4.1 Minimum Velocity at Rail Exit

According to RockSim simulations, the rocket, at rail exit, has a velocity 54.375 ft/s. The rail is 8 ft long, and the rocket exits 0.373 sec after ignition.

The minimum requirement is 52 ft/s at rail exit.

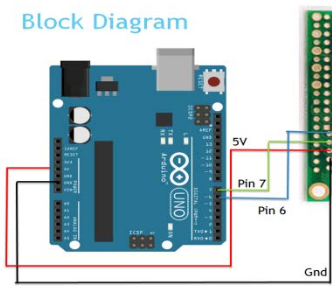
4.5 Payload Overview

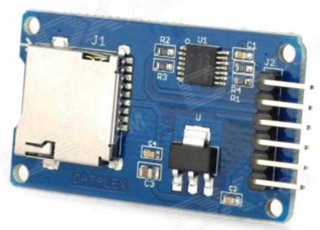
The payload will be a small (2" X 2.25") carbon dioxide sensor that is located in the body tube near the nose cone. Although it is not an external housing, we will have holes on the body tube near the sensor. The sensor's objective is to monitor air quality by measuring the change in CO2 levels as the rocket ascends to 1 mile high. The safe level of carbon dioxide in the atmosphere is 350 ppm (parts per million).

The CO2 Sensor is designed to be recoverable because it is kept safe underneath the protection of the body tube and held in place with nylon shock cords and tube couplers. The payload and arduino are reusable because these devices are designed to be long-lasting and can still work flight after flight without any modifications.

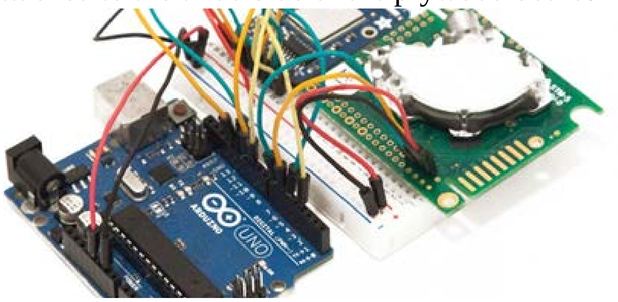
We will be using two Pnuts in our flight. One is for altitude input to the Arduino, and the other is for the judges.

The sensor is the K30 CO2 Sensor and will require a few supporting hardware:
- Arduino
- Breadboard
- Wires
- SD card



The K30 CO2 Sensor will be connected to the Arduino using wires and both devices will be attached to a small piece of plywood board which will neatly fit in the 4 inch diameter body tube. There will also be openings on the sides of the body tube where the sensor is so that the payload can measure the air quality in the atmosphere. The SD card will be connected to the Arduino and will be attached to the underside of the plywood board.



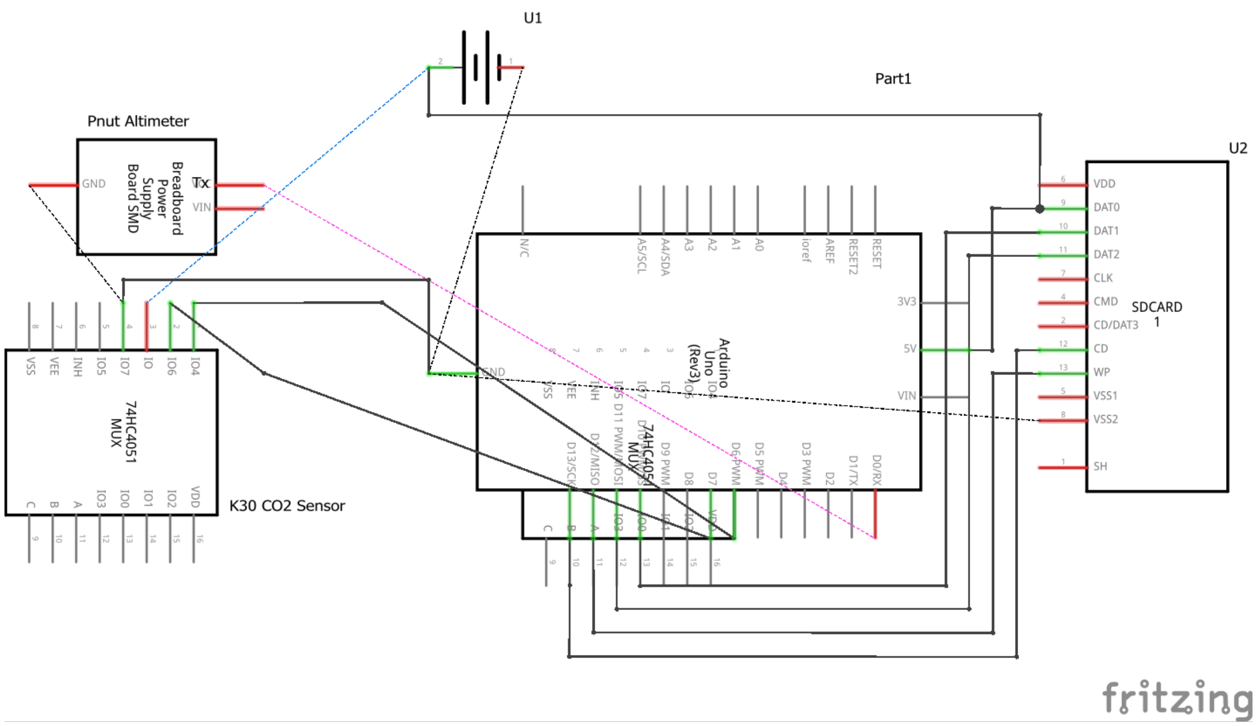
The Sensor has a response time of 2 seconds and a diffusion time of 20 seconds. Its measurement range is from 0 to 10,000 ppm and its repeatability is ± 20 ppm ± 1 % of measured value within specifications. To perform self-diagnostics, we will run a complete function check.
A circuit board is needed to regulate the voltage of the battery, filter out noise, and organize the connection between the K30 CO2 Sensor to the Arduino.

4.5.1 Circuit Board

Item	Function	Comments	Weight
Arduino Uno	electronic prototyping platform allowing interaction with electronic devices	Controls actions of the K30 CO2 Sensor	28 g
LM 7805	Regulate battery voltage	Regulates the battery's voltage (7.4V) to Arduino voltage (5V)	2. g
Ceramic Capacitor	Filters noise	0.33 uF and works with Regulator	0.5 g
Resistor	Adds resistance to an electric current	Use 10 K ohm	0.3 g
LED Diode	Light source	Indicates if control system works	0.4 g
Lithium Ion Battery	Provides power	Two Cell battery. 500 mAH	17 g
K30 CO2 Sensor	Sensor for carbon dioxide	Tests air quality	17 g
Breadboard	A board for making an electrical circuit	All items will be linked to the breadboard	80 g
Micro SD Card	Used for recoding data for later		3.5 g

Module	analysis		
Pnut	An altimeter	One is for the Arduino and one is for the judges	4g
Total Weight			149.2 g

Circuit Diagram



4.6 Major challenges and solutions

A few of the challenges regarding this project include researching and organizing the information into a well-formatted proposal. But our major challenges require the most effort to complete. The three challenges are listed in the table below:

Challenge	Solution
Our team does not have enough money for the	Our team formed a subteam that will be dedicated to fundraising. Our fundraising subteam sells artwork online and also asks for

materials and the experiment.	donations for our experiment.
Reaching an altitude of exactly 1 mile	Our team will use RockSim simulations to test if our rocket's exterior design will be suitable for the desired altitude. Also, our design includes air brakes to control the rocket's ascent.
Making a perfect airbrake control system	One subteam will be dedicated to the electrical engineering portion of our experiment and will diligently design and build airbrakes that will be controlled by a microcontroller, called Teensy.

4.7 Telemetry

Each section of the vehicle that returns separately must have its own tracking electronics. Since our rocket comes down in one piece, we have only one GPS device: the Whistle GPS dog tracker.

4.7.1. GPS

For our GPS, we will be using the Whistle GPS dog tracker. The dog tracker has the dimensions of 0.8" x 1.2"x 4.2", and will transmit the location of the vehicle (latitude, longitude, and altitude) to a team member's cell phone. We have verified that there is cell phone coverage at Lucerne Dry Lake, CA and Bragg Farms, AL. It uses cellular connection to operate the GPS and will thus use a frequency of 1800 Mhz. On the launch site, the team will set up a mock ground station using the Whistle Base Station, the charger and telemetry aspect of the GPS. The base station was originally intended to establish a Whistle Zone, or acceptable range for pets, but the team will utilize this feature by setting up a small whistle zone so that the GPS commences tracking almost immediately after launch.

4.7.2. Radio Frequency Devices

Device	Frequency	Tx Power	Location
Whistle GPS	1800 Mhz	Not provided by company site, in process of contacting	Nose Section

4.8 Air Brakes

For the 2017 Team America Rocketry Challenge (TARC), we developed an air brake system. After testing the design ten times, recording the air brakes in flight with an on-board flight camera, and examining post-flight data, we determined that the air brake system was reliable and applicable for our purposes in Student Launch.

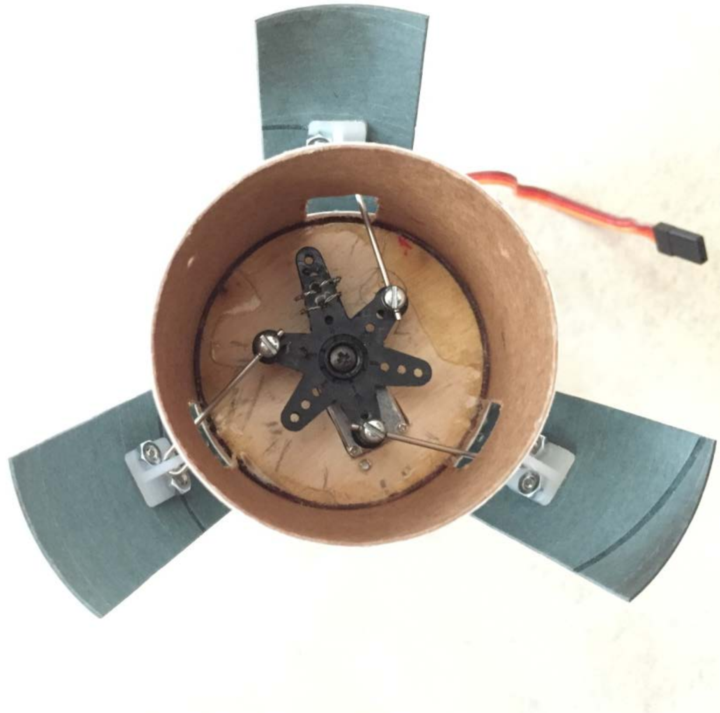
The air brakes will use a Hitec HS-7890T circular servo, which have the following statistics:

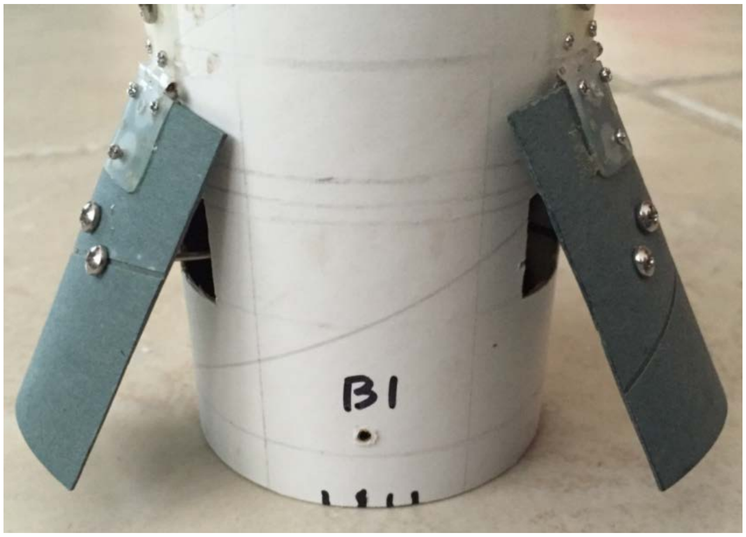
Dimensions	1.72" x 0.88" x 1.57" (43.8 x 22.4 x40 mm)
Product Weight	2.76 oz (78.2g)
No-Load Speed (6.0V)	0.21 sec/60°
No-Load Speed (7.4 V)	0.17 sec/60°
Stall Torque (6.0V)	500oz/in (26 kg.cm)
Stall Torque (7.4V)	611oz/in (44kg.cm)
Travel per µs (out ofbox)	.080°/µsec
Travel per µs (reprogrammed high res)	.132°/µsec

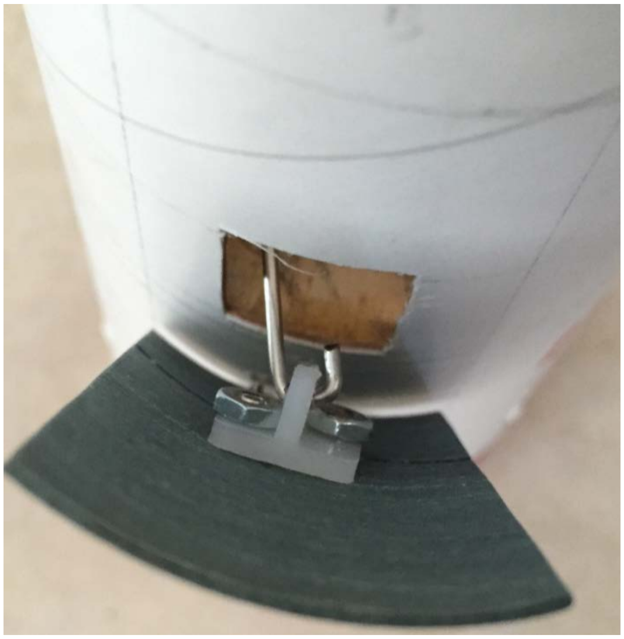
Servocity.com

The air brake will be modeled after our air brakes, which we are using for the Team America Rocketry Challenge this year.

These are the air brakes when they are open.







4.8.1 Mechanical Engineering

The original mechanism for the air brakes involved using a 2” linear actuator to push the air brakes inward and outward, but after developing prototypes to test the reliability and speed of the mechanism, we decided that the linear actuator could not act quickly enough and used too much space.

We the considered other mechanisms that involved a circular servo. We received our inspiration from a YouTube video of a mechanical flower. A student from the University of Twente used this flower for a bachelor thesis. The circular servo was a much more efficient use of space and was able to respond faster compared to the linear actuator.

To make the legs on our airbrake system to push and pull the air brakes, we used strong dental wire and dental tools from Albert's father, who is a dentist. Our system required flexibility around the rotational points, like the ball and socket joint on the human shoulder. We cut and bent the wires into hooks and attached them to loops we made ourselves to accomplish this design.

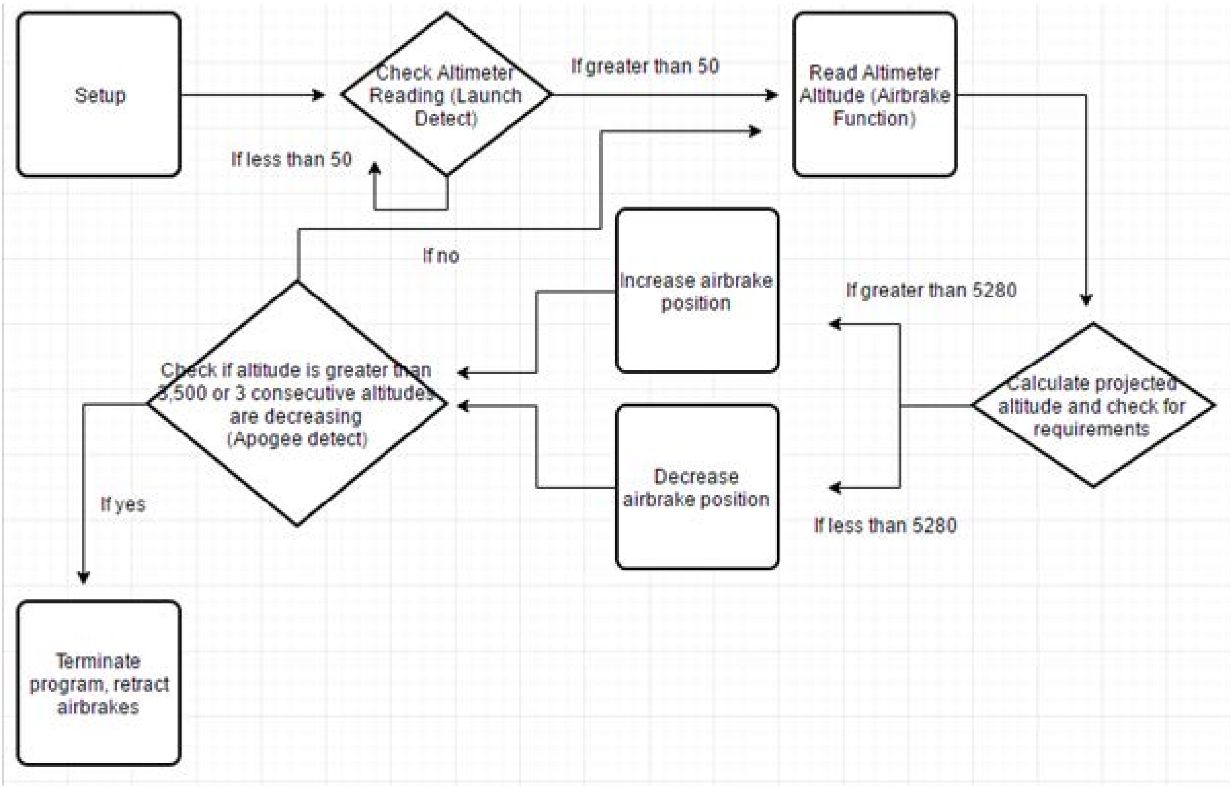
We first made a proof of concept of the mechanism on June 27, which can be found here. Our current design can be found here.

The air brake module itself will be 6 inches long, so we anticipate that the air brakes will be 5 inches long. The current model pushes the air brakes through holes that we carved into the body tube.

4.8.2 Algorithm Development

The overall algorithm we will use to automate our airbrakes has four major facets: the initial setup, the launch detect function, the actual airbrake function, and the apogee detect function. The initial setup, or void setup, initializes the Arduino's serial monitor to a baud rate of 9600 Bd, along with blinking a built in LED light to indicate to the user that the system was functional. Next, the launch detect function is perhaps the most vital piece of the code. It is a boolean function which analyzes the readings from the altimeter, and when it sees a value which is greater than 50 feet, it starts the main airbrake program. The airbrake function then checks the altimeter values and uses basic physics formulas (factoring in air resistance, pressure, etc) to determine velocity and projected altitude. If this projected altitude is greater than the actual altitude, the airbrake will expand to a certain angle (where 120 degrees was the maximum) using a fairly linear formula. The airbrake function works simultaneously with the apogee detect formula, which analyzes the altitudes from the Pnut and checks to see whether the rocket reaches apogee. Since this is a boolean function, it has to satisfy 2 conditions in order to be true. First, three consecutive altitudes has to be descending, as this will indicate a descending rocket and thus the arrival of apogee. However, we have to account for errors in the Pnut readings, so the second condition is that the altitude has to be at least 3,500 feet. If the detect apogee function satisfies these two conditions, it will terminate the airbrake function and stop the overall program, retracting the airbrakes to zero position. After all, there is no use of the airbrakes after apogee.

4.3.3 Algorithm Flowchart



5. Educational Engagement

5.1 - Written plan for soliciting additional community support

We will engage the surrounding community by educating them about rocket science and SL. Phase I includes:

- Use the AIAA network to reach out to AIAA members in Southern California so they can in turn reach out to the schools those members are involved with to make them aware of SL and TARC.
- Contact the Discovery Science Center in Santa Ana, CA, for a possible session with youth and rocketry.

Phase II will include more emphasis on fundraising and less on engaging people in large assemblies:

- Go around the community to collect things or a garage sale and also ask for donations, explaining to them what the team's goal is.

5.2 - Engage a minimum of 200 participants, at least 100 who are middle school students/educators – to be completed prior to the FRR (March 6, 2017).

- The SL team will raise awareness in the local population by holding presentations in Ivymax that will show current and future academy students what SL is all about. Fliers can also be handed out during the presentations to help increase the understanding of the audience.
- The SL team will put together flyers and distribute them around the community to bring to light rocketry and what we will be doing. This will also create interest locally and possibly bring in donations.
- In October, the SL team will help Girl Scouts build small rockets and increase their interest in rocketry. Hopefully, they will spread the word and raise awareness of our team.
- The SL team will contact the Orange County Model Engineers, a 501c nonprofit organization, to see if it is possible to set up an event where we can talk about SL. The organization is located in Fair View Park in Costa Mesa, CA.

6. Project Plan

6.1 Project Plan

The project plan includes the budget, timeline, and educational standards. It is basically about what we're going to do it with, by when we're going to have it done, and what we're learning while we are working on this project. This section is essential for organization, and our team gets everything done and submitted by the time necessary. It also lets us know if we need to start fundraising and how much we need to make.

The timeline is located in Appendix G. This timeline includes the deadlines where we have to have things done by, or the dates we have to be working on the given project. Many things are to be considered before a project is to be started. This timeline will help outline how we will get things done.

The budget is located in Appendix H and is the expense of the project. It includes everything we spend money on, from materials to travel. The budget has categories to locate the expense for the Vehicle, Recovery, GPS system, Motors, and Travel. You can find the estimated total at the bottom at: Total Estimated project expenses.

6.1.1 Curriculum Framework - Outline of standards met locally

Our project meets the educational standards when the students investigate and analyze the data that the rocket receives. We have to use scientific calculations, using calculus and physics, which include Newton's laws of motion, gravitation pull, projectile motion, electrical power, density, and pressure. Our meetings are after school and on weekends, since we do not all attend the same school.

6.1.2 Curriculum Framework - Outline of standards met nationally

Aspects of this project address the following:

- Science meets each student's learning ability
- Teamwork
- Student interaction
- Developing short term goals for students
- Encouraging all students to participate
- Having available time
- Maintaining a safe work environment
- Being able to make sure tasks are authentic
- Having the opportunity to present data
- Studying the motions and forces
- Investigating energy and matter
- Understanding technological design

- Understanding the science and technology that are applicable to this project

6.1.3 Timeline

		Task Name	Physical % Complete	Duration	Start	Finish	Predecessors	Resource Names
1		Proposal	0%	85 days?	Mon 7/11/16	ed 10/12/16		
2		Summer 2016	0%	46 days?	Mon 7/11/16	lon 8/29/16		
3		First Draft	0%	1 day	Wed 8/17/16	Ved 8/17/16		
4		Completed First Draft	70%	1 day	Wed 8/17/16	Ved 8/17/16		
5		Work on Second Draft	0%	46 days?	Mon 7/11/16	lon 8/29/16		
6		Completed Second Draft	0%	8 days?	Sat 8/20/16	Mon 8/29/16		
7			0%	1 day?	Mon 7/11/16	Mon 7/11/16		
8		School Opens in IUSD	100%	1 day	Wed 8/24/16	Ved 8/24/16		
9		Fall 2016	0%	85 days?	Mon 7/11/16	ed 10/12/16		
10			0%	1 day?	Mon 7/11/16	Mon 7/11/16		
11		Work on Third Draft	0%	19 days	Mon 8/29/16	Sat 9/17/16		
12		General information	0%	17 days	Wed 8/31/16	Sat 9/17/16		
13		General Information	90%	17 days	Wed 8/31/16	Sat 9/17/16		
14		Facilities and Equipment	0%	17 days	Wed 8/31/16	Sat 9/17/16		
15		Facilities and Equipment	95%	17 days	Wed 8/31/16	Sat 9/17/16		
16		Safety	0%	17 days	Wed 8/31/16	Sat 9/17/16		
17		Vehicle Risk Mitigation	95%	17 days	Wed 8/31/16	Sat 9/17/16		
18		Recovery Risk Mitigation	95%	17 days	Wed 8/31/16	Sat 9/17/16		
19		Payload Risk Mitigation	95%	17 days	Wed 8/31/16	Sat 9/17/16		
20		Launch Safety Rules	95%	17 days	Wed 8/31/16	Sat 9/17/16		
21		Technical Design	0%	17 days	Wed 8/31/16	Sat 9/17/16		
22		Vehicle Design	20%	17 days	Wed 8/31/16	Sat 9/17/16		
23		Preparation and Launch	80%	17 days	Wed 8/31/16	Sat 9/17/16		
24		Recovery Electronics	90%	17 days	Wed 8/31/16	Sat 9/17/16		
25		Motor Type and Design	95%	17 days	Wed 8/31/16	Sat 9/17/16		
26		Science/Engineering Payloa	95%	17 days	Wed 8/31/16	Sat 9/17/16		
27		Requirements for Rocket ar	90%	17 days	Wed 8/31/16	Sat 9/17/16		
28		Testing	0%	17 days	Wed 8/31/16	Sat 9/17/16		
29		Educational Engagement	0%	17 days	Wed 8/31/16	Sat 9/17/16		
30		Educational Engagement	80%	17 days	Wed 8/31/16	Sat 9/17/16		
31		Project Plan	0%	17 days	Wed 8/31/16	Sat 9/17/16		
32		Project Plan	95%	17 days	Wed 8/31/16	Sat 9/17/16		
33		Plan for Sustainability	95%	17 days	Wed 8/31/16	Sat 9/17/16		
34		Deliverables	0%	17 days	Wed 8/31/16	Sat 9/17/16		
35		Flight Card?	0%	17 days	Wed 8/31/16	Sat 9/17/16		
36		Budget	99%	17 days	Wed 8/31/16	Sat 9/17/16		
37		Appendices	0%	17 days	Wed 8/31/16	Sat 9/17/16		
38		MSDS	95%	17 days	Wed 8/31/16	Sat 9/17/16		
39		NAR and TRA Safety Comp	15%	17 days	Wed 8/31/16	Sat 9/17/16		
40		Hazardous Materials Safety	95%	17 days	Wed 8/31/16	Sat 9/17/16		
41		Shop Safety Rules	95%	17 days	Wed 8/31/16	Sat 9/17/16		
42		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		

		Task Name	Physical % Complete	Duration	Start	Finish	Predecessors	Resource Names
42		Timeline	25%	17 days	Wed 8/31/16	Sat 9/17/16		
43		Safety Statement	16%	17 days	Wed 8/31/16	Sat 9/17/16		
44		Technical Requirements Cr	0%	17 days	Wed 8/31/16	Sat 9/17/16		
45		Proposal Requirements Cro	0%	17 days	Wed 8/31/16	Sat 9/17/16		
46		Major Challenges	0%	17 days	Wed 8/31/16	Sat 9/17/16		
47		Comprehensive budget	0%	19 days	Mon 8/29/16	Sat 9/17/16		
48		Completed Third Draft	0%	1 day	Sat 9/17/16	Sat 9/17/16		
49			0%	1 day?	Mon 7/11/16	Mon 7/11/16		
50		Submitted Third Draft	0%	1 day	Fri 9/30/16	Fri 9/30/16		
51		Proposals awarded	0%	1 day	Wed 10/12/16	'ed 10/12/16		
52			0%	1 day?	Mon 7/11/16	Mon 7/11/16		
53		**PDR**	**0%**	**132 days?**	**Mon 7/11/16**	**Sun 12/4/16**		
54		**Fall 2016**	**0%**	**132 days?**	**Mon 7/11/16**	**Sun 12/4/16**		
55		Kickoff and Q & A	0%	14 days	Fri 11/4/16	'hu 11/17/16		
56		Web Presence Established	100%	14 days	Tue 11/1/16	on 11/14/16		
57		**PDR Document**	**0%**	**14 days**	**Fri 11/18/16**	**Sun 12/4/16**		
77		**Testing**	**0%**	**126 days?**	**Mon 7/11/16**	**on 11/28/16**		
78		Black Powder Testing	0%	14 days	Sat 11/12/16	on 11/28/16		
79		GPS Testing	0%	1 day	Sat 11/12/16	Sat 11/12/16		
80			0%	1 day?	Mon 7/11/16	Mon 7/11/16		
81		Payload Assembly	0%	5 days?	Sat 11/5/16	Wed 11/9/16		
82		Scale Model Assembly	0%	7 days	Sun 11/13/16	Sat 11/19/16		
83		Launch Day	0%	1 day?	Mon 11/21/16	on 11/21/16		
84		**PDR reports, presentation slid**	**0%**	**119 days?**	**Mon 7/11/16**	**Fri 11/18/16**		
85		PDR web teleconference	0%	16 days	Thu 11/3/16	Fri 11/18/16		
86			0%	1 day?	Mon 7/11/16	Mon 7/11/16		
87		**CDR**	**0%**	**178 days?**	**Mon 7/11/16**	**Tue 1/31/17**		
88		**Winter 2016**	**0%**	**36 days**	**Wed 11/30/16**	**Tue 1/10/17**		
89		CDR Q & A	0%	1 day	Wed 11/30/16	'ed 11/30/16		
90		CDR Document	0%	32 days	Sun 12/4/16	Tue 1/10/17		
91		Payload Revisions and Assembly	0%	6 days	Mon 12/12/16	un 12/18/16		
92		Launch Vehicle Assembly	0%	11 days	Tue 12/13/16	Sat 12/24/16		
93		Launch Day	0%	1 day	Sat 12/31/16	Sat 12/31/16		
94		**CDR reports, presentation slides**	**0%**	**178 days?**	**Mon 7/11/16**	**Tue 1/31/17**		
95		CDR teleconference	0%	11 days	Tue 1/17/17	Tue 1/31/17		
96			0%	1 day?	Mon 7/11/16	Mon 7/11/16		
97		**FRR**	**0%**	**34 days**	**Wed 2/8/17**	**Fri 3/24/17**		
98		**Winter 2016**	**0%**	**15 days**	**Wed 2/8/17**	**Mon 2/27/17**		
99		FRR Q & A	0%	1 day	Wed 2/8/17	Wed 2/8/17		
100		FRR Document	0%	12 days	Sat 2/11/17	Mon 2/27/17		

		Task Name	Physical % Complete	Duration	Start	Finish	Predecessors	Resource Names
101		**Spring 2017**	**0%**	**15 days**	**Mon 3/6/17**	**Fri 3/24/17**		
102		FRR Submitted	0%	1 day	Mon 3/6/17	Mon 3/6/17		
103		FRR teleconference	0%	13 days	Wed 3/8/17	Fri 3/24/17		
104								
105		**LRR**	**0%**	**229 days?**	**Mon 7/11/16**	**lon 4/10/17**		
106		**Spring 2017**	0%	1 day?	Mon 7/11/16	Mon 7/11/16		
107		LRR	0%	1 day	Tue 4/4/17	Tue 4/4/17		
108		Rocket Fair	0%	1 day	Thu 4/6/17	Thu 4/6/17		
109		Launch Day	0%	2 days?	Fri 4/7/17	Mon 4/10/17	108	

6.2 Budget for the Whole Project

Description	**unit costs**	**extended costs**
Scale Vehicles and Engines		
3" Fiberglass Frenzy XL	$200	
3" G12 Thin-Wall Airframe (12" length)	$20	
3" G12 Coupler (2 of 6" length)	$28	
3" G12 Coupler (9" length)	$21	
HS-7980TH	$190	
2-56 wire	$10	
Heavy unit easy connector	$5	
Iris Ultra 60" Compact parachute	$225	
15" Elliptical Parachute	$60	
Total Scale Vehicle Cost		$759
contingent second rocket in case rocket is destroyed	$759	
Vehicle		
4" G12 Coupler (12" length)	$31	
4" G12 Coupler (2 of 8" length)	$42	
4" Fiberglass Frenzy XL	$300	
4" G12 Airframe (12" length)	$23	
75mm Aerotech K560 (3 units)	$210	
HS-7980TH	$190	
2-56 wire	$10	
Heavy unit easy connector	$5	
Aerotech K560 (3 units)	$52	

Total Vehicle Cost		$863
contingent second rocket in case rocket is destroyed	$863	
Recovery		
Iris Ultra 120" Compact Parachute	$504	
24" Elliptical Parachute	$60	
4F Black Powder	Kept by mentor	
Batteries (9v & $7 for 2)	$21	
Battery Holder ($1 each)	$5	
Stratologger CF Flight Computer	$55	
RRC3 Flight Computer	$70	
PerfectFlight Pnut (2 units)	$110	
Total Recovery Cost		$825
contingent second recovery in case first is destroyed	$825	
Payload		
K30 CO2 Sensor	$85	
Arduino Uno kit (includes LED, resistors, regulators, etc)	$35	
SD card + Adapter	$10	
PerfectFlite Pnut Altimeter (2 for $50)	$100	
Lithium Ion Batter (rechargable)	$100	
Total Payload Cost		$230
contingent second payload in case first is destroyed	$230	
GPS System		
Whistle GPS Dog Tracker Kit	$75	
Cellular Service Fee (3 months free, 5 months to pay)	$40	
Total Payload Cost		$115
contingent GPS rocket transmitter	$115	
Educational Outreach		
Color fliers (250 copies)	$170	
Total Educational Outreach Cost		$170

Travel (7 Members)		
Trips to Lucerne ($2.80/gal, 112mi; $21.00 per trip per car)		
Huntsville, Alabama (roundtrip plane ticket, $332 pp)	$2,324	
Hotel ($130 per room, 2 people per room, 6 days)	$3,120	
Food ($25 per day)	$1,050	
Total Travel Cost (Estimated)		$6,494
Total Estimated Project Expenses		$9455.95

6.3 Funding Plan

Our rocket team will procure funds from various sources. Action plans include the following: sell See's candies and Mary Kay cosmetics to fundraise, go around the community to collect items for a garage sale and also ask for donations, explain to them what the team's goal is, send letters to local businesses and aerospace companies requesting financial aid, and speak to vendors involved in rocketry and other supplies for discounts and donations. We have already obtained funds from selling artwork to art patrons and will continue doing so. Some the sponsors we have currently are Apex Desks, Pegasus Management, and Yogurtland.

6.4 Plan for Sustainability

The SL team is part of the AIAA OC Section educational outreach whose goal is to inspire youth in science and engineering, emphasizing aeronautical and astronautical engineering. The team mentors have formed the AIAA OC Section Rocketry Club (NAR Section #718). This club and group of SL team members in turn guide a group of young rocketeers each month as they meet to learn about aerospace and build their rockets. In addition, this club has at least one launch outing each month. The club encourages participation in TARC (Team America Rocketry Challenge) and already has two teams this year, one all junior high school students and the other all high school students. As these youth continue to mature in their rocketry skills, our team will begin to offer more challenging group projects that are larger in scale. This program is known to work, as we have had several members go on to get their NAR Level 1 Jr. certifications and to pursue aerospace engineering careers at Purdue and Cal Poly Pomona.

The team and rocketry club last year started a "tradition" of participating in the Orange County Fairgrounds Youth Expo. This booth was well-received by the attendees as well as the Youth Expo staff and were excited that we will continue to return in subsequent years.

We have spoken with a retired high school physics teacher at the ROC Launches who would like to form a launch for all TARC teams that did not make the finals. We will actively pursue this together with the AIAA to start this launch tradition.

Appendix A: Proposal Cross Reference

Number	Requirement	Section
General Information		
1.	A cover page that includes the name of the middle, high school or informal organization, mailing address, title of the project, and the date	Cover, 1.1
2.	Name, title, and contact information (including phone number) for up to two adult educators	1.2,
3.	Name and title of the individual who will take responsibility for implementation of the safety plan (Range Safety Officer)	1.3
4.	Name, title, contact info of student team leader	1.4
5.	Approximate number of student participants who will be committed to the project and their proposed duties. Include an outline of the project organization that identifies the key managers (students and/or educator administrators) and the key technical personnel. Only use the first names for identifying team members; do not include the surnames (See requirement 5.3 and 5.3 for definition of team members)	1.5
6.	Name of NAR/TRA section(s) the team is planning to work for purposes of mentoring, review of designs and documentation, and launch assistance.	1.6
Facilities/Equipment		
1.	Description of facilities and hours of accessibility, necessary personnel, equipment, and supplies that are required to design and build a rocket and payload.	2
Safety		
1.	Provide a written safety plan addressing the safety of the materials used, facilities involved, and student responsible, i.e. Safety Officer, for ensuring that the plan is followed. A risk assessment should be done for all these aspects in the addition to proposed mitigations. Identification of risks to the successful completion of the project should be included.	3
1.1	Provide a description of the procedures for NAR/TRA personnel to perform. Ensure the following: • Compliance with NAR high power safety code requirements [http://nar.org/NARhpsc.html].	3.1

	• Performance of all hazardous materials handling and hazardous operations.	
1.2	Describe the plan for briefing students on hazard recognition and accident avoidance, and conducting pre-launch briefings.	3.2
1.3	Describe methods to include necessary caution statements in plans, procedures and other working documents, including the use of proper Personal Protective Equipment (PPE).	3.3
1.4	Each team shall provide a plan for complying with federal, state, and local laws regarding unmanned rocket launches and motor handling. Specifically, regarding the use of airspace, Federal Aviation Regulations 14 CFR, Subchapter F, Part 101, Subpart C; Amateur Rockets, Code of Federal Regulation 27 Part 55: Commerce in Explosives; and fire prevention, NFPA 1127 "Code for High Power Rocket Motors."	3.4
1.5	Provide a plan for NAR/TRA mentor purchase, store, transport, and use of rocket motors and energetic devices.	3.5
1.6	A written statement that all team members understand and will abide by the following safety regulations:	3.6
1.6.1	Range safety inspections of each rocket before it is flown. Each team shall comply with the determination of the safety inspection or may be removed from the program.	3.6.1
1.6.2	The Range Safety Officer has the final say on all rocket safety issues. Therefore, the Range Safety Officer has the right to deny the launch of any rocket for safety reasons.	3.6.2
1.6.3	Any team that does not comply with the safety requirements will not be allowed to launch their rocket.	3.6.3
Technical Design		
1.	A proposed and detailed approach to rocket and payload design.	4, 4.1, 4.5
1.a.	Include general vehicle dimensions, material selection and justification, and construction methods.	4.1, 4.2
1.b.	Include projected altitude and describe how it was calculated.	4.2
1.c.	Include projected parachute system design.	4.3

1.d.	Include projected motor and brand designation	4.4
1.e.	Include detailed description of the team's projected payload	4.5
1.f.	Address the requirements for the vehicle, recovery system, and payload.	4
1.g.	Address major technical challenges and solutions.	4.6
Educational Engagement		
1.	Include plans and evaluation criteria for required educational engagement activities (see requirement 5.5)	5
Project Plan		
1.	Provide a detailed development schedule/timeline covering all aspects necessary to successfully complete the project.	6.1
2.	Provide a detailed budget to cover all aspects necessary to successfully complete the project including team travel to launch.	6.2
3.	Provide a detailed funding plan.	6.3
4.	Develop a clear plan for sustainability of the rocket project in the local area. This plan should include how to provide and maintain established partnerships and regularly engage successive classes of students in rocketry. It should also include partners (industry/community), recruitment of team members, funding sustainability, and educational engagement.	6.4

Appendix B: Shop Safety Rules

<u>AIAA OC Section Shop Safety Rules</u>
<u>For all rocketry activities (Youth – TARC – modified for SL)</u>

In an emergency, dial 911
California Poison Control Center: 1-800-222-1222

There is always a risk when someone is handling shop tools or is near another who is handling shop tools. Great precaution measures should always be taken. The following are the AIAA Orange County Section shop rules:

Generally:

- Keep work area orderly and clean; neatly arrange all equipment and material. Put all tools and materials back where they belong.
- Always think through an entire task before starting it, and never rush a process or take chances.
- If you are unsure about safety operation or process, ask for assistance from a program manager or mentor.
- At all times when using chemicals, X-Acto knives, electrical tools, or any tool that creates a danger of fumes or particles entering your eyes, wear safety glasses.
- Flammable liquids such as paints, solvents, and thinners must be stored in their original containers or in approved safety cans with flame arresters.
- If there are any unsafe conditions, report them to a program manager or mentor right away. Rely on the best of your own judgment and knowledge of safety to guide you.
- When lifting a heavy object, lift with your legs and not with your back; keep your back straight.
- Do not use an air hose for cleaning or dusting yourself off. Never point it towards anyone.
- If you have long hair, you must tie it back or keep it from falling down so it won't be caught in rotating tools.
- Horseplay of any kind is not allowed.
- Heavy glues and household chemicals should only be used in well ventilated areas; heavy sanding, painting, and use of chemicals are to be done outdoors.
- For documents that require work with potentially hazardous tools or operations, specific sections will be marked with the following: HAZARDOUS OPERATION – SEE SAFETY PLAN

Electrical Tools

- Do not work with power tools unless there is at least one other person in proximity.
- Before operating any machine or equipment, make sure that all safety guards are in place. The guards must be replaced as soon as repairs or servicing on a machine has been completed and put into operation.
- Never oil, remove guards, or attempt to repair machinery while it is on or in motion.
- Never use a rag near moving machinery.
- It is prohibited to tie down, block out, or otherwise make inoperative of any type of safety device, attachment method, or guard.

- Before energizing or operating any equipment, be sure to verify the safety of all personnel.
- When a machine is de-energizing for the purpose of changing the setup or making a minor adjustment, turn off the machine and pull the plug. Allow the machine to come to a complete stop before proceeding with your task.
- Do not handle electrical equipment while standing on damp or wet surfaces or when your hands are wet.
- Wear suitable clothing for the work that you are doing. Loose clothing, neckties, rings, watches, and even gloves can create a hazard when operating tools. Long sleeves or non-synthetic clothes should be worn when sparks or hot metal is present.

Appendix C: Launch Safety Rules

AIAA OC Section Launch Safety Rules
For all rocketry activities (Youth – TARC – modified for SL)

In an emergency, dial 911
California Poison Control Center: 1-800-222-1222

Our team rules completely comply with the rules stated above. The AIAA Orange County Sections rules are stated below and contain a table similar to the one included above.

- The lightweight materials that will be used are; paper, wood, rubber, plastic, fiberglass or only when it's necessary, metal.
- The motors that will be used will be certified for commercially made rocket motors. They will not be tampered with or used for anything except for what is recommended by the manufacturer. Under no circumstances will there be smoking, open flames or any other heat sources within 25 feet of the motors.
- The rocket will be launched with an electrical launch system, and with electrical motor igniters that are installed when the rocket is on the launch pad or in the designated prepping area. The launch system will have a safety interlock that is in series with the unactivated launch switch until the rocket is ready for launch and will use a launch switch that returns to the off position when released. If the rocket has an onboard ignition system for motors and or recovery devices, they will have safety interlock that interrupts the current path until the rocket is at the launch pad. If the ignition systems have a second battery and relay at the pad, then the batter will be disconnected while the rocket is placed on the launch pad, and the igniter will be connected to the launch system.
- The launcher that is used will be a stable device that provides rigid guidance until the rocket has gotten to a speed that ensures it will be stable in flight. It is also pointed within twenty degrees of vertical. If the wind is over five miles per hour, then the launcher length will permit the rocket to attain safe velocity before separating from the launcher. In addition, blast deflector will be used to prevent the motor's exhaust from hitting the ground. In accordance with the minimum distance table, there will be no dry grass around each launch pad.
- If the rocket does not launch, then the launcher's safety will interlock or disconnect the battery. After the launch attempt, we will wait sixty seconds before allowing anyone to approach the rocket. If the ignition system includes a second battery and relay at the pad, that battery will be disconnected before approaching the rocket.
- The rocket will be verified for stability, sound construction, and any previous damage before it is allowed to fly. The rocket will not have a total thrust more than 40,960 N-Sec.

- The launch pad area will be reviewed to make sure there is no one closer to the launch pad than the minimum distance table states. The sky will be checked above the launch site to make sure that there are no airplanes, helicopters, or aircrafts in the area before launching. Someone will state: "range is clear" and "sky is clear" before proceeding to launch. These statements will be followed by a five second countdown to warn anyone in the launch area.
- The rocket will not be launched between the hours of sunset and sunrise or in the dark.

- The rocket will be launched outdoors in opens area where trees, power lines, buildings and person(s) not involved in the launch do not represent a hazard. The lot side must be at least, on its smallest dimension, as one-half of the maximum altitude for which rockets are allowed to be flown at that site, or 1500 feet, whichever is greater.
- The rocket will not be launched at targets into clouds or obscuring phenomena, near airplanes or on trajectories that make it fly directly over the heads of spectators, or beyond the boundaries of the launch site. It will not have a flammable or explosive payload in the rocket.
- The rocket will not be launched to an altitude where the horizontal visibility is less than five miles or if winds exceed twenty miles an hour. The person(s) launching the rocket will fully comply with the Federal Aviation Administration airspace regulations when flying and will make sure our rocket does not exceed any applicable altitude limit in effect at the launch site.
- The launching location will be at least 1500 feet away from any inhabited building or public highway on which traffic flow exceeds ten 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.
- All spectators shall remain behind the person launching the rocket. No person(s) shall be closer to the launch that the minimum safe distance table. Additionally, no person(s) shall be closer to the launch of our rocket than the person who is actually flying the rocket.
- The rocket will use a recovery system so that all parts of the rocket return safely and undamaged and can be flown again. Only flame-resistant or fireproof recovery system wadding and heat shields will be used in our rocket.
- No person(s) will attempt to recover the rocket from power lines, tall trees, or other dangerous places. The rocket must be flown under conditions where it is likely to recovery in spectators areas or outside the launch site. No one will attempt to catch the rocket as it approaches the ground.
- The two jobs that exist to ensure safety are the range safety officer and the launch control officer.
- The RSO (Range Safety Officer): has the overall control and responsibility for the safety of the range and can shut down the launch site if is thought to be necessary. They are responsible to make sure that each rocket flown is safe to fly before it is launched. They make certain the fins and launch lug are present and securely fastened to the body tube. They make sure that the recovery system is functional and the engine is installed properly. Although all persons responsible for designing and building a rocket need to make certain it is safe to fly, the range safety officer has the ultimate responsibility.

  The RSO reserves the right to stop a launch for safety reasons.
- The LCO (Launch Control Officer) is responsible for supervising the actual launching of the rockets and that all conditions are safe to do so. This includes making sure that the launch pads are not armed when people are close to them. Before each launch they must check for people, including spectators, that might be in an unsafe location and check for nearby aircrafts. For the first launch of a rocket, or if the launch includes any unusual risks, the flight will be announced as a “Heads-Up” flight. This person must track each flight until the rocket returns to ground level. Again, although all persons are responsible

for designing and building the rocket and need to take these same precautions, the launch control officer has the ultimate responsibility.

Appendix D: Material Safety Data Sheet (MSDS)

MSDS Outline

MSDS is an important document that states the health risks for an item in case an accident happens and the proper procedures that need to be undertaken just in case the health of the affected is at risk.

Fiberglass

Product Name(s): Woven Unidirectional Fiberglass Fabric (A-Style Warp Unidirectional), Stitchbonded Fiberglass Fabric, Woven Fiberglass Fabric
Manufacturer: Owens-Corning, World Headquarters, One Owens-Corning Parkway Attn. Product Stewardship, Toledo, OH, 43659, Telephone: 1-419-248-8234 (8am-5pm ET weekdays). OC Fabrics, 1851 S. Sequin Ave., New Braunfels, TX, 78130 Telephone: 1-210-629-4009 (8am-5pm CT weekdays).
Emergency Contacts: Emergencies ONLY (after 5pm ET and weekends): 1-419-248-5330, CHEMTREC (24 hours everyday): 1-800-424-9300, CANUTEC (Canada- 24 hours everyday): 1-613-996-6666. Health and Technical Contacts:
Health Issues Information: (8am-5pm ET):1-419-248-8234, Technical Product Information (8am-5pm ET): 1-800-GET-PINK.

Common Name	Chemical Name	CAS No.	Wt. %
Fiber Glass Continuous Filament (non respirable)	Fibrous Glass	65997-17-3	94-100
Size	Size	None	0-2
Polyester Yarn	Polyester Yarn	None	0-4

Appearance and Odor: White/off-white colored solid with no odor.
Primary Route(s) of Exposure: Inhalation, skin, eye
Potential Health Effects:

- **Acute (short term):** Fiber glass continuous filament is a mechanical irritant. Breathing dusts and fibers may cause short term irritation of the mouth, nose and throat. Skin contact with dust and fibers may cause itching and short term irritation. Eye contact with dust and fibers may cause short term mechanical irritation. Ingestion may cause short term mechanical irritation of the stomach and intestines. See Section 8 for exposure controls.
- **Chronic (long term):** There is no known health effects connected with long term use or contact with this product. See Section 11 of MSDS for more toxicological data.

Medical Conditions Aggravated by Exposure: Long term breathing or skin conditions that are aggravated by mechanical irritants may be at a higher risk for worsening from use or contact with this product.
Inhalation: Move person to fresh air. Seek medical attention if irritation persists.
Eye Contact: Flush eyes with running water for at least 15 minutes. Seek medical attention if irritation persists.

Skin Contact: Wash with mild soap and running water. Use a washcloth to help remove fibers. To avoid more irritation, do not rub or scratch affected areas. Rubbing or scratching may force fibers into skin. Seek medical attention if irritation persists.
Ingestion: Ingestion of this material is unlikely. If it does occur, watch the person for several days to make sure that intestinal blockage does not occur.
Flash Point and Method: None
Flammability Limits (%): None
Auto Ignition Temperature: Not Applicable
Extinguishing Media: Water, foam, CO2 or dry chemical.
Unusual Fire and Explosion Hazards: None known
Fire Fighting Instructions: Use self contained breathing apparatus (SCBA) in a sustained fire.
Hazardous Combustion Products: Primary combustion products are carbon monoxide, carbon dioxide and water. Other undetermined compounds could be released in small quantities.
Land Spill: Scoop up material and put into suitable container for disposal as a nonhazardous waste.
Water Spill: This material will sink and disperse along the bottom of waterways and ponds. It can not easily be removed after it is waterborne; however, the material is non-hazardous in water. **Air Release:** This material will settle out of the air. If concentrated on land it can then be scooped up for disposal as a non-hazardous waste.
Storage Temperature: Not applicable
Storage Pressure: Not applicable
General: No special storage or handling procedures are required for this material.

Black Powder 4F

Hazardous Components

Material or Component	%	CAS no.	TLV	PEL
Potassium Nitrate	70-76	007757-79-1	NE	NE
Sodium Nitrate	70-74	007631-99-4	NE	NE
Charcoal	8-18	N/A	NE	NE
Sulfur	9-20	007704-34-9	NE	NE
Graphite	Trace	007782-42-5	15 mppct (TWA)	2.5 mg/m^3

Physical Data

Boiling Point: N/A
Vapor Pressure: N/A
Vapor Density: N/A
Solubility in Water: Good
Specific Gravity: 1.70 - 1.82 (mercury method) andŠ 1.92 - 2.08 (pycnometer)
pH: 6.0-8.0

Evaporation Rate: N/A
Appearance and Odor: Black granular powder. No odor detectable.

Hazardous Reactivity

Instability: Keep away from heat, sparks, and open flame. Avoid impact, friction, and static electricity.
Incompatibility: When dry, black powder is compatible with most metals; however, it is hygroscopic, and when wet, attracts all common metals except stainless steel. Black powder must be tested for compatibility with any material not specified in the production/procurement package with which they may come in contact. Materials include other explosives, solvents, adhesives, metals, plastics, paints, cleaning compounds, floor and table coverings, packing materials, and other similar materials, situations, and equipment.
Hazardous Decomposition: Detonation produces hazardous overpressures and fragments (if confined). Gases produced may be toxic if exposed in areas with inadequate ventilation.
Polymerization: Will not occur.

Fire and Explosion Data

Flashpoint: N/A
Auto Ignition Temperature: Approximately 464 C (867 F)
Explosive Temperature (5sec): Ignites at approximately 427 C (801 F)
Extinguishing Media: Water
Special Fire Fighting Procedures: ALL EXPLOSIVES: DO NOT FIGHT EXPLOSIVES FIRES. Try to keep fire from reaching explosives. Isolate area. Guard against intruders.

- Division 1.1 Explosives (heavily encased): Evacuate the area for 5000 feet (1 mile) if explosives are heavily encased.
- Division 1.1 Explosives (not heavily encased): Evacuate the area for 2500 feet (½ mile) if explosives are not heavily encased.
- Division 1.1 Explosives (all): Consult the 2000 Emergency Response Guidebook, Guide 112 for further details.

Unusual Fire and Explosion Hazards: Black powder is a deflagrating explosive. It is very sensitive to flame and spark and can also be ignited by friction and impact. When ignited unconfined, it burns with explosive violence and will explode if ignited under even slight confinement.

Health Hazards

General: Black powder is a Division 1.1 Explosive, and detonation may cause severe physical injury, including death. All explosives are dangerous and must be handled carefully and used following approved safety procedures under the direction of competent, experienced persons in accordance with all applicable federal, state, and local laws, regulations, and ordinances.
Carcinogenicity: None of the components of Black powder are listed as a carcinogen by NTP, IARC, or OSHA.

First Aid

Inhalation: Not a likely route of exposure. If inhaled, remove to fresh air. If not breathing, give artificial respiration, preferably by mouth-to-mouth. If breathing is difficult, give oxygen. Seek prompt medical attention.
Eye and Skin Contact: Not a likely route of exposure. Flush eyes with water. Wash skin with soap and water.
Ingestion: Not a likely route of exposure.. If ingested, induce vomiting immediately by giving two glasses of water and sticking finger down throat.

Injury from Detonation: Seek prompt medical attention.

Spill or Leak Procedures

Spill/Leak Response: Use appropriate personal protective equipment. Isolate area and remove sources of friction, impact, heat, low level electrical current, electrostatic or RF energy. Only competent, experienced persons should be involved in cleanup procedures. Carefully pick up spills with non-sparking and non-static producing tools.

Waste Disposal: Desensitize by diluting in water. Open train burning, by qualified personnel, may be used for disposal of small unconfined quantities. Dispose of in compliance with federal regulations under the authority of the Resource Conservation and Recovery Act (40 CFR Parts 260-271).

Special Protection Information

Ventilation: Use only with adequate ventilation.

Respiratory: None

Eye: None

Gloves: Impervious rubber gloves

Other: Metal-free and non-static producing clothes

Ammonium Perchlorate Composite Propellant (APCP)

Product Name: Ammonium Perchlorate

Other/Generic Names: AP, ammonium salt of perchloric acid

Product Use: Analytical chemistry, oxidizer in various propellant or explosive mixtures, various industrial uses involving need for oxidizing or ionization in aqueous solution properties.

Manufacturer: American Pacific Corporation, Western Electrochemical Co. 10622 West 6400 North, Cedar City, UT 84721

For More Information Call: (435) 865-5000

In Case of Emergency Call: (435) 865-5044

Ingredient Name	CAS no.	Einecs no.	Wt. %
Ammonium Perchlorate	7790-98-9	232-235-1	100

OSHA Hazard Communication Standard: This product is considered hazardous under the OSHA Hazard Communication Standard. The stated hazards classifications are applicable to the ammonium perchlorate as manufactured by AMPAC and as delivered in the DOT/UN approved shipping containers. Any rework, modification, amending or additional processing of the ammonium perchlorate may change the hazards classification and may require further hazards classification testing to determine the appropriate classification. AMPAC will not be responsible for personnel or property damage caused by a failure to conduct or provide adequate safe measures needed due to any individual company’s production activities.

Emergency Overview: An odorless white crystal material. Perchlorate is an Oxidizing Agent; there is a risk of explosion if heated under confinement. As with any toxicant, dose and exposure are critically important variables to understand any potential treatment. Harmful if swallowed or inhaled in large doses.

Potential Health Effects:

- **Acute (short term):** Eye contact causes irritation, redness, and tearing. Skin contact causes irritation to mucous membranes and skin. Inhalation may cause respiratory tract irritation such as coughing, and shortness of breath; high concentrations may cause more significant respiratory effects. Ingestion: may cause gastrointestinal irritation; larger doses may cause nausea and vomiting.
- **Chronic (long term):** Perchlorates act to reversibly and competitively inhibit iodine uptake by the thyroid gland. Perchlorate is soluble in water, so exposure to ammonium perchlorate can be via water contaminated with ammonium perchlorate or inhalation in the workplace. With chronic exposure given sufficient dose (see NRC, 2005) and duration, ammonium perchlorate can cause thyroidal stores of iodine to be reduced, which may lead to hypothyroidism. For those individuals that live in areas of the world where endemic iodine deficiency occurs, it is important that these people receive adequate iodine in the diet or are supplemented with iodine.

May be explosive when mixed with combustible material. Risk of explosion if heated under confinement.

Routes of Exposure	Signs and Symptoms of Exposure:	Emergency and First Aid Procedures:
Skin:	May cause local irritation or stinging effect.	Wash exposed area immediately with plenty of water. Remove contaminated clothing and footwear.
Inhalation:	Airborne concentrations of ammonium perchlorate can aggravate pre-existing respiratory problems.	If experiencing breathing difficulties, move to fresh air. Administer oxygen if exposed person is unconscious such as mouth to mouth resuscitation. Never give anything by mouth to an unconscious person.
Ingestion:	Ingestion of large quantities has been reported to cause staggering in small mammals. Chronic ingestion of sufficient quantities may interfere with uptake of iodine by the thyroid.	Give water. Induce vomiting, keep airway clear. Seek medical attention.
Eyes:	Irritation of the eyes will cause stinging effect.	Flush eyes with fresh water for at least 15 minutes and move exposed person to a non-contaminated area.

Flash Point: Not flammable
Flash Point Method: Not applicable
Autoignition Temperature: Not applicable. Ammonium perchlorate decomposes spontaneously at 300o C in its pure state. Contaminants may cause decomposition at lower temperatures typically down to 2700C but decomposition temperature has been listed as low as 240oC in one case

Upper Flammability Limit (volume % in air): Not applicable.
Lower Flammability Limit (volume % in air): Not applicable.
Extinguishing Media: Water - other extinguishing materials are ineffective
Unusual Fire and Explosion Hazards: Ammonium perchlorate is an oxidizing agent and may cause rapid combustion or explosions if mixed with fuels, including organic materials or powdered metals. This does not include DOT shipping containers if intimate mixtures are not present and the shipping container is not inordinately contaminated. Plastic containers have been observed to burn and leave standing cylinders of ammonium perchlorate. Molten metal from aluminum containers may contribute fuel in an instance hot enough to melt aluminum.
Special Fire Fighting Precautions/Instructions: Do not fight fires involving mixtures of ammonium perchlorate and fuels. Ammonium perchlorate is an oxidizing agent and may cause rapid combustion or explosions if mixed with fuels. Burning ammonium perchlorate may produce chlorine, chlorine dioxide, hydrogen chloride, and oxides of nitrogen as well as mixtures with any other compounds involved in the combustion. These are common by-products of combustion and are likely to be serious health concern; thus, keep upwind or wear self-contained breathing apparatus when attempting to rescue.
In Case of Spill or Other Release: (See section 8 for recommended personal protective equipment.) Sweep up material and containerize. Clean contaminated floor surface with water. Ammonium perchlorate is water soluble; thus, manage water to avoid release into the environment. Dispose of in accordance with local, state, and federal regulations.
Normal Handling: (See section 8 for recommended personal protective equipment.) Avoid contact with skin, eyes and clothing. Avoid breathing dust. Wash thoroughly after handling and follow good personal hygiene and good housekeeping practices. Keep containers closed. Handle in a manner to minimize dusting. Use of containers that meet the requirements to be DOT approved shipping containers which are managed in a manner to inhibit intimate mixtures of the container material with the product is recommended. Materials such as plastic drums, steel drums, flexible intermediate bulk containers, and fiberboard containers approved or constructed to the same specifications as DOT requirements are normally safe. FIBC are normally constructed of plastic materials in which intimate contamination soaked into the plastic is difficult to achieve. If in doubt wet and wash the FIBC and manage the water used to wash in accordance with good environmental principles to avoid contaminating drinking water sources or organic materials more subject to intimate mixtures.
Storage Recommendations: Store away from combustibles and flammables. Keep container closed when not in use. Control static electricity and other ignition sources. Store in dry areas away from sources of extreme heat.
Special Mixing and Handling Instructions: Ground and bond process equipment. Mixing ammonium perchlorate with fuels of any type may result in rapid combustion or explosions. When handling materials contaminated with ammonium perchlorate such as dust collector bags or any other combustible material, thoroughly wet the bags with water before handling, keep the bags wet while handling, and use non-sparking tools or tools coated with non-sparking material if non-sparking tools are not available. AVOID friction, impact, or static electricity ignition sources when organic materials are contaminated with ammonium perchlorate. Fire resistant fabrics do not reduce the hazard. Finely powdered metals are frequently as combustible with ammonium perchlorate as are organics.
Engineering Controls: Ventilate as necessary to minimize dust exposures. Inspect and clean ventilation systems regularly.

Personal Protective Equipment Skin Protection: Wear impervious aprons or rain gear to reduce contamination of cotton or other fiber clothing. Plastic, rubber or latex gloves are recommended. Leather or cotton gloves should not be used unless a management program is implemented to ensure detection of contamination and immediate cleaning and change in case of contamination. Cotton clothing may be used if chance of contact is minimal or if clothing is monitored for contamination and changed if contamination occurs. In any case where combustible protection is used, a strong management system must be in place to monitor contamination and ensure appropriate removal and cleaning or severe risk of fire and personal injury or death exists. There are no known cloth materials that will not combust vigorously with perchlorates including nomex, Kevlar based materials, or clothing that is normally considered fire retardant or resistive. Observation and management of contamination is the only practicable safety measure. See additional recommendations below.

- **Eye Protection:** Under normal conditions, wear safety glasses. Under dusty conditions, wear chemical safety goggles.
- **Respiratory Protection:** Under normal conditions, not required. Where dusty conditions develop, use a NIOSH approved respirator for dusts.
- **Additional Recommendations:** Avoid contamination of cotton or other absorbent material. As in any industrial working environment, workers should routinely wear clean clothes to work. Do not wear any work clothing that has become contaminated with ammonium perchlorate. Remove contaminated clothing immediately and keep wet until thoroughly washed. Keeping contaminated clothing wet minimizes hazards until the laundering is completed. Showering is recommended after handling any industrial chemical. Smoking of tobacco should not be permitted while wearing contaminated clothing. Leather boots may become contaminated and could be a source of combustion damaging feet. Rubber boots are recommended unless a very strict management program to detect contaminated leather boots is in place much as listed on the glove section above.

Appearance: White Crystal	**Physical State:** Solid	**Molecular Weight:** 117.50	**Chemical Formula:** NH_4ClO_4	**Odor:** None
Specific Gravity (water = 1.0): 1.95	**Solubility in Water (weight %):** 20.8 g/100 ml at 20 C	**pH:** Materials is a solid however, dissolved in water the pH is slightly acidic	**Boiling Point:** None, rather it decomposes	**Melting Point:** Decomposes at 300 C in its pure state, impurities may lower the decomposition temperature significantly.
Vapor Pressure: Solid, none	**Vapor Density (air = 1.0):** At 20 C, None	**Evaporation Rate:** None		
Flash Point: Not flammable				

Normally Stable (Conditions To Avoid): Stable under normal conditions. Do not mix with organic materials, reducing agents, metal powders or powdered carbon. Avoid elevated temperatures over 270°C, which can cause spontaneous exothermic decomposition. Cloth fabric of any type including dust collector bags intimately contaminated with ammonium perchlorate is subject to ignition through friction or impact. High-energy static electricity may also serve as an ignition source when contamination or combustibles are intermixed.

Incompatibilities: Sulfuric acid, powdered metals, and intimate mixtures with organics.

Hazardous Decomposition Products: Chlorine, chlorine dioxide, oxygen, nitrogen oxides, hydrogen chloride.

Hazardous Polymerization: Will not occur.

As with any toxicant, dose and exposure are critically important variables to understand any potential toxicity. It is always advisable to minimize dusting and use respiratory protection for environments where substantial dust is generated or where there may be exposure to water with high concentrations of perchlorate. Ammonium perchlorate acts to reversibly and competitively inhibit iodine uptake by the thyroid gland. The half-life of ammonium perchlorate ranges from 8 to 12 hours. Ammonium perchlorate does not bioaccumulate. Perchlorate is not metabolized and is excreted from the kidneys. Harmful if swallowed or inhaled in large doses. In the early 1960s another salt of perchlorate, potassium perchlorate, given in very high doses for weeks of exposure as an oral therapeutic agent to treat hyperthyroidism was reported to be associated with a few cases of aplastic anemia and agranulocytosis (National Research Council, 2005). Since that time, there have been no known reports of aplastic anemia. There have been no reports of ammonium perchlorate associated with aplastic anemia or agranulocytosis.

Immediate (Acute) Effects: Oral LD50: rat; 4200 mg/kg Rat-par-LDLo = 3500 mg/kg Oral LD50: rabbit; 1900 mg/kg Rabbit-par-LDLo = 750 mg/kg Inhalation LC50: No references found. Skin sensitization: not reported to be a skin sensitizer

Delayed (Subchronic And Chronic) Effects:

- **Thyroid:** No long-term health effects have been reported with exposure to ammonium perchlorate. Perchlorate is water soluble, so exposure to ammonium perchlorate can be via water contaminated with ammonium perchlorate or inhalation in the workplace. With chronic exposure, sufficient dose, and duration, ammonium perchlorate may cause thyroidal stores of iodine to be reduced, which may lead to goiter (enlarged thyroid gland) and hypothyroidism. Occupational studies indicated no adverse health effects on workers exposed for 3 years or more to perchlorate. These studies also demonstrate that blood chemistry and hormone values are not altered with occupational exposures as high as 0.48 mg per kilogram body weight (Braverman et al., 2005; Lamm et al., 1999). In 2005, a National Academies of Science Committee reviewed the literature and oral exposures to perchlorate and identified a no-observable-adverse-effect-level 0.4 mg/kg/day in humans. That dose is inhibits iodide uptake by nearly 70 percent without effecting thyroid hormones or thyroid stimulating hormone. The NAS also identified a no-observed-effect-level of 0.007 mg/kg/day in humans, based on Greer, et. al. 2002, which is a dose that does not cause inhibition of iodide uptake. For those individuals that live in areas of the world where endemic iodine deficiency occurs, it is important that these people receive adequate iodine in the diet or are supplemented with iodine.

Appendix E: Implementation of the Architectural and Transportation Barriers Compliance Board for Electronic and Information Technology

The Rehabilitation Act of 1973 prohibits the discrimination of the disabled in programs run by federal agencies. Any person with disabilities have the same access to the information as anyone without disabilities when Federal Agencies use electronic and information technology. Therefore, teams part of SL fall under the same restrictions as the Federal Agency, as these teams participate in a NASA project, which is a Federal Agency program. This applies to three subparts:

- 1194.21 Software applications and operating systems: No delivery of software applications or operating systems.
- 1194.22 Web-based intranet and internet information and applications: Documents posted on the Internet are accessible to everyone, with or without disabilities. Any documents developed in Microsoft Office have built in features that allows for speech recognition, keyboard shortcuts, and customization of layout and toolbars. Any documents posted through Adobe Acrobat permits the customization of colors, contrast, layout, and other keyboard options.
- 1194.26 Desktop and portable computers: Although no teams in the AIAA OC Section currently have disabled members, all tools and PCs are designed in a way that allow for easy access for the disabled.

Appendix F: Testing

Blackpowder 4F

a. Ground Testing - Goggles, step away and measure the optimized amount of blackpowder needed

Carbon Dioxide Analyzer

a. Blow on it to test if functional, should see high parts per million (ppm) concentration in response

Flight Testing

a. Fly repeatedly to make sure all functions are correctly working

GPS Location

a. Ground testing - drive a certain distance away to make sure functional

b. Fly to make sure it works in the air and then lands with the correct GPS

Air Brakes

a. Ground testing - Make sure it opens completely, use a leaf blower to check its resistance to wind

b. Flight - point camera during flight to make sure it opens.

c. Sub-scale testing - fly the air brakes on a smaller rocket (a TARC rocket)

Code

a. Run simulations through the leaf blower and analyze the airbrake position readings afterwards to test accuracy of the code.

b. Utilize an SD card to analyze data after flights to see if air brakes or weather add significant impact to flights