Statement of Work

Measurement of Aerosols in Lower Atmosphere Using Optical Detection

NASA Student Launch for Middle and High School

Madison West High School

ATTN: Ms. Christine L. Hager

30 Ash Street Madison, WI, 53726

Submitted: 09/19/2018

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General Information

Educators

Ms. Christine L. Hager
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Dr. Pavel Pinkas
Team Mentor
5006 Whitcomb Dr., Apt. #4
Madison, WI, 53711

pavel@westrocketry.com
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Team Leader

Hyun-seok
Project Leader
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Safety Officer

Matilda
Safety Officer
matildabeecarne@gmail.com

The safety officer is supervised by Dr. Pinkas, who carries all accountability.

Supporting NAR/TRA Sections

NAR Section #558 WOOSH

President: Nicole Therriault
http://www.wooshrocketry.org

Tripoli Wisconsin

President: Frank Nobile
http://tripoliwisconsin.com

Tripoli Quad Cities

President: Gary Kawabata
https://sites.google.com/view/qcrs

Student Participants

A total of 17 students will participate in the proposed project. A table of members and proposed duties is outlined below.

Vehicle Team: Responsible for vehicle design, flight safety parameters, altitude target, propulsion, and launch operations.

Ryley
Lead Vehicle Engineer

Grant
Vehicle Safety Engineer

Ella
Construction Engineer

Kyle
Vehicle Design Specialist

Sultani
Construction Engineer

Payload Team: Responsible for payload design, payload preflight preparations and activation and postflight payload data analysis.

Mason
Lead Payload Engineer

Kab
Payload Function Specialist

Nicholas
Software Technician

Norlha
Social Media Coordinator

Telemetry Team: Responsible for maintaining wireless contact with the rocket, receiving data from onboard GPS, avionics and payload, tracking and locating the rocket.

Ben
Lead Telemetry Engineer

Hyun-seok
Team Leader, Software Engineer

Daniel
Chief Hardware Engineer

Modelling Team: Responsible for 3d modelling for Payload and Vehicle teams.

Michael H.
Lead Payload Modelling

Michael M.
Lead Vehicle Modelling

Edwin
Payload Technician

Project Management and Safety: Responsible for following safety procedures and updating safety documentation.

Matilda
Chief Safety Officer

Maya
Details Coordinator

Table 1: Team members and proposed duties

Facilities and Equipment

Facilities

Planning, discussion, design concept and writing will occur at UW Madison, Dept. of Atmospheric and Oceanic Sciences, Room #1039, located at 1225 W Dayton St., Madison, Wisconsin, 53706, on the weekends. Construction of the rocket will occur at a workshop at 3555 University Ave, Madison, Wisconsin, 53705, on the weekends or as necessary. The team has 24/7 access to this facility. The workshop has three connected rooms, one room dedicated to machinery, another designated for electronics manufacturing/staging area, and a third room used for discussion and design.

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

Team organizational meetings will occur during lunchtime every Monday in Room #3051 of Madison West High School, 30 Ash Street, Madison, Wisconsin, 53726.

Launching of low-powered scale model rockets will occur on weekends from November through April, at Cross Plains site, located at 3876 Observatory Rd, Cross Plains, WI 53528. Large Model Rocket Launch notification will be made to comply with FAA regulations Part 101. NFPA code 1122 and NAR Model Rocket Safety Code will be followed during these launches. Mentors will supervise all launches.

Launching of high powered rockets will occur at Richard Bong Recreational Area located in Southeast Wisconsin at 26313 Burlington Rd, Kansasville, Wisconsin, 53189. We will obtain Power Rocket Altitude waivers from the FAA prior to high power launches. High power launches will coincide with the high power launch of WOOSH, Section 558 of the NAR and Tripoli Wisconsin. Additional high power launches will be conducted at TRA QCRS (Tripoli Quad Cities) launches near Princeton, IL. Mentors will supervise all launches.

Hours

Workshop hours are set based on team member's availability and project needs. The suggested schedule for this year is outlined in the table below.

Day	Start	End	Activity	Location
Monday	11:45 AM	12:30 PM	Organizational Meeting	Madison West HS Rm. #3051
Friday	04:00 PM	09:00 PM	Rocketry Workshop	Workshop, 3555 University Ave.
Saturday	08:00 AM	06:00 PM	Launching of Rockets	Cross Plains / Bong / Princeton
Sunday	10:00 AM	04:00 PM	Writing Session	1225 W Dayton St., Rm #1039

Table 2: Facility Hours

Personnel

We have four engineers working with students in workshop on regular basis:

Dr. Pavel Pinkas: Chemical and software engineer, also trained in electronics design.
Mr. James Guither: Mechanical engineer, head of 3D printing and mechanical design.
Dr. Robert Williamson: Mechanical engineer, consulting and lead for SL teams.
Mr. Brent Lillesand: Mechanical engineer, high power construction and flight tests.

In classroom setting, the following educators work with students on regular basis:

Dr. Ankur Desai: Professor at the UW Dept. of Atmospheric Oceanic Space Sciences.
Ms. Christine Hager: Microbiologist and biology teacher, 14 years of SL experience.
Dr. Pavel Pinkas: Chemical and software engineer, 14 years of SL experience.
Dr. Robert Williamson: Mechanical engineer, 3 years of SL experience.

Equipment

The team has full access to a workshop, fully equipped and suitable for machining, electronics development, design meetings and discussions. The aquarium has three rooms:

1. **Machinery room**: This room is equipped with heavy machinery including a band saw, router, drill press, rotary saw, belt sander, and jigsaw. Handheld power tools such as drills, dremel rotary tools, and orbital sanders, as well as hand tools like hacksaws, X-acto knives, box cutters, clamps, screwdrivers, crescent wrenches, hammers, pliers, clippers and vices are all available here in various sizes and settings. Gluing and assembly is also done in this room. Use of personal protective equipment is mandated and industrial strength air filtering is available for use in this room.

2. **Electronics room**: This room is equipped for design and assembly of printed circuit boards, as well for miscellaneous soldering tasks. We have several Hakko soldering stations with fine temperature control, hot air rework stations, crimpers for various connectors, fluorescent lit magnifier lamps (for SMD assembly), vices to hold printed circuit boards during assembly and a selection of helping hand type grips. Use of personal protective equipment is mandated in this room. This room has sufficient filtering for soldering tasks and connects to the air filtering circuit of machinery room.

3. **Computer and meeting room**: This room contains several computers for use with computer aided design software (RockSim, OpenRocket, SolidWorks, PCB Artist) and data analysis. 3D printing tasks are also carried out in the three 3D printers located in this room. Most of the wall space in this room is covered with whiteboards, allowing students to participate in design discussions and problem solving sessions.

Supplies

During the active season the team will maintain reasonable stock of common supplies and parts for rocket construction.

- **Rocket parts** are purchased on as-needed basis or selected from surplus from past projects. Fiberglass tubes are preferred (weight budget permitting) and fins are also mostly built from G10 sheets (acquired from McMaster-Carr company). Since 2016, the nose cones for the vehicle has been produced in house with a 3D printer. Other items, such as bulkheads and centering rings, are also fabricated in house. Anchors and other hardware are purchased from local hardware stores (Ace, Home Depot, Menards). Parachutes are bought from online vendors (eg. Giant Leap Rocketry). The shock cords (if not available from past projects) are purchased at a local REI store (outdoor equipment retailer) or Wildman Rocketry (online).
- **Glues** of several kinds are stocked in the workshop, including short- and long-cure epoxy (Loctite and West brands), super-glue and wood glue. A necessary assortment of tapes, including electrical tape, masking tape and double sided tape, is maintained.
- **Electronic components** and soldering supplies are acquired from several online vendors, including superstores such as Mouser, DigiKey or Newark, smaller hobby oriented stores, such as SparkFun, AdaFruit and Parallax.
- **Miscellaneous supplies** such as notepads, rulers, pens, rubber gloves, safety goggles, solvents and batteries are procured from local retail stores.

Safety

Written Safety Plan

The following risks could endanger the successful completion of the proposed project (listed with proposed mitigations):

Facility Risks

- **Workshop inaccessible:** A rental agreement is in place between the landlord and the team. Should it become temporarily inaccessible, the team will work with the landlord to resolve the issue in a timely manner. Events scheduled in workshop will be migrated temporarily to Mr. Lillesand's house while the issue is being resolved.

- **Classrooms unavailable:** The classrooms are provided by Atmospheric Oceanic Space Sciences Dept. with several choices available should the primary classroom become inaccessible. Other options in the event of classroom unavailability include meeting at a local public library meeting room, or meeting at a team member's residence.

- **Launch site unavailable / inclement weather:** Redundant launch windows are routinely scheduled to ensure that enough opportunities are available to carry out all necessary flights. The team is currently working with three rocketry organizations (NAR Section WOOSH, TRA WI and TRA QCRS) to maximize our launch opportunities.

Project Risks

- **Project behind schedule:** Project progress is constantly compared against a list of required milestones and working hours are extended as necessary to meet all milestones. All deadlines are considered hard.

- **Key team member unavailable:** No task is assigned to a single team member; all tasks are carried out by a pair or a small group of equally knowledgeable students. Students will be required to spread their participation past a single area of expertise.

- **Unsolvable technical problem:** A thorough feasibility review is conducted before the Statement of Work is submitted. Alternative solutions will be sought.

- **Unresolvable personal disagreements:** Should the students involved fail to reach an acceptable compromise, the educators will protect the progress of the project, regardless of the individual interests of the parties in the dispute. All students were informed of this rule before their admission to the program.

- **Part unavailability:** All purchasing is conducted as soon as practically possible. The team also works with several vendors to maintain part availability.

- **Budget overrun:** The initial fundraising goal is set at 140% of estimated project expense.

Vehicle Risks

- **Repeated test flight failure:** Rocket design review, performance prediction evaluation, static stability check and static ejection tests will be carried out before each test flight. A due consideration will be given to weather conditions to maximize the probability of safe flight and successful recovery. All flight data will be analyzed to identify problems before next flight.

- **Vehicle lost/irreparably damaged during test flight:** A sufficient time reserve will be built into project schedule to allow for vehicle replacement. All team members will participate in additional workshop hours. The airborne vehicle will be tracked using three different methods: CAT (Cloud Aided Telemetry), onboard RF telemetry and sonic beacon. A GPS device will also be used to locate the rocket after launch.

- **Propellant unavailability:** All purchasing is conducted as soon as practically possible and motor alternatives are thoroughly investigated during the vehicle design. The team also works with several vendors to maintain propellant availability.

- **Final vehicle heavily overweight, unable to reach target altitude:** 30% of total vehicle weight is added to the initial estimate of vehicle weight and all initial simulations are carried out with coefficient of drag (Cd) set to 0.7 (reasonable estimate for a single diameter, cylindrical vehicle). This prevents overly optimistic estimates of vehicle performance and also simulates the vehicle weight increase accurately.

Payload Risks

- **Construction falls behind the schedule:** A significant amount of 3D printing will be necessary to build the payload. The team will begin fabrication as soon as the payload design is finalized to ensure that all parts are completed on schedule

Telemetry Risks

- **Construction falls behind schedule:** Construction and and assembly of the telemetry module will begin as soon as possible. Progress is constantly compared against a list of required milestones and test flights and working hours are extended as necessary to meet all milestones.

- **Coding deficiencies/Libraries not maintained:** A thorough feasibility review of the coding required for the telemetry was conducted before the submission of the SOW. All libraries that will be used are maintained by the vendors of the sensors, and have sufficient community support among developers, ensuring that code maintenance will be a minimal issue at worst.

- **Transmission interference:** Xbee modules will be used in the telemetry unit. The very design of the Xbee transmission sequence allows for minimal interference. Additional shielding will be used if it is deemed necessary after test flights

Personal Risks

- **Physical injury:** The use of Personal Protective Equipment is mandated during all construction tasks and preparation of the rocket for flight or static test. Adult supervision is provided at all times. The use of headphones and personal electronics during rocketry activities and workshop hours is strictly prohibited

- **Toxicity:** SDS documentation is available for all chemicals used in the project and dangerous chemicals are avoided as much as possible. Adult supervision is provided at all times, PPE (Personal Protection Equipment) use is mandated.

NAR/TRA Personnel

Dr. Pavel Pinkas (L2 certified, NAR and TRA member) is the mentor for the team and designated owner of the rocket for liability purposes. Dr. Pinkas will accompany the team to Huntsville, AL.

All hazardous materials will be purchased, handled, used, and stored by Mr. Lillesand (L3 certified, NAR and TAR member, LEUP holder) or project educators (Dr. Pinkas or Ms. Hager). Dr. Pinkas and Mr. Lillesand will be the only people purchasing and handling energetics. The use of hazardous chemicals in the construction of the rocket, will be carefully supervised by NAR mentor and project educators.

In the construction of our vehicle, only proven, reliable materials made by established manufacturers, will be used under the supervision of the mentor and educators. We will comply with all NAR standards regarding the materials and construction methods. Reliable, verified methods of recovery will be exercised during the retrieval of our vehicle. Motors will be used that fall within the NAR HPR Level 2 power limits as well as the restrictions outlined by the SL program.

Additionally, All HPR flights will be conducted only at public launches covered by an HPR waiver (mostly the WOOSH/NAR Section #558 10,000 ft MSL waiver for Richard Bong Recreation Area launch site and 15,000 ft MSL waiver for Princeton, IL, TRA QCRS site). We will be assisted by members of hosting section (WOOSH, TRA WI or TRA QCRS) and follow all instructions issued by their range personnel and our mentors.

All LMR flights will be conducted only at the launches with the FAA notification phoned in at least 24 hours prior to the launch. NAR and NFPA Safety Codes for model rockets and high power rockets will be observed at all launches.

Team Members Safety Briefing

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

Safety Documentation Procedures

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

Compliance with Federal, State and Local Laws

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

The team is cognizant and will abide with the following federal, state and local laws regarding unmanned rocket launches and motor handling:

- **Use of airspace:** FAR 14 CFR, Subchapter F, Part 101, Subpart C
- **Handling and use of low explosives:** Code of Federal Regulation Part 55
- **Fire Prevention:** NFPA 1127 Code for High Power Rocket Motors

All of the publications mentioned above are available to the team members and mentors via links to the online versions of the documents (see: List of Outside Applicable Resources).

Energetics Purchase, Storage, Transport and Use

NAR/TRA mentor, Dr. Pinkas, holds a Level 2 HPR certification. Mr. Lillesand has Low Explosives User Permit (LEUP). If necessary, the team can store propellant with Mr. Goebel (Level-3 certified), who owns a ATF approved magazine for storage of solid motor grains containing over 62.5 grams of propellant. In most cases, the motors and electrical matches are purchased from the on-site vendor, Mr. Tim Lehr of Wildman Rocketry and used on the same day. Dr. Pinkas and Mr. Lillesand will be the only people to purchase and handle energetics (motors, ejection charges and igniters). Mr. Lillesand will be responsible for depositing unused propellant with Mr. Goebel should the need arise. Only NAR/TRA certified motors will be used.

Written Safety Statement

All team members and educators understand and will unconditionally abide by the following safety regulations

Range Safety Inspection

Range safety inspections of each rocket shall be carried out before the rocket is flown. The team shall comply with the determination of the safety inspection.

RSO Ruling Compliance

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.

Mentor Approval Compliance

The team mentor, that is, Dr. Pavel Pinkas, is ultimately responsible for the safe flight and recovery of the team's rocket. The team will not fly a rocket until the mentor has reviewed the design, examined the build and is satisfied the rocket meets established rocketry design and safety guidelines.

Team Compliance with Safety Requirements

Should the team fail to comply with the safety requirements they will not be allowed to launch their rocket.

Technical Design

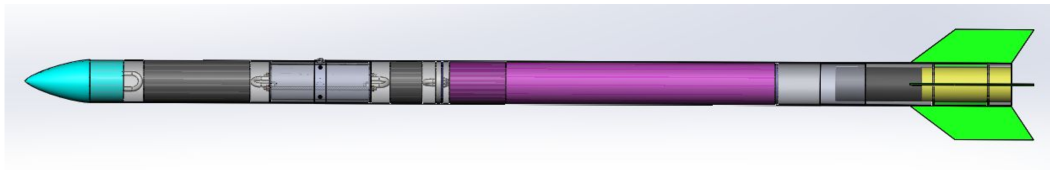


Figure 1: Solidworks model of the proposed vehicle

Vehicle Design

A single stage, K-class vehicle will be used to deliver our payload to the target altitude in the range between 4,000 ft - 5,500 ft specified (exact target will be chosen at the Preliminary Design Review). The proposed project will investigate the concentration of aerosols in the planetary boundary layer.

The vehicle will be 90.47 in long, with a 4.0 in diameter. It will be constructed from fiberglass tubing and use 1/16” G10 fiberglass fins, helping it withstand the stresses of high powered rocketry flight and deployment. The vehicle will be constructed to launch form a standard size, 8ft launch rail.

With an estimated liftoff mass of 33.15 lbs (including 30% of simulated weight increase), the primary propulsion choice is the K class Aerotech K1000-T. This motor has a total impulse of 2512 Ns, and requires a 75mm motor casing.

The rocket will use dual deployment to minimize drift.

Objective

The criteria for determining a successful vehicle design are as follows :

1. The flight is stable and reaches an altitude that is between
2. 4,000 feet and 5,500 feet and within 5% accuracy of the target altitude of our choosing.
3. The descent is safe and both main and drogue parachutes deploy properly
4. There are no unplanned or out of sequence events
5. The vehicle sustains no damage
6. The rocket is recovered and returned within 2 hours after the launch

Summary

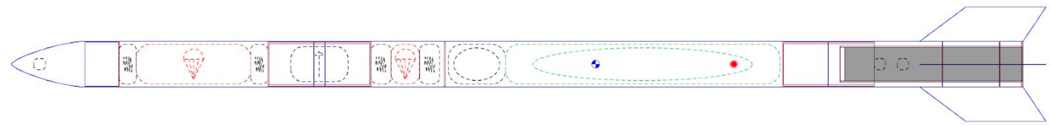


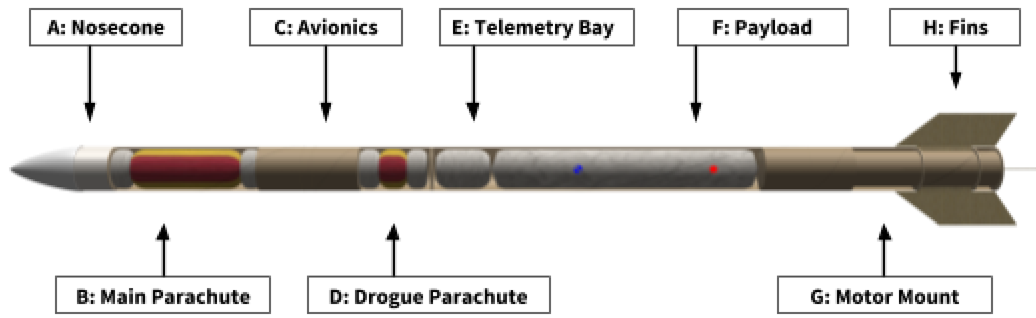
Figure 2: A two-dimensional schematic of the vehicle

Length	Mass	Diameter	Motor Selection	Stability Margin	Thrust to Weight Ratio
90.47 in	25.5 lbs	4.0 in	ATK-K1000-T	3.11 cal	14.8

Table 3: Vehicle parameters

The following figure shows all compartments and sections of the rocket. The rocket separates into three tethered parts (nosecone, main parachute bay and booster section). The payload travels in the booster section. We will use standard dual deployment triggered by two fully redundant PerfectFlite StratoLogger CF altimeters.

Sectional Overview

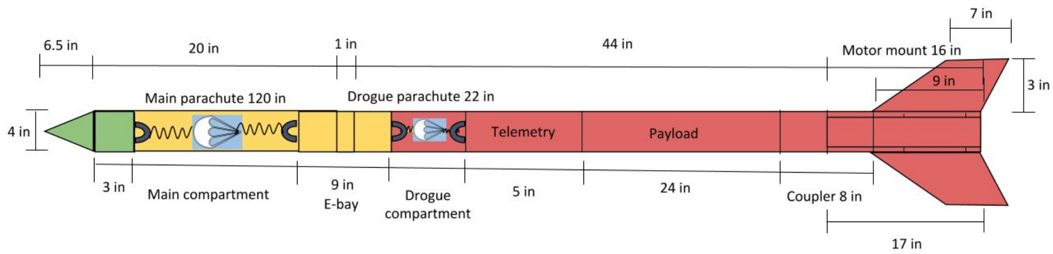


(A)	Nosecone
(B)	Main parachute
(C)	Avionics
(D)	Drogue parachute
(E)	Telemetry Bay
(F)	Payload
(G)	Motor mount
(H)	Fins

Figure 3: A three-dimensional schematic of the vehicle

The table and diagram above outlines the major components and parts of the rocket. The main parachute is packed in the fore of the rocket, directly under the nose cone. The avionics bay, which houses the flight electronics will be located under the main parachute and on top of the drogue parachute. A bulkhead separates the recovery section from the rocket's payload section, which houses both the telemetry bay and the payload. Finally, the vehicle finishes off with a motor mount and fins to facilitate in its propulsion and stability.

Dimensions



Part	Size
Overall length	90.5 in
Body diameter	4.0 in
Avionics Bay (E-bay) length	9.0 in
Main compartment length	13.0 in
Drogue compartment length	3.0 in
Fin foot cord	7.0 in
Fin tip cord	7.0 in

Figure 4: A dimensional drawing of the vehicle

The fully assembled vehicle will have a length of 90.5 in (7.54 ft) and a body diameter of 4.0 in. The booster section (colored red), containing the telemetry, payload, motor mount, fins and drogue parachute compartment will span 60 in with 24 in dedicated for the payload and 5 inches dedicated to the telemetry system. The upper vehicle section (yellow) consists of the avionics bay and the main parachute compartment and will span 24 in. Finally the nose cone section (green), which will be ejected at main deployment, consists of a 6.5 in Von Karman nose cone with a 3 in shoulder.

Material Selection

Fiberglass is the primary choice of material for most of the rocket. Fiberglass can be precisely machined, has the desired strength to weight ratio and can be easily finished.
Simulations show that a K-class motor has enough impulse to reach between 4000 and 5,500 feet in a 4.0 inch diameter fiberglass rocket.

Rocket Part	Material
Nosecone	3D printed PLA plastic, Von Karman shape
Tubing	Fiberglass tubing, 4 in diameter
Fins	1/16 in G10 fiberglass
Parachutes	Ripstop nylon
Couplers	Fiberglass 4 in coupler tubing
Motor Mount	Fiberglass 75 mm tubing
Centering Rings	1/8 in G10 fiberglass
Anchors	1/4 in stainless steel U-bolts
Tie Rods	#10/24 stainless steel threaded rods
Motor Retention	Aeropack aluminium flange mounted retainer

Table 4: Materials for rocketry construction

Construction Methods

Work will be done under the supervision and advice of mentor Dr. Pavel Pinkas and engineer Mr. Brent Lillesand to make sure that the rocket is built correctly. We plan to use West System epoxy with appropriate fillers for rocket assembly. The rocket will be all-fiberglass construction, including bulkheads and centering rings. The rocket construction will be done in the workshop, which is fully equipped for high power rocketry projects. Mr. Jim Guither is our advisor and production manager for 3D printed parts.

Performance Predictions

All performance predictions were made using OpenRocket v15.03.

Altitude Profile

The graph below shows the simulated flight profile for the AeroTech K1000-T motor. The vehicle reaches the apogee of 5272 feet around 18.17 seconds after ignition. For the purpose of this preliminary simulation, and based on prior experiences with single diameter rockets, the average coefficient of drag was set at 0.7 for simulations. The entire flight duration is estimated at 101.6 seconds and the drift under 15 mile per hour wind conditions is simulated at 1,365 feet.

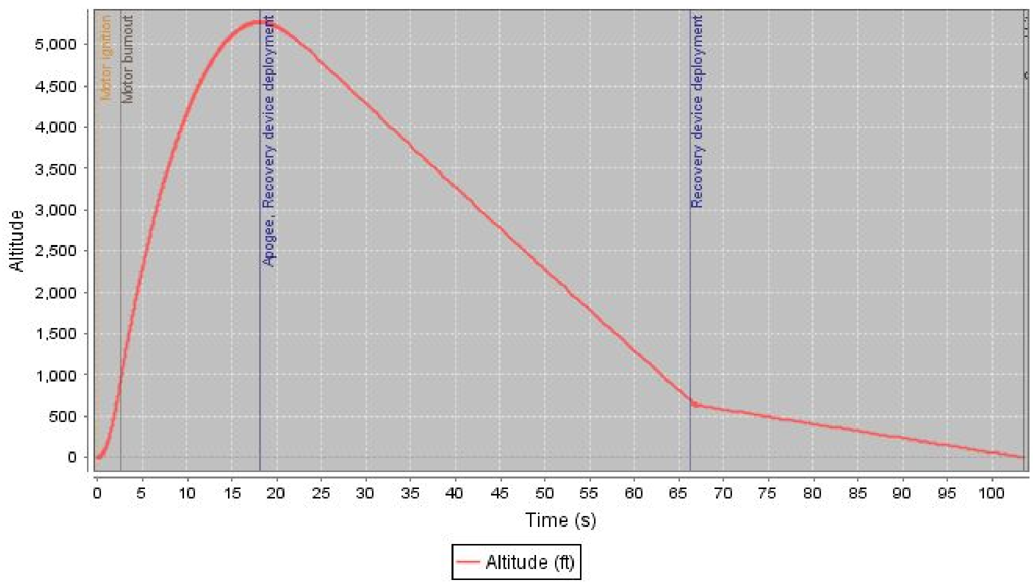


Figure 5: Altitude (ft) vs. Time Simulation

Simulations are not a final indication for the performance of the vehicle. The team will refine the projections and make accurate ballast decisions after the test flights of the scale model and full scale vehicle. The final test flight will use the same motor as we will use for our flight in Huntsville to ensure that the rocket will not exceed the target altitude.

Wind Speed vs. Altitude

The effect of the wind speed on the apogee of the entire flight is was simulated and is shown in the table below. A launch of the vehicle in 20 mile per hour winds, the max wind speed allowed for launches under NAR rules, will see the apogee change by 1.023%

Wind Speed	Apogee	Δ Apogee
0 mph	5272 ft	0.00%
5 mph	5262 ft	1.001%
10 mph	5240 ft	1.006%
15 mph	5213 ft	1.011%
20 mph	5161 ft	1.023%

Table 5: Wind Speed vs. Altitude Chart

Thrust Profile

The graph below shows the thrust profile for the AeroTech K1000-T motor. The motor reaches its maximum thrust of 1140 newtons after 0.02 seconds and burns at approximately constant thrust level for about 1.6 seconds. The thrust to weight ratio of the vehicle when using this motor's average thrust is 8.9, while the thrust to weight ratio of the rocket at maximum is 10.1. The rocket is projected to launch from an eight foot rail with the velocity of 69.5 feet per second (47.4 mph).

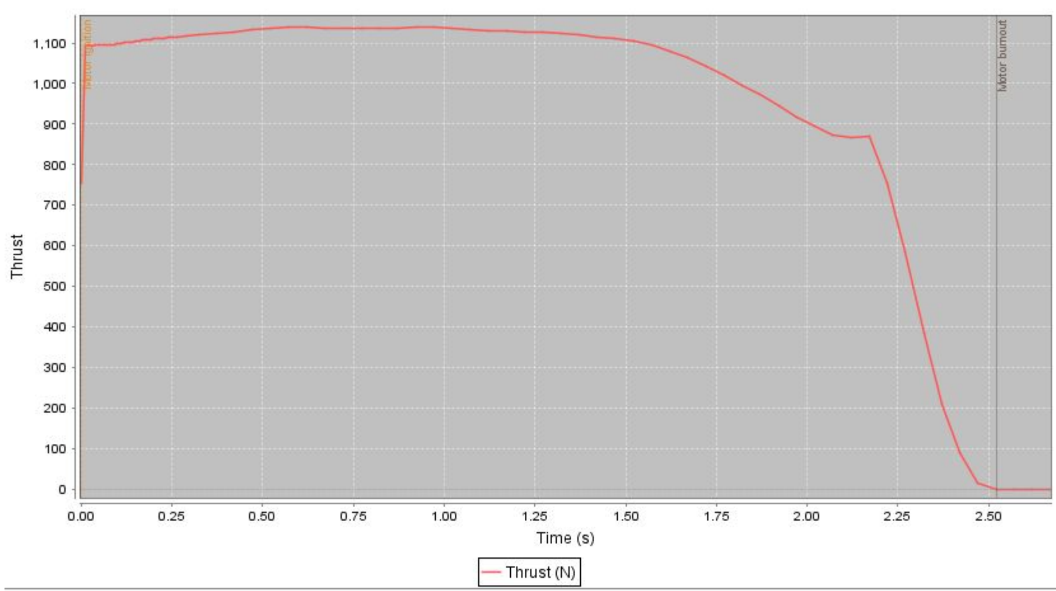


Figure 6: Thrust (N) vs. Time Simulation

Velocity Profile

The velocity profile projects that the rocket will reach maximum velocity of 637 feet per second (0.83 mach) shortly before burnout, which is simulated at 2.5 seconds after liftoff. The rocket remains subsonic for the entire duration of its flight.

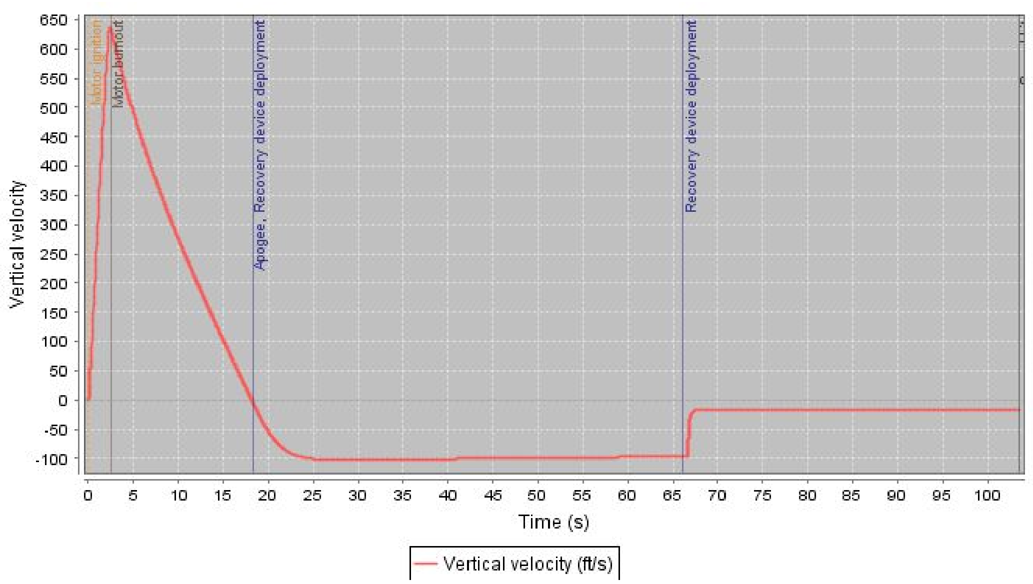


Figure 7: Velocity (ft/s) vs. Time Simulation

Acceleration Profile

The graph below shows that the rocket will experience maximum acceleration of about 9.32 G (299.9 ft/s^2). The vehicle will be robust enough to endure the the acceleration shocks associated with rocket flight.

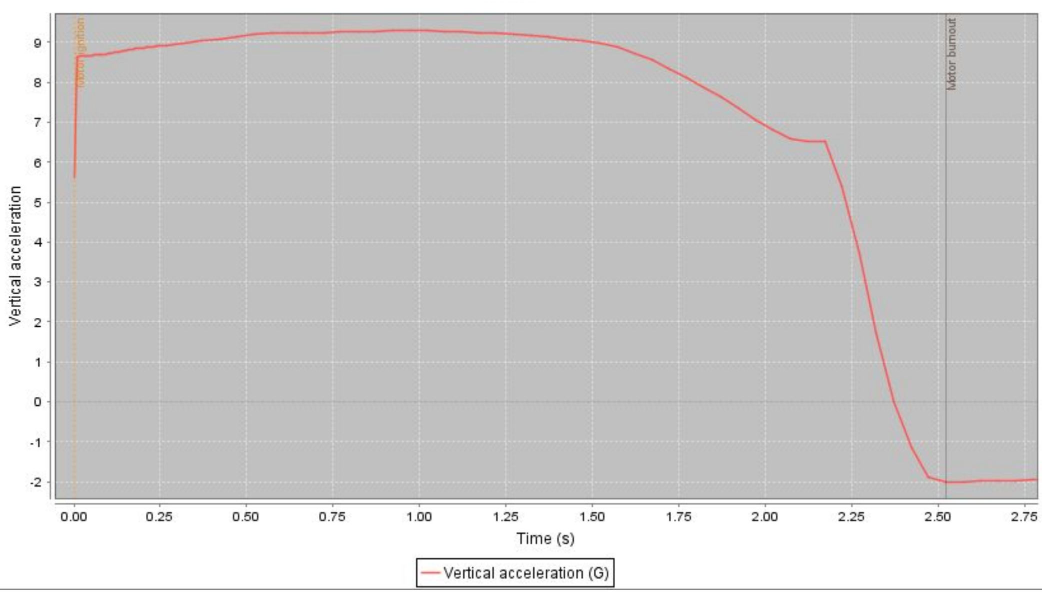


Figure 8: Acceleration (G) vs. Time Simulation

Vehicle Flight Sequence

The vehicle flight sequence is shown on the figure below. The rocket is a standard dual deployment rocket that will be recovered as three tethered sections. The drogue parachute deploys at apogee and the main parachute is set to deploy at 700 ft. The payload does not separate from the rocket at any point during flight. Total decent time is projected at 83.37 seconds.

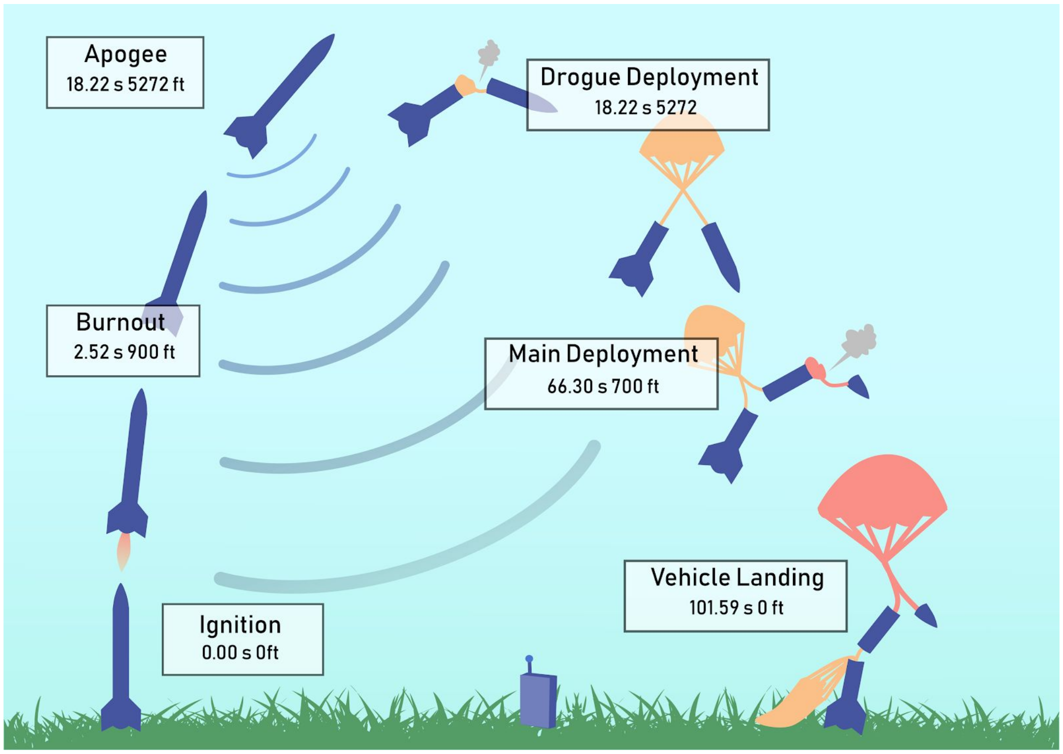


Figure 9: Mission profile chart

The table below summarizes the flight events for the entire mission.

Sequence	Event	Time	Altitude	Trigger
1	Ignition/Boost	0.00 s	0 ft	Launch Control
2	Burnout	2.52 s	900 ft	--
3	Apogee	18.22 s	5272 ft	--
4	Drogue deployment	18.22 s	5272 ft	Altimeter
5	Main deployment	66.30 s	700 ft	Altimeter
6	Vehicle Landing	101.59 s	0 ft	--

Table 6: Flight Events

Fin Flutter Profile

The graph below shows the safety margin of fin flutter based on the simulated altitude and velocity of our vehicle. Calculation are based on the improved fin flutter equation shown below with V_f being the velocity of flutter boundary:

$$V_f = 1.223\ C_s\ e^{0.4\ \frac{h}{H}} \sqrt{\frac{G}{p_0}} \sqrt{\frac{2+B}{1+\lambda}} \sqrt{\left(\frac{T}{B}\right)^3}$$

With constants:

The speed of sound at sea level:	$C_s = 335\ m/s$
Atmospheric pressure at sea level:	$p_0 = 101352$ Pa
Boundary of the troposphere:	$H = 8077\ m$
Shear Modulus of G10 fiberglass:	$G = 5520000000$ Pa

With derived values:

Taper Ratio	$\lambda = \frac{C_t}{C_r}$	$\lambda = 0$
Aspect Ratio	$B = \frac{b^2}{S}$	$B = 0.375$
Normalized Thickness	$T = \frac{t}{C_r}$	$T = 0.00694$

With the fin geometry values:

Root Chord	$C_r = 9\ in$
Tip Chord	$C_t = 7\ in$
Semi Span	$b = 3\ in$
Thickness	$t = 0.0625\ in$
Area	$S = 24\ in$

Figure 11: The Fin Flutter Equation

The tables above outline the values used for the fin flutter equation. The graph was produced with data obtained from Openrocket with altitude (with variable h in the fin flutter calculations) being used as the independent variable and percentage of flutter boundary being calculated by the following equation.

$$Percentage\ of\ Flutter\ Boundary = \frac{V_s}{V_f} \times 100\%$$

Were:

V_f	Flutter boundary velocity as calculated by the fin flutter equation
V_s	Velocity of rocket as simulated by Openrocket

Figure 12: The percentage of flutter boundary equation

Anything above 80% of flutter boundary is considered dangerous.

A 50% safety margin at maximum stress is simulated for the proposed 1/16 inch fin constructed from G10 fiberglass. The vehicle must exceed mach 1 for fin flutter to be a concern.

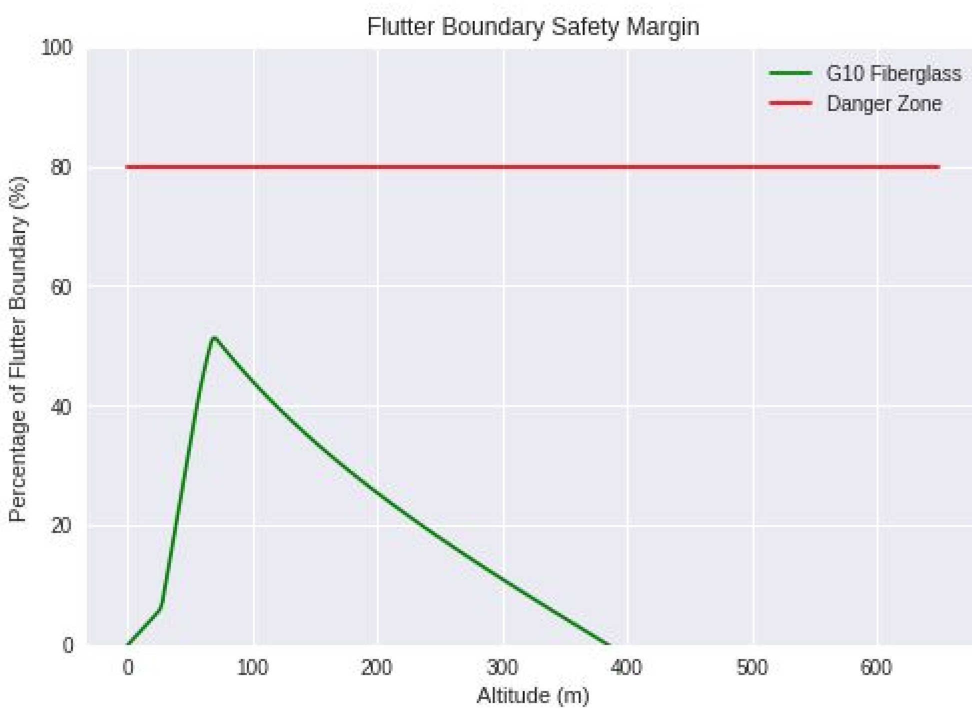


Figure 13: Fin flutter boundary safety margin graph

Recovery System Design

Pursuant to section 2.8 and section 3 of the Student Launch handbook requirements, the vehicle will consist of three independent, tethered sections. Recovery will consist of a dual deployment setup where the drogue parachute will deploy at apogee and the main parachute will deploy at 700 feet. Deployment will be performed by the commercially available altimeters and the setup will be tested on the ground before flight. The impact energy of each section will remain under 75 ft-lbf.

Parachute System Design

The vehicle will separate into three tethered sections:

1. A nose cone section that weighs 3.49 lbs and constitutes 16.1% of the descent weight
2. An upper vehicle section weighing 2.79 lbs and constitutes 12.9% of the descent weight
3. A booster section weighing 15.42 lbs and constitutes 71.1% of the descent weight. This section will also hold the telemetry and payload for the rocket.

The table below shows the estimated parachute sizes, descent rates, ejection charge sizes, deployment altitudes and landing impact energy for the proposed parachute system. The upper vehicle section and nose cone section will remain connected during the decent under the drogue parachute, with the sections separating during main parachute deployment

Parachute	Diameter	Descent Rate	Charge Mass	Alt. Deployed	Descent Weight		Impact Energy
Drouge	22 in	95.3 fps	0.63 g	Apogee	6.28 lbs	28.9%	886.5 ft-lbf
					15.4 lbs	70.9%	2174 ft-lbf
					--	--	--
Main	120 in	16.3 fps	1.27 g	700 ft	3.49 lbs	16.1%	14.4 ft-lbf
					2.79 lbs	12.9%	11.5 ft-lbf
					15.4 lbs	70.9%	63.6ft-lbf

Table 6: Parachute Parameters

Drift

The following table shows the estimated drift of the rocket considering the descent rates in the table above. A flight with 20 mile per hour winds will still remain within 2,500 feet from the launchpad. Calculations are made based on the assumption that the apogee event occurs directly above the launch pad.

Wind Speed	Drift (ft)	Drift (mi)
0 mph	0 ft	0.000 mi
5 mph	455 ft	0.086 mi
10 mph	910 ft	0.172 mi
15 mph	1365 ft	0.259 mi
20 mph	1820 ft	0.345 mi

Table 7: Drift Predictions

Tracking

The rocket will be tracked using a Trackimo tracker. Trackimo is a CAT (Cloud Aided Telemetry) device that utilizes GPS sensor and cellular network to report its location in regular intervals. The device uploads its current coordinates to a data cloud. The Trackimo smartphone app then retrieves the tracker's coordinates from the cloud and displays its location on a map. The Trackimo is a USB rechargeable device that takes can run for 24 hours on a single charge. Its small footprint, which is around 1.5 inches x 1.5 inches in size make it suitable for use in the vehicle.

The telemetry device (discussed in detail above) in our rocket also relays GPS coordinates and can be used as a secondary means to locate the rocket should the Trackimo fail. A 140 decibel sonic beacon will be used as a tertiary tracking device.

Propulsion Selection

Based on computer simulations, an AeroTech K1000-T motor was chosen as the primary propulsion choice for the vehicle. An AeroTech K661 motor was selected as the secondary motor. Characteristics for each motor is shown in the table below.

Motor	Diameter	Total Impulse	Burn Time	Stability Margin	Thrust to Weight Ratio
K1000-T	75mm	2511.5 Ns	2.5s	3.11 cal	10.1
K661	75mm	2436.5 Ns	3.7s	3.09 cal	6.69

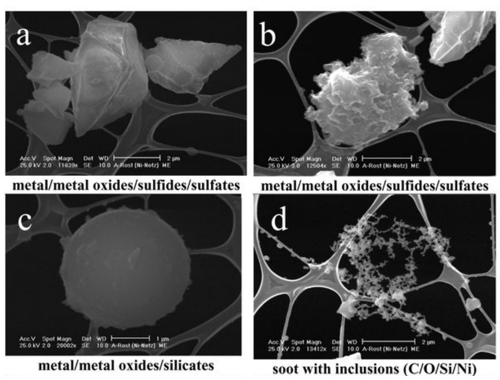
Table 8: Propulsion Selection

While the primary motor is preferred and is used in all the simulations, the secondary motor produces similar metrics and will be used as a backup in case the primary motor becomes unavailable.

Payload

Motivation

Aerosols are abundant in Earth's Atmosphere and heavily influence air quality and public health. It is important to understand the size and concentration of these particles specifically in the lower atmosphere because they influence cloud composition and cloud formation. Cloud presence changes absorption and reflection of sunlight directly affecting Earth's energy budget and weather patterns. The Cloud-Aerosol LIDAR and Infrared Pathfinder Satellite Observation (CALIPSO) satellite has been collecting data on aerosol concentration in the atmosphere using active LIDAR instrument with passive infrared and visible images. However, this method is less accurate when collecting data near the Earth's surface where there is increased cloud composition. Our project aims to use optical detection to measure aerosol concentration and size distribution in the lower atmosphere.



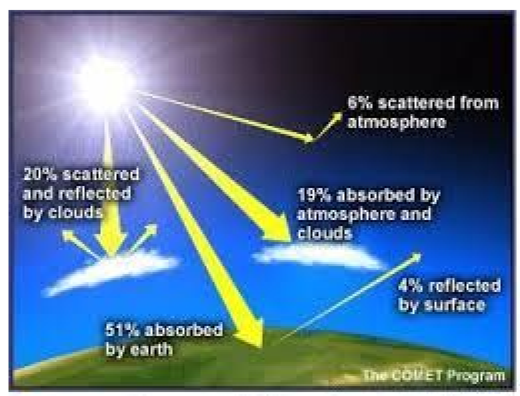


Figure 14: Microscopy of example aerosols (left).
Figure 15: Diagram explaining solar ray scatter on Earth (right).

Objective

Our project's objective is to analyze particle concentration and size distribution at specific altitudes. During vehicle ascent, air and particles will enter the payload. Each chamber will have a camera and LED light in order to perform optical detection. The particles will continuously flow out of the exit tube at the end of each chamber throughout the vehicle's ascent in order to circulate air from the current altitude. A continuous circulation allows us to collect the most accurate data from each altitude.

Hypothesis

Because the atmosphere decreases in density as altitude increases, we hypothesize that as the vehicle ascends, particle size will decrease, and the concentration of smaller aerosols will increase relative to the concentration of larger aerosols due to the tendency of smallers aerosols to be carried higher into the atmosphere. Our hypothesis is summarized in the figures below.

Payload Design And Experimental Setup

To capture images during vehicle ascent, a Raspberry Pi Camera will be used. Air input/output ducts will be used to direct air into the interior of the vehicle. The airflow will be confined between two glass plates, allowing for the camera and LED system to capture an image. Each of the three payload units will contain its own Raspberry Pi computer that will control the LED and camera, and store the images taken.

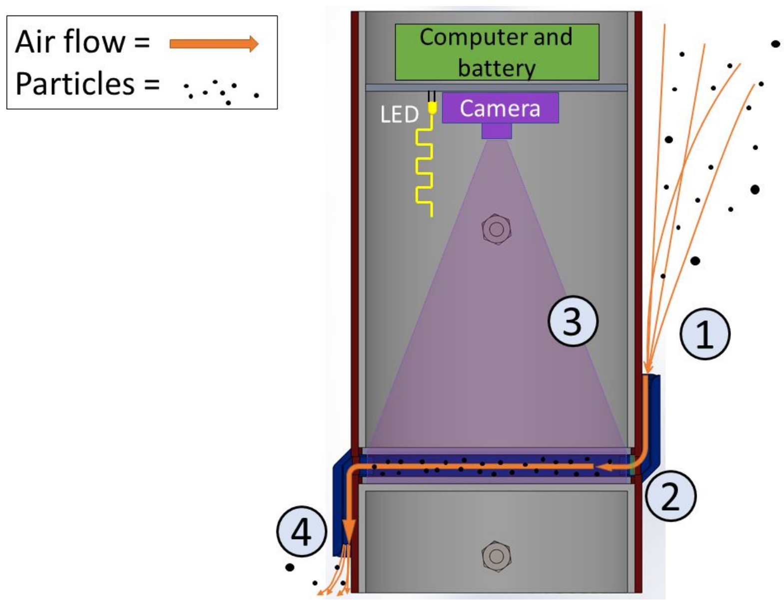


Figure 16: Payload unit for measuring air particle concentration

1. Air and particles enter the payload through the external air intake
2. The air and particles enters an air channel between 2 glass plates
3. The led flashing in time with the camera reflects light off the particles into the camera, the camera captures this as images
4. Air and particles exit the payload through the external air outtake

Payload Assembly

A 3d model of one of three independently functioning payload units is shown in the following image.

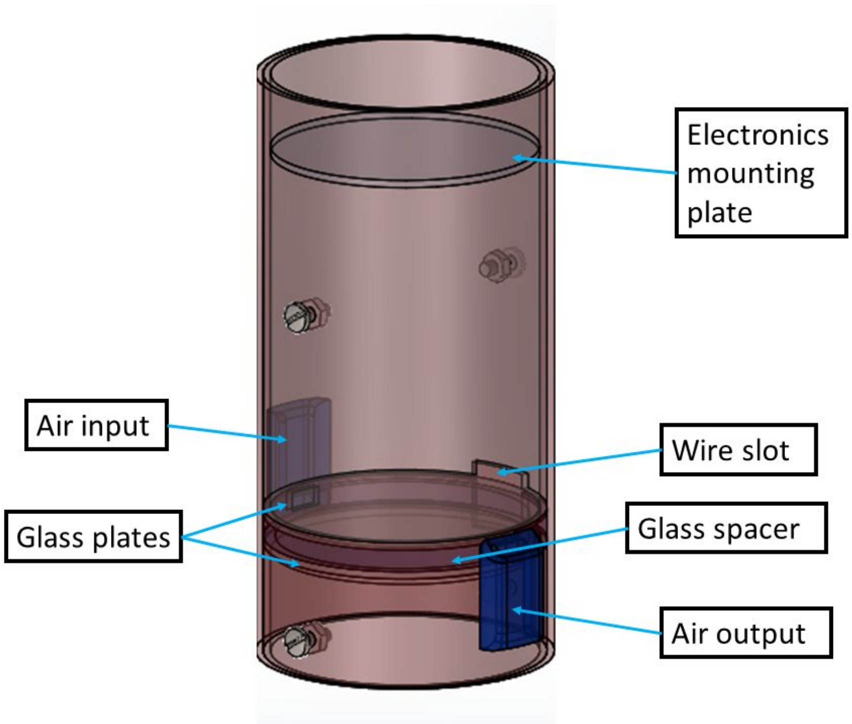


Figure 17: 3D model of a single payload unit (one of three)

The data from each of the cameras is collected using a Raspberry Pi computer. The raspberry pi computer also controls the timing on the LED and camera.

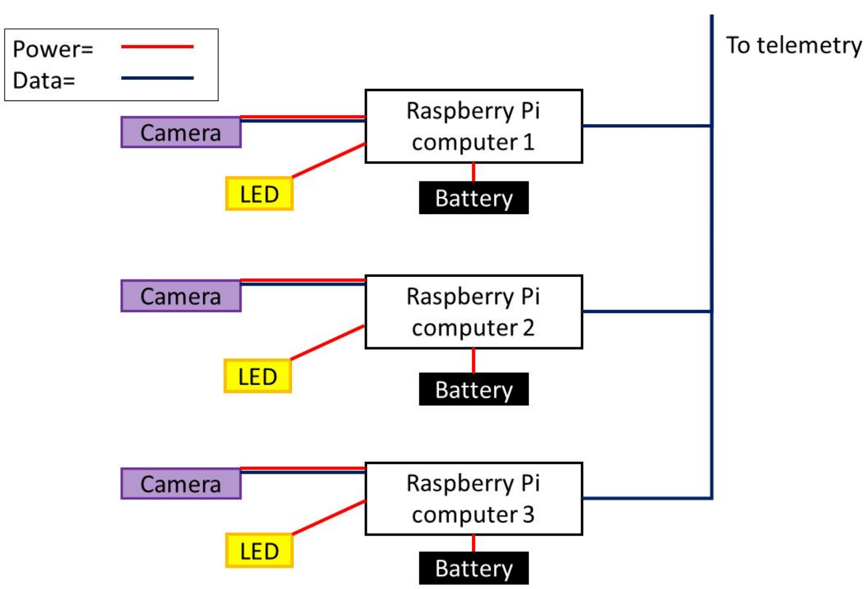


Figure 18: Payload Block Scheme

Experimental Sequence

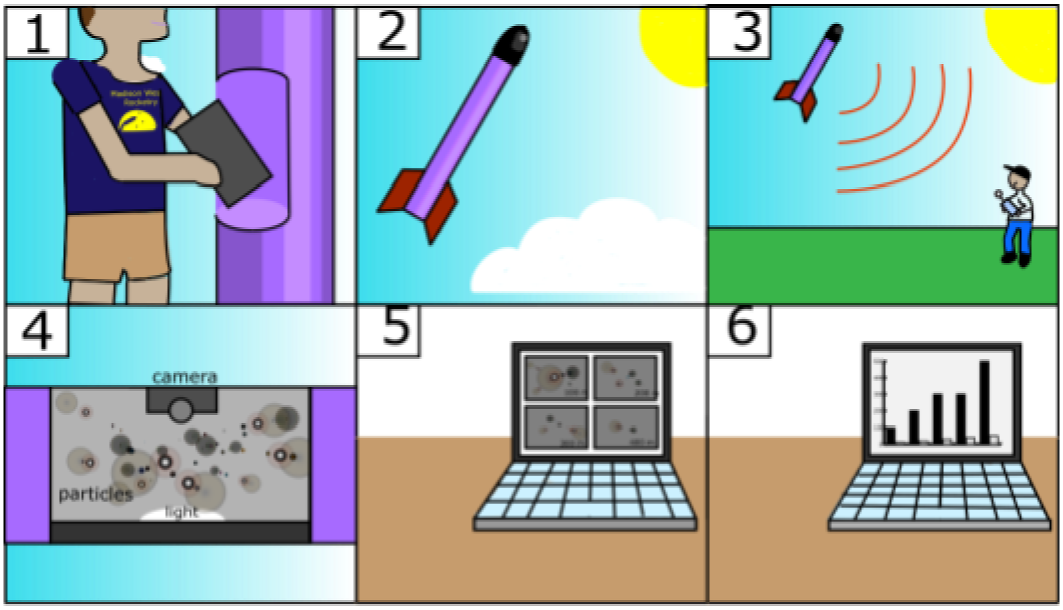


Figure 19: Experimental Sequence

1. We will load and turn on the payload prior to launch.
2. The vehicle will be launched.
3. Throughout rocket flight, telemetry information will be relayed to the ground.
4. During vehicle ascent, particle images will be taken by onboard cameras.
5. During flight, images will be analyzed for particle concentration and data will be sent to telemetry module for transmission to the ground.
6. Finally, we will write the post-launch assessment report.

Data Analysis

The data analysis is outlined in the section below. For each image we will use a python algorithm to identify particles and record the concentration of each size of particles. Data from the image will be matched to a specific altitude based on an image timestamp recorded by the Raspberry Pi computer and transmitted to the ground by the telemetry unit for further analysis.

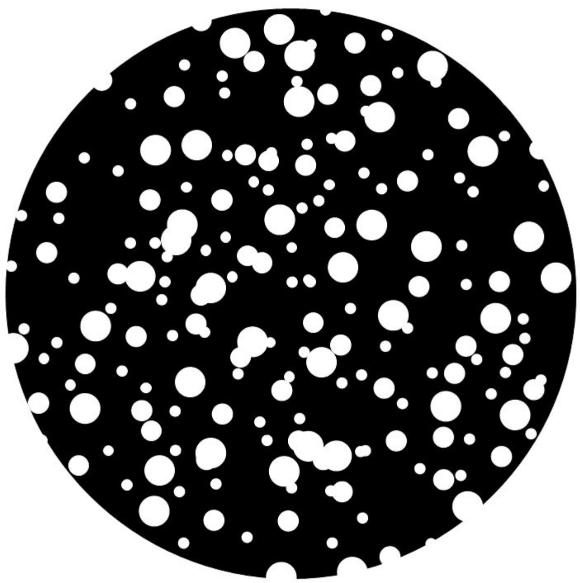


Figure 20: Example image that the camera will produce

On the ground, the data will be visualized using graphs and histograms showing the concentrations and sizes of particles at different altitudes. Sample visualizations of what these graphs might look like follow:

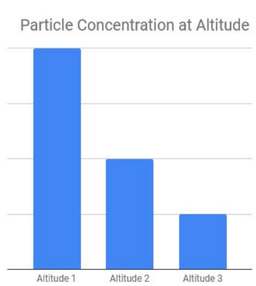


Figure 21: Example graph showing particle concentrations at different altitudes.

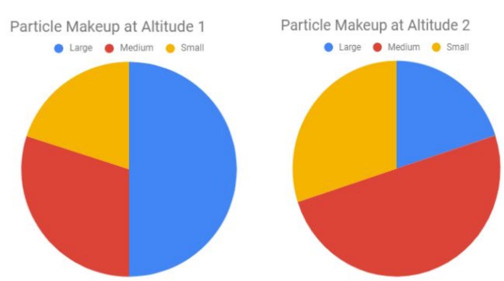


Figure 22: Example graphs showing the concentrations of different particle sizes at different altitudes

Correlations will then be measured using statistical analysis. The following figure outlines the independent variables and dependant variables that will be used to measure correlations.

Independent Variables:
- A - Altitude
- h - Humidity
- T - Temperature

Dependent Variables
- C_a - Aerosol Concentration
- S_p - Particle Size Range

Correlations Measured:
- $C_a = f(A)$ - Concentration as a function of altitude
- $C_a = f(h)$ - Concentration as a function of humidity
- $C_a = f(T)$ - Concentration as a function of temperature
- $S_p = f(A)$ - Particle size as a function of altitude
- $S_p = f(h)$ - Particle size as a function of humidity
- $S_p = f(T)$ - Particle size as a function of temperature

Figure 23: Summary chart of data analysis

Telemetry

Motivation

Telemetry, or the wireless transfer of data from a launch vehicle to the ground, is a common practice in large scale rocketry. Rockets such as the Saturn V, Delta IV, Atlas V, Ariane V, and Falcon 9, all use a telemetry system to transmit and log critical data on the health, functionality, and safety of a rocket, payload and crew.

Implementing telemetry into our rocket will allow us to collect data in real time and prepare us for the unlikely situation where the local data inside the rocket becomes corrupted or lost (eg. the rocket cannot be located/recovered after the flight). This will increase the chance of successful payload data recovery. Additionally, the rocket's trajectory, speed, and altitude will be known while the rocket is flying, providing the team with a better understanding of the rocket's design, functionality, and safety.

In addition to standard rocket metrics, such as acceleration and altitude, the telemetry unit will also collect and transmit atmospheric data. This will aid in augmenting our understanding of the data collected from our primary payload.

Objective

The criteria for a successful telemetry flight is as follows:

1. The telemetry unit required no more than 30 min to integrate into the rocket at the launch field
2. The telemetry unit transmitted all collected data the ground control station for the entire duration of the flight without errors.
3. Data collected from the telemetry unit is accurate
4. The telemetry unit was not damaged and can be flown on the same day with a simple battery replacement.

Telemetry Overview

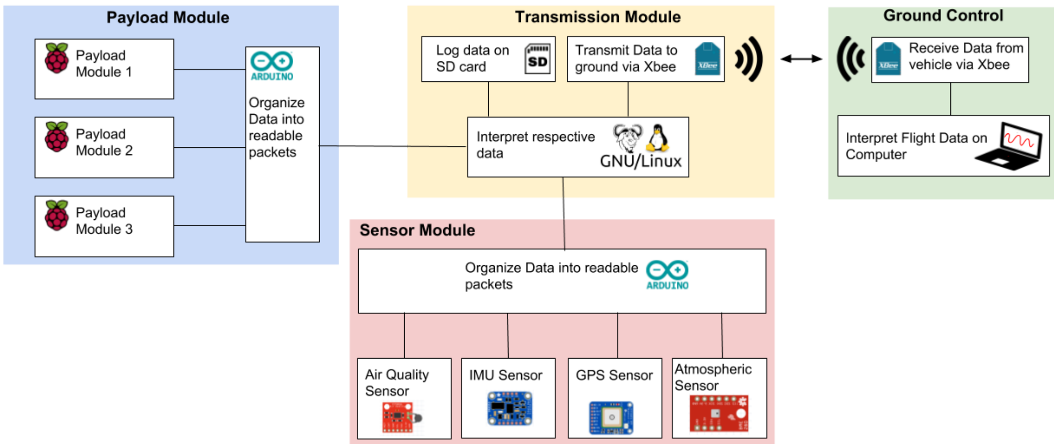


Figure 24: Payload Integration Block Scheme

The telemetry payload will be comprised of multiple modules: the payload integration module; which will collect data on the particulate matter (aerosols) in the atmosphere, the sensor module; which will collect specific data on the rocket flight and environmental conditions, and the transmission module; which will organize data from both the sensor and the payload module and will subsequently transmit the data back to the ground.

The data will be received on the ground using another wireless Xbee RF transmitter and will be interpreted, in real time, on a computer.

Payload-Telemetry Data Staging

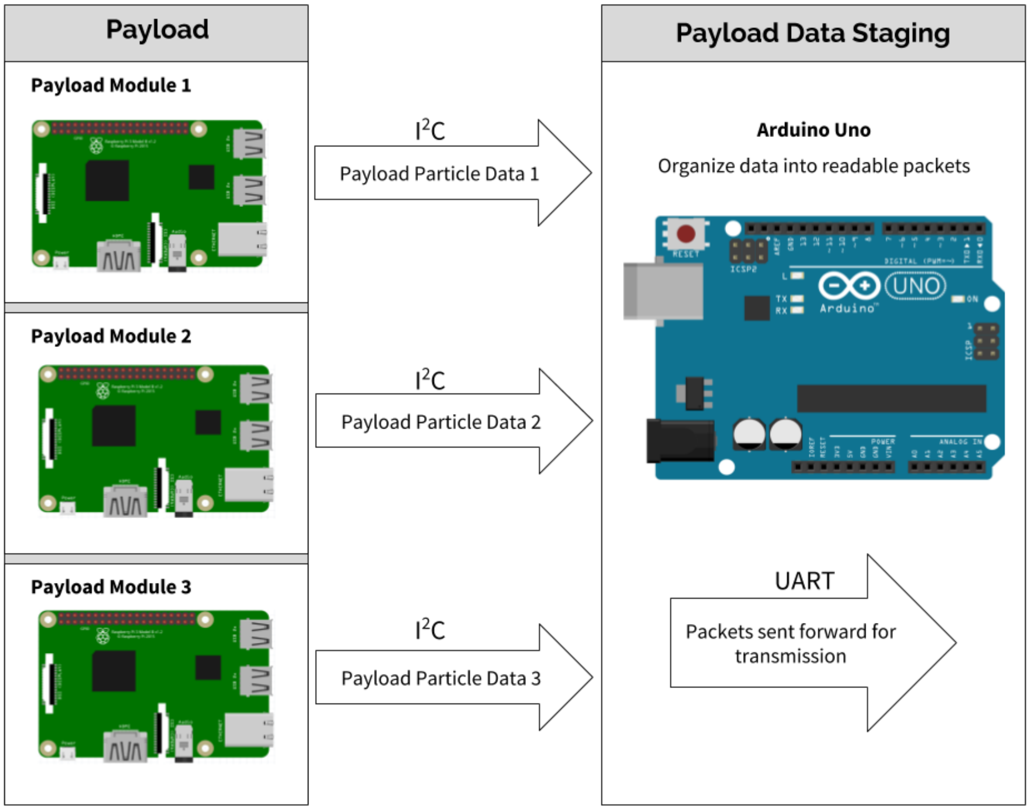


Figure 25: Payload Block Scheme

The payload module will integrate with the telemetry unit to provide redundancy for the data collected. Each payload module will communicate data to a data relay Arduino via an I^2C interface. This Arduino will then organize the data into readable packets which will subsequently transferred to the transmission module via a UART interface.

Sensor Module Overview

The table below outlines which instruments will be used in the sensor modules. An Adafruit Metro M4 was selected to be the microcontroller for the telemetry unit, due to its high amount of flash memory and RAM compared with the traditional Arduino Uno.

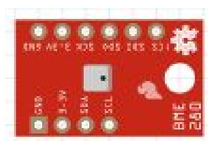
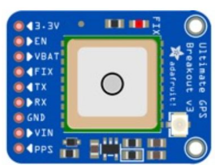
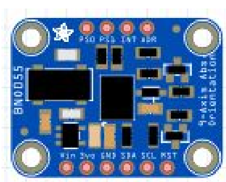
Instrument	Device	Data Rate/Second	Max. Sampling Rate	Data
Atmospheric Data Logger 	BME280	106 bytes	180 Hz	Temperature (°C)
				Humidity (% RH)
				Barometric Pressure (Pa)
				Altitude (m)
GPS 	MTK3339	73 bytes	10 Hz	GPS Coordinates (long, lat, altitude)
IMU 	BNO055	77 bytes	100 Hz	Absolute Heading (Euler Angles, Quaternions)
Air Quality Sensor 	CCS811	36 bytes	4 Hz	Total Volatile Organic Compounds (TVOC)
				Equivalent Calculated CO_2 Levels (ECO_2)
				Metal Oxide Levels (MOX)
Microcontroller 	Metro M4	N/A	N/A	Data Collection

Table 9: Sensor Module Components Table

Sensor Module Block Scheme

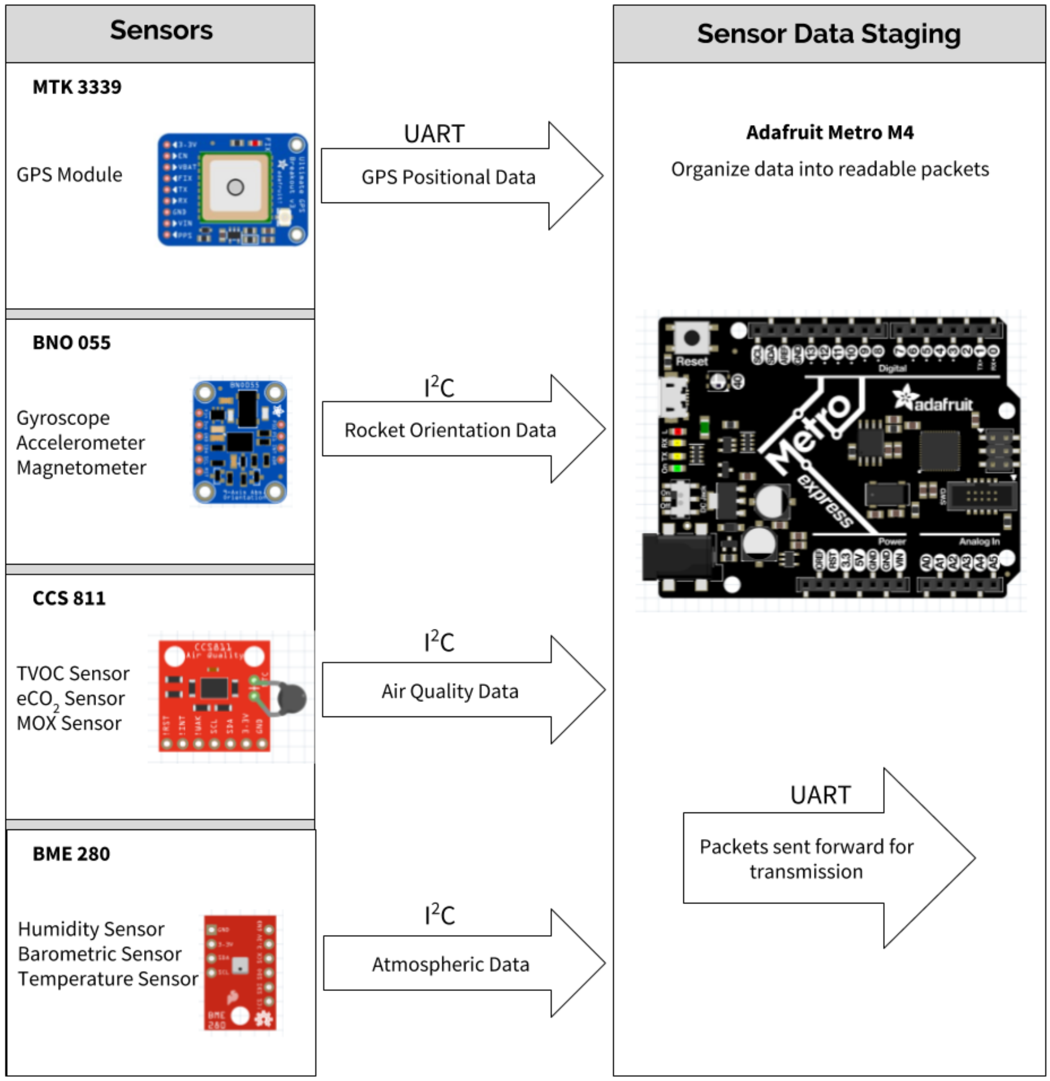


Figure 26: Telemetry Block Scheme

Each individual sensor will forward its data to a microcontroller that will process the data using a variant of the C programming language and facilitate its transfer into an RF transmission via an Xbee Pro S1 module. Data will also be stored in an SD card to ensure that data pertinent to our experiment is recovered should the transmissions fail. A lithium polymer battery along with a voltage regulator/charger will provide the microcontroller and sensors with power for proper functionality.

Transmission Module

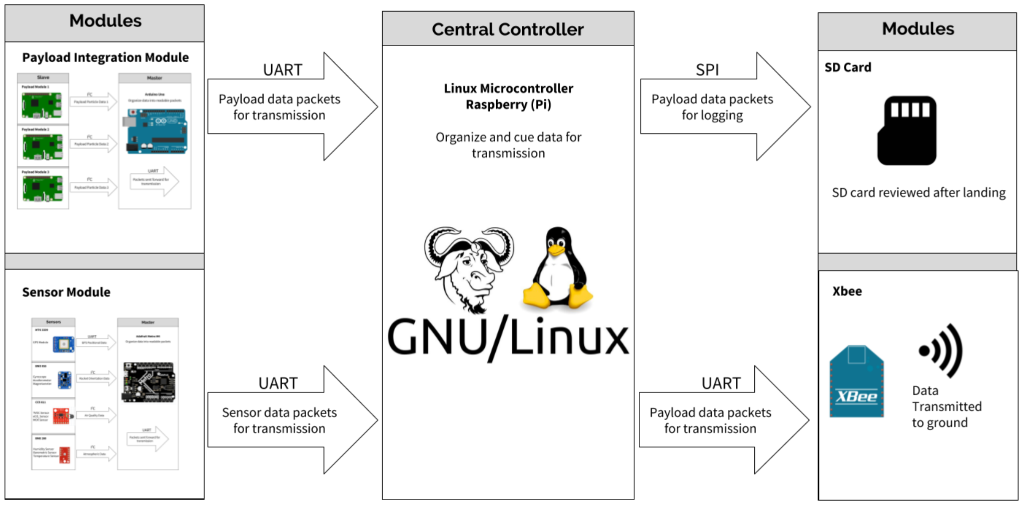


Figure 27: Telemetry Transmission Module Block Scheme

The transmission module will consist of a central single board computer (SBC) which will consolidate the data collected from the payload integration and sensor modules, facilitating its transmission and storage. The Xbee will be connected to the microcontroller via a UART interface. Data will be stored on an SD card in case of transmission failure.

Ground Control

RF transmissions from the rocket will be received on a ground control station consisting of an Xbee hooked up to a portable computer. This computer will then take and process the data into a display showing the heading, GPS location, orientation, altitude, acceleration and atmospheric sensor output from the rocket. Software for the displaying of the data in real time will be written in the Processing programming language.

Project Requirements

Vehicle

All vehicle requirements are in detail addressed in Project Requirements section, with Vehicle Requirements starting on page 72. The vehicle itself is described in the Technical Design section, starting on page 23.

Recovery System

All recovery system requirements are in detail addressed in Project Requirements section, with Recovery System Requirements starting on page XX. The detailed description of the recovery system starts on page XX.

Payload

All payload requirements are in detail addressed in Project Requirements section, with Payload Requirements starting on page XX. The detailed description of the proposed payload starts on page XX.

Major Technical Challenges and Proposed Solutions

For the Vehicle

- **Launch site dimensions:** The launch site in Huntsville allows for only 2,500ft drift during recovery. Drogue and main parachute sizes will have to carefully selected to ensure that the vehicle will not drift outside the launch site. The parachute will need enough time to deploy main parachute and land safely with no section of the vehicle exceeding the maximum impact energy of 75 ft-lbf. Descent rates will be monitored during our test flights and adjustments to parachutes and deployment schedule will be performed as necessary.

- **Weather variability and tracking:** When flying to between, tracking the rocket and retrieving it can become a significant challenge because of the possibility of high winds and limited visibility. A GPS tracking system will be used to locate and track the rocket should the optical tracking become impossible.

For The Payload

- **Camera functionality:** to achieve the required 2 hours of functionality on the launch pad the camera must have sufficient battery power. We will test batteries with the camera to maximize efficiency and ensure functionality for the required duration.

- **Flushing air and sanitary environment:** When constructing the payload, dust and other contaminants in the environment could settle on components such as the camera lense. This will cause data that is collected to be invalid. To avoid contamination we will run air through the payload before launch flushing out and contaminants.

- **Moving air through the payload efficiently:** If air is not able to flow through the payload efficiently the payload data will be invalidated. We will test and adjust the design of the payload and air intake valves to maximize airflow.

- **Risk of damaging glass plates during modifications:**The process of modifying the glass plates could easily cause scratches and smudges which would create blind spots in the imaging plane, to reduce the risk of this happening we will not be modifying the glass plates and will be handling the glass plates with care. Construction of the relevant sections of the payload will be streamlined so that if glass plates are damaged replacements can be purchased. And damaged components can be replaced.

For the Telemetry

- **Program Timing:** Various telemetry modules, such as an atmospheric logger and the air quality sensor, have variable sampling rates. The microcontroller will be programmed to account for different sampling times and ensure that data transfers smoothly.

- **Encoding Data:** As the data is transferred, the data must be encoded in a readable format in which each sensor can be easily distinguished from each other. Tags will be added to separate the data before transmission to allow for easy distinction.

- **Transmission Range:** If the rocket drifts out of the range of the transmitter or obstructed by environmental factors, sensor data will not be transmitted. To mitigate the risks concerning transmission, the transmitter will have a range of 2 miles. Additionally, the telemetry section of the rocket will be transmitting all data instantaneously, as well as saving it in an onboard SD card. In the event that the data is unable to transmitted, data can be retrieved upon recovery of the rocket.

STEM Engagement

Each year the team participates in numerous outreach events. These events range from single classroom activities at the local elementary schools to large public events that span multiple days and see visitors from around the state of Wisconsin, including but not limited to the Physics Open House at UW Madison or the Wisconsin Science Festival. The team will be returning to these events at the request of the event organizers this year

After a steady building of our reputation through outreaches for nearly a decade, the name Madison West Rocket Club is well recognized and many schools request our participation in their STEM related events. This year, the team expects to reach approximately 10,000 people. All supplies and materials for outreach events are supplied by the club. Minimum cost outreach designs, such as paper pneumatic rockets or surplus items from the workshop are used to ensure that a large number of children can participate in outreach opportunities and witness a meaningful demonstration or rocketry forces.

The team's fundraising efforts, dubbed Raking for Rockets, allows the club to keep in contact with local communities. Last year, the club raked over 120 yards, allowing the team to not only collect funds, but also connect with the local community and spread awareness of the club. Several times during the Raking for Rockets program our raking and yardworking teams helped people who otherwise could not yardwork in the spirit of altruism.

In addition to the programs outlined above, new members for the club are recruited continuously at Madison West High School. This is done through a number of methods, including participation in club fairs at West High School, personal referrals and friendly encouragement. Programs, such as the Spare Parts Airborne program during the summer allow curious members to try out rocketry and attempt an L1 certification flight in the process. These programs not only help with bolstering membership, but also bring exposure to rocketry and STEM fields to those who are either too busy or too intimidated to participate in the main programs of our club.

The table below shows the outreach programs that we have planned for this year. The programs target primarily elementary and middle schools. This list will be continuously updated as requests come in from more schools and event organizers.

Outreach Calendar

Date	Event	Activities	Eval. Criteria	Est. Attendance
10/04	Boy Scouts	Show & tell, static motor firing, ejection tests, rocket launches	Direct Education	50
10/13 - 10/14	Wisconsin Science Festival	Pneumatic rockets, SLI payload	Direct Education	7000
10/22	West High School Homecoming	Parade, displaying rockets to Randall Elementary kids	Indirect Outreach	200
11/03	The Stars Above	Fully functional plasma thruster, 3D printers	Direct Outreach	1000
11/13	Mt. Horeb Girl Scouts	Pneumatic rocket, show & tell, displays	Direct Education	150
02/17	Physics Open House	Displays, pneumatic rockets	Direct Education	530
03/09	Super Science Saturday	Displays, pneumatic rockets	Direct Education	250
03/26	Wingra School Family Science Night	Displays, pneurocs	Direct Education	150
04/16	Crestwood Elementary	Displays, pneurocs, 3D printers	Direct Education	170
04/19	MSCR K12 Showcase	Displays, pneurocs, 3D printers	Direct Education	350
04/23	Shorewood Elementary	Displays, pneurocs, 3D printers	Direct Education	150
		Estimated Total Attendance:		**10000**

Table X: Outreach Calendar

Project Plan

Development Schedule

GANTT Chart

The GANTT chart below shows the sequence, dependencies, overlaps and possible conflicts between different phases of the project. We use this chart to determine optimal schedule that will lead to successful and timely completion of our project. A full timeline of the season is outlined in the next section.

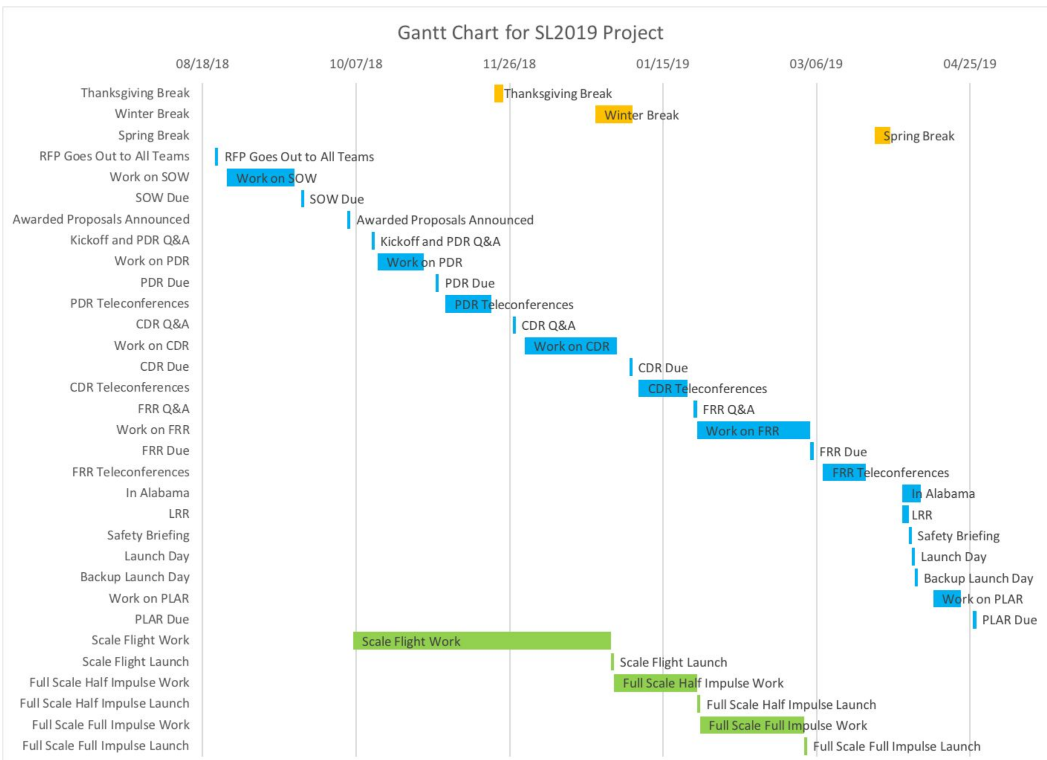


Figure 28: Gantt Chart

Timeline Key

	School
	SLI writing sessions
	Organizational meeting
	Workshop
	Fundraising
	Test launch
	Outreach
	SL Event Dates

Timeline

AUGUST	
Saturday 25	SLI writing session
SEPTEMBER	
Saturday 1	SLI writing session
Wednesday 5	School starts
Friday 7	Workshop
Saturday 8	SLI writing session
Monday 10	Organizational meeting
Friday 14	Workshop
Saturday 15	SLI writing session
Monday 17	Organizational meeting
Wednesday 19	SOW due 3:00 p.m.
Friday 21	Workshop
Saturday 22	SLI writing session
Monday 24	Organizational meeting
Friday 28	Workshop
Saturday 29	SLI writing session
OCTOBER	
Monday 1	Organizational meeting
Thursday 4	Outreach with Boy Scouts
Thursday 4	Accepted Proposals Announced
Friday 5	Workshop
Saturday 6	SLI writing session
Monday 8	Organizational meeting
Thursday 12	Kickoff and Preliminary Design Review (PDR) Q&A
Friday 12	Randall Elementary Outreach
Friday 12	Workshop
Saturday 13	SLI writing session
Sunday 14	Fundraising
Monday 15	Organizational meeting
Friday 19	Workshop
Saturday 20-21	Wisconsin science festival
Saturday 20	SLI writing session
Sunday 21	Fundraising

Monday 22	Organizational meeting
Friday 26	Social media list due 8:00 a.m.
Friday 26	No school
Friday 26	Workshop
Saturday 27	SLI writing session
Sunday 28	Fundraising
Monday 29	Organizational meeting
NOVEMBER	
Friday 2	Workshop
Friday 2	PDR Due by 8:00 a.m.
Saturday 3	SLI writing session
Saturday 3	The stars above
Saturday 3	ACT testing
Sunday 4	Fundraising
Monday 5	Organizational meeting
Monday 5-Monday 19	PDR Video Teleconferences
Friday 9	Workshop
Saturday 10	SLI writing session
Sunday 11	Fundraising
Monday 12	Organizational meeting
Tuesday 13	Mt. Horeb Girl scouts
Friday 16	Workshop
Saturday 17	SLI writing session
Sunday 18	Fundraising
Monday 19	Organizational meeting
Wednesday 21- Friday 23	No school
Saturday 24	SLI writing session
Sunday 25	Fundraising
Monday 26	Organizational meeting
Tuesday 27	Critical Design Review (CDR) Q&A
Friday 30	Workshop
DECEMBER	
Saturday 1	SLI writing session
Sunday 2	Fundraising
Monday 3	Organizational meeting
Friday 7	Workshop
Saturday 8	SLI writing session
Sunday 9	Scale Model flight
Monday 10	No school
Friday 14	Workshop
Saturday 15	SLI writing session
Monday 17	Organizational meeting
Monday 24 - Sunday, Jan. 6	WINTER BREAK
JANUARY	
Friday 4	CDR due by 8:00 a.m.
Friday 4	Workshop
Saturday 5	SLI writing session
Monday 7	Organizational meeting
Monday 7 - Tuesday 22	CDR Video Teleconferences

Friday 11	Workshop
Saturday 12	SLI writing session
Friday 18	Workshop
Saturday 19	SLI writing session
Monday 21	No school
Friday 25	Flight Readiness Review (FRR) Q&A
Friday 25	Workshop
Friday 25	No school
Saturday 26	SLI writing session
Monday 28	Organizational meeting
FEBRUARY	
Friday 1	Workshop
Saturday 2	SLI writing session
Monday 4	Organizational meeting
Friday 8	Workshop
Friday 8	No school
Saturday 9	SLI writing session
Sunday 10	Vehicle Demonstration Flight
Monday 11	Organizational meeting
Friday 15	Workshop
Saturday 16	SLI writing session
Saturday 16	Physics open house
Monday 18	Organizational meeting
Wednesday 20	ACT testing
Friday 22	Workshop
Saturday 23	SLI writing session
Sunday 24	Payload Demonstration Flight
Monday 25	Organizational meeting
MARCH	
Friday 1	Workshop
Saturday 2	SLI writing session
Monday 4	Organizational meeting
Monday 4	Vehicle Demonstration Flight deadline FRR due by 8:00 a.m
Friday 8 – Thursday 21	FRR Video Teleconferences
Friday 8	Workshop
Saturday 9	SLI writing session
Saturday 9	Super Science Saturday
Monday 11	Organizational meeting
Friday 15	Workshop
Saturday 16	SLI writing session
Sunday 17	Payload demonstration flight
Monday 18	No school
Wednesday 20	Wingra Science Night
Friday 22	Workshop
Saturday 23	SLI writing session

Monday 25	Payload Demonstration Flight deadline Vehicle demonstration Re-flight deadline FRR Addendum due 8:00 a.m.
Monday 25-29	No school
Saturday 30	SLI writing session
APRIL	
Wednesday 3	Travel to Huntsville, AL Launch Readiness Reviews (LRR)
Friday 5	Launch Week Activities
Saturday 6	Launch Day
Sunday 7	Backup Launch Day
Monday 8	Organizational meeting
Friday 12	Workshop
Saturday 13	SLI writing session
Monday 15	Organizational meeting
Friday 19	Workshop
Friday 19	MSCR k12 Showcase
Saturday 20	SLI writing session
Monday 22	Organizational meeting
Friday 26	No school
Friday 26	Workshop
Friday 26	Shorewood elementary
Friday 26	Post-Launch Assessment Review due 8:00 a.m.
Saturday 27	SLI writing session
Monday 29	Organizational meeting

Project Budget

The estimated project budget for the material costs relating to the proposed SLI project stands at around $3460.90 Prices were calculated from past knowledge and publicly available online prices. The following tables detail the funds required for the project by category.

Full -Scale Vehicle

Item	Price
Tubing, nose cone, bulkheads, rings	$300.00
Fin Material	$100.00
Paint and Primer	$100.00
PerfectFlite Stratologger Altimeter (x2)	$150.00
Motor Retention	$100.00
Motor Casing	$105.00
Parachutes, Shock Cords, Nomex	$200.00
Epoxy, Fillers	$100.00
Trackimo	$140.00
Misc. Supplies (tools, batteries, wires, etc.)	$300.00
Full Scale Vehicle Total:	**$1595.00**

Table 11: Full-Scale Vehicle Budget

Scale Vehicle

Item	Price
Tubing	$100.00
Parachutes and Shock Chord	$50.00
Fin Material	$50.00
Paint and Decal	$100.00
Motor Retention and Casing	$100.00
Misc. Supplies (tools, batteries, wires, etc.)	$60.00
Scale Vehicle Total:	**$460.00**

Table 12: Scale Model Budget

Payload

Item	Price
1kg PLA Plastic 3D printing filament (x2)	$40.00
Raspberry Pi 3 B+ (x3)	$120.00
Pi Cameras (x3)	$75.00
Li-Poly Battery Packs (x3)	$30.00
White LEDs (100 pack)	$5.00
Miscellaneous supplies (wires, solder, etc.)	$100.00
Payload Total:	**$370.00**

Table 13: Payload Budget

Telemetry

Item	Price
Sensors	$120.00
Microcontroller	$30.00
2.5 Ah Li-poly Battery Pack	$15.00
Circuitry	$50.00
Xbee Transmitters (x2)	$75.00
Miscellaneous Supplies (wires, solder, etc.)	$25.00
Telemetry Total:	**$315.00**

Table 14: Telemetry Budget

Energetics

Item	Price
CTI K661 (x2)	$265.90
Full Scale Half Impulse Motor	$115.00
Subscale Motor	$40.00
Energetics Total:	**$420.90**

Table 15: Energetics Budget

Total

Item	Price
Full-Scale Vehicle	$1595.00
Scale Model	$460.00
Payload	$370.00
Telemetry	$315.00
Energetics	$420.90
Taxes, Shipping & Handling, etc.	$300.00
Total Project Budget:	**$3460.90**

Table 16: Project Budget

Travel Budget

Overview

The following tables show the estimated expenses from traveling to Huntsville. Prices were calculated from past knowledge and publicly available online prices. The total travel cost is currently estimated at $12,347 with a per capita cost of $726.29. This budget does not include items that are purchased at the discretion of the individual such as food or souvenirs.

Flight

Cost per Person	Number of People	Flight Cost Total
$345.00	17	$5,865.00

Table 17: Flight Budget

Lodging

Cost per Room per Night	Number of Rooms	Number of Nights	Hotel Cost Total
$119.00	10	5	$5,355.00

Table 18: Hotel Fees Budget

Ground Support

Rental Cost	Gas and Other Costs	Ground Support Total
$500.00	$627.00	$1,127.00

Table 19: Ground Support Budget

Total

Item	Price
Flight	$5,865.00
Lodging	$5,355.00
Ground Support	$1,127.00
Project Budget Total:	**$12,347.00**
Cost Per Team Member:	**$726.29**

Table 20: Total Travel Budget

Funding Plan

Madison West Rocket Club has sufficient money earning opportunities (raking leaves/yard-work and donations from families or local companies) to earn enough money to cover the estimated budget and cover for possible discrepancies between the estimated budget and actual project expenses. Additionally, it is the policy of our team to provide necessary economic help to all SLI students who cannot afford the travel expenses associated with the program with full and partial travel scholarships. The monetary amounts and the names of recipients of scholarships are not disclosed.

Based on our previous experiences, the following breakdown of finances is expected:

Expenses

Item	Cost
Project Cost	$3,460.90
Workshop Rental	$2,400.00
Workshop Insurance	$500.00
Teleconferencing Fees*	$0.00
Outreach Costs	$500.00
Travel Expenses	$12,347.00
Total Expenses:	**$19,207.90**

* Teleconferencing venue and equipment provided for free by the university.

Table 21: Expenses Summary

Funds

Item	Cost
Raking Fundraiser	$6,000.00
Donations	$2,500.00
Travel Funds*	$12,347.00
Total Expenses:	**$20,847.00**

* Students pay the travel expenses associated with SL launch.

Table 22: Funds Summary

Sustainability of Rocket Science Program

Community Support

From the University of Madison-Wisconsin

After sixteen years of the club's existence, the club is well known at various departments of the UW and many researchers are eager to work with us. During the thirteen years of participation in SLI the club has met and collaborated with a number of UW faculty and staff from a number of departments. These fine people have helped in many aspects of previous Student Launch projects and have been incredibly helpful in designing and refining our experiments. Furthermore, they have opened up more opportunities for the club members to pursue their interests, by internships and collaborative opportunities. For example, the club has assisted Professor Wendt in displaying a NSF funded, fully functional plasma thruster at the Milwaukee Plasma Expo. The list of professors and experts who help in club endeavors are listed below in alphabetical order:

- **Professor Anderson** - Dept. of Mechanical Engineering
- **Dr. Barker** - Dept. of Botany
- **Professor Bonazza** - Dept. of Mechanical Engineering.
- **Professor Desai** - Dept. of Atmospheric Oceanic Space Sciences
- **Professor Eloranta** - Dept. of Atmospheric Oceanic Space Sciences
- **Professor Fernandez** - Dept. of Botany
- **Professor Gilroy** - Dept. of Botany
- **Professor Masson** - Dept. of Genetics
- **Professor McCammon** - Dept. of Physics
- **Professor Pawley** - Dept. of Zoology
- **Professor Sebastian-Bednarek** - Dept. of Biochemistry
- **Professor Wendt** - Dept. Electrical and Computer Engineering

We are officially affiliated with UW Madison and our research meetings are now held in at classrooms belonging to Department of Atmospheric Oceanic Space Sciences. This provides us with state of art classrooms, including projection technology and document camera that we can use during our meeting. We are also participating in UW outreach activities, such as Physics Open House, Super Science Saturdays (in summer) and most importantly Wisconsin Science Festival, where we can reach over 8,000 people. Additionally, UW Madison provides teleconferencing venue and equipment, saving us over $2,000.00 in teleconferencing expenses.

From the Local Community

Sixteen years has also allowed the club to build a reputation among the community as a reliable and educational entity. Event organizers often request our presence at STEM related events to talk about rocketry and provide fun activities. Children are especially eager to construct and launch their own pneumatic rockets. The enthusiasm of the children and the reputation of the club among event organizers makes it much easier for the team to reach a large number of people during public outreaches. Many of the new members in our club cite our presence at an outreach as the main reason they decided to join rocket club.

On top of support during outreaches, the team raises funds by raking leaves in the local neighborhood during the fall. We find this is an excellent way to earn the support of the community and increase our visibility. Leaf raking requests have steadily grown over the years and people regularly donate over $100 per yard to show their appreciation and support for the club.

The club has also been projected into the spotlight a number of times. In 2012 we have won TARC national contest for second time in our club history. As a result of this, we have received communications from both senators, the mayor, the Dane County board and others. NBC channel broadcasted a 4 minute documentary about our club, the Wisconsin State Journal printed a full length article, and the club was scheduled for an hour long show at local community radio station (WORT 89.9FM). In 2018, our club was again propelled into the spotlight after a highly successful season at NASA Student Launch and were honored in a meeting of the Dane County Board as well as featured in an interview segment that was broadcast on several local news channels.

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

Parents also support the club through their assistance in fundraisers, meetings, outreach projects, and launches. They provide food and transportation during the cold winter events and launches, take on administrative roles such as fundraising and logistics, and, perhaps most importantly, provide encouragement and support.

We have established our social media presence and at peak times our postings reach over 2,500 people.

Recruitment and Programs

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

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

Incoming students are enrolled in the TARC program, where they attend classroom sessions taught by the mentors in order to learn the basic rocketry knowledge and methodologies essential to the contest. The TARC program is currently enjoying a streak of success at national finals, placing in top 25 for last eight consecutive years.

Rockets For Schools is a program that has been beneficial to our members and efforts and it has returned for the 2018 and 2019 seasons. In this contest, students are given a high power rocket kit and asked to design a scientific payload to be flown from Sheboygan, WI over Lake Michigan. Not only does this project offer good training for the process of obtaining an SLI grant, it also gives an additional activity option to first-year club members: while they are not invited to participate in the Student Launch program, our highest-level activity, they may participate in the R4S competition. The R4S program is modeled after the SLI program, placing emphasis on the scientific project and development process. All R4S students are encouraged to seek L1 HPR certification as a part of the R4S program. Our first seven R4S teams (2010, 2011, 2012, 2013, 2014, 2016 and 2017) consisted of all first-year members, and their high scores won additional SLI invitations for the club for 2011, 2012, 2013, 2015, 2017, 2018 seasons. The club has also obtained a high ranking in the 2018 season of R4S.

This year the club has continued the HPR L1/L2 Certifications program, which is affectionately called the Spare Parts Airborne program. A number of L1 certifications were obtained by younger club members. This highly successful summer L1 program (outside school year) was invented, coordinated and administered by the SLI-2008, SLI-2009 and SLI-2010 participant, Ms. Zoë Batson, until her departure to college, after which it was continued by the club due to its massive popularity.

This year, the workshop was thoroughly cleaned and prepared for the season with new furniture and tools. Exploration into 3D printing capabilities and CAD modeling will continue. The club currently holds 60 educational licenses for the SolidWorks CAD modeling program and interest in the area seems to be growing rapidly. Other activities, such as the basics of PCB design and manufacturing are also taught to interested club members.

Project Requirement Guidelines

1. General Requirements

1.1. **Students on the team will do 100% of the project, including design, construction, written reports, presentations, and flight preparation with the exception of assembling the motors and handling black powder or any variant of ejection charges, or preparing and installing electric matches (to be done by the team's mentor). Students will do 100% of work on the project, write the documentation and presentations and present the project during teleconferences.** Dr. Pavel Pinkas is the Level 2 mentors for the team and he will handle all motor and ejection charge assembly.

1.2. **The team will provide and maintain a project plan to include, but not limited to the following items: project milestones, budget and community support, checklists, personnel assigned, educational engagement events, and risks and mitigations.** A project plan will be maintained and update as project progresses.

1.3. **Foreign National (FN) team members must be identified by the Preliminary Design Review (PDR) and may or may not have access to certain activities during launch week due to security restrictions. In addition, FN's may be separated from their team during these activities.** The list of foreign nationals will be provided to NASA by PDR teleconference and will be informed about the restrictions they might face.

1.4. **The team must identify all team members attending launch week activities by the Critical Design Review (CDR). Team members will include:**

1.4.1. **Students actively engaged in the project throughout the entire year.** All team members are identified in the Student Participants section near the beginning of this document.

1.4.2. **One mentor (see requirement 1.13).** Dr. Pavel Pinkas is the mentor for the team.

1.4.3. **No more than two adult educators.** Ms. Christine Hager and Dr. Ankur Desai are the two adult educators for our team.

1.5. **The team will engage a minimum of 200 participants in educational, hands-on science, technology, engineering, and mathematics (STEM) activities, as defined in the STEM Engagement Activity Report, by FRR. To satisfy this requirement, all events must occur between project acceptance and the FRR due date and the STEM Engagement Activity Report must be submitted via email within two weeks of the completion of the event. A sample of the STEM Engagement Activity Report can be found on page 33 of the handbook.** Our education engagement plan includes 10,000 students from local elementary and middle schools and members of general public. At least 1000 of those are middle school students. Educational engagement forms will be completed and submitted within two weeks of each event's completion.

1.6. **The team will establish a social media presence to inform the public about team activities**. A social media presence will be created and update throughout the duration of the project.

1.7. **Teams will email all deliverables to the NASA project management team by the deadline specified in the handbook for each milestone. In the event that a deliverable is too large to attach to an email, inclusion of a link to download the file will be sufficient.** All deliverables will be emailed on time to NASA project management with either an attachment or a download link.

1.8. **All deliverables must be in PDF format.** All deliverables will be in PDF format.

1.9. **In every report, teams will provide a table of contents including major sections and their respective sub-sections.** The aforementioned format of each report will be followed.

1.10. **In every report, the team will include the page number at the bottom of the page.** Page numbers will be included at the bottom of each page in all reports.

1.11. **The team will provide any computer equipment necessary to perform a video teleconference with the review panel. This includes, but is not limited to, a computer system, video camera, speaker telephone, and a broadband Internet connection. Cellular phones can be used for speakerphone capability only as a last resort.** We will be using fully equipped teleconference rooms in the Atmospheric and Oceanic Sciences building at UW Madison.

1.12. **All teams will be required to use the launch pads provided by Student Launch's launch service provider. No custom pads will be permitted on the launch field. Launch services will have 8 ft. 1010 rails [2.4 m 1010 rails], and 12 ft. 1515 rails [3.7 m 1515 rails] available for use. The launch rails will be canted 5 to 10 degrees away from the crowd on launch day. The exact cant will depend on launch day wind conditions.** We will use the launch pads provided by Student Launch's launch service provider. We will need an 8 ft, 1010 rail for this project.

1.13. **Each team must identify a "mentor." A mentor is defined as an adult who is included as a team member, who will be supporting the team (or multiple teams) throughout the project year, and may or may not be affiliated with the school, institution, or organization. The mentor must maintain a current certification, and be in good standing, through the National Association of Rocketry (NAR) or Tripoli Rocketry Association (TRA) for the motor impulse of the launch vehicle and must have flown and successfully recovered (using electronic, staged recovery) a minimum of two flights in this or a higher impulse class, prior to PDR. The mentor is designated as the individual owner of the rocket for liability purposes and must travel with the team to launch week. One travel stipend will be provided per mentor regardless of the number of teams he or she supports. The stipend will only be provided if the team passes FRR and the team and mentor attends launch week in April.** Dr. Pavel Pinkas is the mentor for the team. He is Level 2 certified and satisfies all requirements listed above. He will accompany team to the Huntsville launch.

2. Vehicle Requirements

2.1. **The vehicle will deliver the payload to an apogee altitude between 4,000 feet [1,219 meters] and 5,500 feet [1,676 meters] above ground level (AGL) Teams flying below 3,500 feet [1067 meters] or above 6,000 feet [1829 meters] on Launch Day will be disqualified and receive zero altitude points towards their overall project score.** The current simulation predicts that the rocket will reach 5,268 ft. The coefficient of drag is set to C_D= 0.7 C_D. We have obtained this value from our previous experiments using a similar constant diameter K-class delivery vehicle. The performance predictions will be updated as data from scale model flight and half-impulse flight become available. If necessary, the rocket will be ballasted to prevent it from exceeding target altitude.

2.2. **Teams shall identify their target altitude goal at the PDR milestone. The declared target altitude will be used to determine the team's altitude score during Launch Week.** The Target altitude goal will be identified at the PDR milestone.

2.3. **The vehicle will carry one commercially available, barometric altimeter for recording the official altitude used in determining the Altitude Award winner. The Altitude Award will be given to the team with the smallest difference between their measured apogee and the official target altitude on launch day.** The vehicle will carry two identical barometric altimeters (PerfectFlite StratoLogger CF), each capable of serving the role of official scoring altimeter. The team will designate and visually identify one of the altimeters as the official scoring altimeter, before the actual flight.

2.4. **Each altimeter will be armed by a dedicated arming switch that is accessible from the exterior of the rocket airframe when the rocket is in the launch configuration on the launch pad.** Independent external switches are standard requirement for all Madison West high powered rocketry projects. This performance target will be satisfied and documented.

2.5. **Each altimeter will have a dedicated power supply.** Independent and dedicated power supply for each deployment altimeter are standard requirement for all Madison West high powered rocketry projects. This performance target will be satisfied and documented.

2.6. **Each arming switch will be capable of being locked in the ON position for launch (i.e. cannot be disarmed due to flight forces).** We use switches operated by a key. None of the switches can be moved after the key has been removed. None of the switches is momentary.

2.7. **The launch vehicle will be designed to be recoverable and reusable. Reusable is defined as being able to launch again on the same day without repairs or modifications.** The vehicle is designed as reusable and can be launched several times a day. The maximum flight preparation time is 2 hours.

2.8. **The launch vehicle will have a maximum of four (4) independent sections. 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 vehicle consists of three tethered sections (nose cone, compartment housing both the payload and main parachute and the booster section).

2.8.1. **Coupler/airframe shoulders which are located at in-flight separation points will be at least 1 body diameter in length** All coupler and airframe shoulders located at in flight separation points will be one body diameter in length.

2.8.2. **Nosecone shoulders which are located at in-flight separation points will be at least ½ body diameter in length** All Nosecone shoulders located at in-flight separation points will be at least ½ body diameter in length.

2.9. **The launch vehicle will be limited to a single stage.** The launch vehicle is a single stage rocket.

2.10. **The launch vehicle will be capable of being prepared for flight at the launch site within 2 hours of the time the Federal Aviation Administration flight waiver opens.** The maximum preparation time for the rocket is 2 hours. The team will practice the vehicle preparation in order to assure their ability to ready the vehicle for launch within allocated time.

2.11. **The launch vehicle will be capable of remaining in launch-ready configuration at the pad for a minimum of 2 hours without losing the functionality of any critical on-board components.** The launch vehicle can remain in launch-ready configuration for several hours. The altimeters are rated for 24 hours of wait time and the payload can remain in wait-state for 8 hours. Battery capacities and standby times will be tested extensively during project development.

2.12. **The launch vehicle will be capable of being launched by a standard 12-volt direct current firing system. The firing system will be provided by the NASA-designated launch services provider.** The vehicle is using Aerotech motor which is compatible with 12V igniters. Electrical current of 3A is sufficient to fire the igniter. The vehicle can be launched from the standard 12V launch system.

2.13. **The launch vehicle will require no external circuitry or special ground support equipment to initiate launch (other than what is provided by the launch services provider).** No external circuitry other than the standard 12V launch system is required to launch the vehicle.

2.14. **The launch vehicle will use a commercially available solid motor propulsion system using ammonium perchlorate composite propellant (APCP) which is approved and certified by the National Association of Rocketry (NAR), Tripoli Rocketry Association (TRA), and/or the Canadian Association of Rocketry (CAR).** Only motors satisfying this performance target are used in design, testing and operation of the vehicle. Currently, Aerotech K1000T 75mm motor is the primary propulsion choice.

2.14.1. **Final motor choices must be made by the Critical Design Review (CDR) milestone.** We will finalize our propulsion choice by Critical Design Review (CDR).

2.14.2. **Any motor changes after CDR must be approved by the NASA Range Safety Officer (RSO), and will only be approved if the change is for the sole purpose of increasing the safety margin. A penalty against the team's overall score will be incurred when a motor charge is made after the CDR milestone, regardless of the reason.** We will comply with all instructions provided by NASA should this situation arise.

2.15. **Pressure vessels on the vehicle will be approved by the RSO and will meet the following criteria:**

2.15.1. **The minimum factor of safety (Burst or Ultimate pressure versus Max Expected Operating Pressure) will be 4:1 with supporting design documentation included in all milestone reviews.** Not applicable.

2.15.2. **Each pressure vessel will include a pressure relief valve that sees the full pressure of the valve that is capable of withstanding the maximum pressure and flow rate of the tank.** Not applicable

2.15.3. **Full pedigree of the tank will be described, including the application for which the tank was designed, and the history of the tank, including the number of pressure cycles put on the tank, by whom, and when.** Not applicable.

2.16. **(...) The total impulse provided by a Middle and/or High School launch vehicle will not exceed 2,560 Newton-seconds (K-class).** None of the three motor alternatives considered for this project exceeds the 2,560Ns impulse limit. The primary motor choice has total impulse of 2,436 Ns.

2.17. **The launch vehicle will have a minimum static stability margin of 2.0 at the point of rail exit. Rail exit is defined at the point where the forward rail button loses contact with the rail.** The vehicle stability margin is predicted as 3.11 calibers at liftoff.

2.18. **The launch vehicle will accelerate to a minimum velocity of 52 fps [15.8 m/s] at rail exit.** The predicted rail exit velocity is 52 fps.

2.19. **All teams will successfully launch and recover a subscale model of their rocket prior to CDR. Subscales are not required to be high power rockets.** We are planning to launch the subscale model prior the Critical Design Review due date. This is a standard step in our project development cycle.

2.19.1. **The subscale model should resemble and perform as similarly as possible to the full-scale model, however, the**

full-scale will not be used as the subscale model. The subscale model will be a half-scale model of the full-scale vehicle. The stability margin will be same and the same deployment scheme will be used.

2.19.2. **The subscale model will carry an altimeter capable of reporting the model's apogee altitude.** The subscale model will be equipped by the same altimeter brand as the full-scale vehicle (PerfectFlite StratoLogger CF).

2.19.3. **The subscale rocket must be a newly constructed rocket, designed and built specifically for this year's project.** We will design and build the subscale rocket specifically for this years project.

2.19.4. **Proof of a successful flight shall be supplied in the CDR report. Altimeter data output may be used to meet this requirement** We will provide altimeter data as proof of a successful flight. This data will be supplied in the CDR report.

2.20. **All teams will complete demonstration flights as outlined below.**

2.20.1. **All teams will successfully launch and recover their full-scale rocket prior to FRR in its final flight configuration. The rocket flown at FRR must be the same rocket to be flown on launch day. The purpose of the full-scale demonstration flight is to demonstrate the launch vehicle's stability, structural integrity, recovery systems, and the team's ability to prepare the launch vehicle for flight. A successful flight is defined as a launch in which all hardware is functioning properly (i.e. drogue chute at apogee, main chute at a lower altitude, functioning tracking devices, etc.). The following criteria must be met during the full-scale demonstration flight:**

2.20.1.1. **The vehicle and recovery system will have functioned as designed.** The vehicle recovery system will be operated in full configuration on all planned test flight.

2.20.1.2. **The full scale rocket must be a newly constructed rocket, designed and built specifically for this**

year's project. The full scale rocket will be a newly constructed rocket. It will be designed and built specifically for this years project.

2.20.1.3. **The payload does not have to be flown during the full-scale test flight. The following requirements still apply:** We intend to have the payload fully functional for our final test flight.

2.20.1.3.1. **If the payload is not flown, mass simulators will be used to simulate the payload mass.** Before the payload is ready for flight, payload will be simulated by mass simulators during test flights.

2.20.1.3.2. **The mass simulators will be located in the same approximate location on the rocket as the missing payload mass.** Payload mass simulators, if used, will represent the predicted mass of the payload and will be located at the payload's intended location within the vehicle to maintain the same mass distribution.

2.20.1.4. **If the payload changes the external surfaces of the rocket (such as with camera housings or external probes) or manages the total energy of the vehicle, those systems will be active during the full-scale demonstration flight.** All changes to the external surface of the vehicle will be active during the full-scale demonstration flight.

2.20.1.5. **Teams shall fly the launch day motor for the Vehicle Demonstration flight. The RSO may approve the use of an alternate motor if the home launch field cannot support the full impulse of the launch day motor or in other extenuating circumstances.** We intend to fly our demonstration flight with the exactly same motor that will be used for our flight at the SLI launch in Huntsville.

2.20.1.6. **The vehicle must be flown in its fully ballasted configuration during the full-scale test flight. Fully**

ballasted refers to the same amount of ballast that will be flown during the launch day flight. Additional ballast may not be added without a re-flight of the full-scale launch vehicle. The vehicle will be fully ballasted (if ballast is necessary) for the final full-scale test flight.

2.20.1.7. **After successfully completing the full-scale demonstration flight, the launch vehicle or any of its components will not be modified without the concurrence of the NASA Range Safety Officer (RSO).** Except for necessary repairs, there will not be any changes made to the launch vehicle after the full-scale demonstration flight. If any repairs are necessary, the NASA Range Safety Officer will be contacted before making any changes to the vehicle.

2.20.1.8. **Proof of a successful flight shall be supplied in the FRR report. Altimeter data output is required to meet this requirement** We will provide altimeter data as proof of a successful flight in the FRR report.

2.20.1.9. **Full-scale flights must be completed by the FRR submission deadline. If the Student Launch office determines that a re-flight is necessary, then an extension will be granted. This extension is only valid for re-flights, not first-time flights. Teams completing a required re-flight must submit an FRR addendum by the FRR Addendum deadline.** Full scale flights will be completed by the FRR deadline. In the event that a reflight is deemed necessary an FRR addendum will be submitted by the FRR Addendum deadline.

2.20.2. **All teams will successfully launch and recover their full-scale rocket containing the completed payload prior to the Payload Demonstration Flight deadline. The rocket flown must be the same rocket to be flown on launch day. The purpose of the payload demonstration flight is to prove the launch vehicle's ability to safely retain the constructed payload during flight and to show that all**

aspects of the payload perform as designed. A successful flight is defined as a launch in which the rocket experiences stable ascent, the payload is fully retained during ascent and descent, and the payload is safely deployed on the ground.

2.20.2.1. **The payload must be fully retained throughout the entirety of the flight, all retention mechanisms must function as designed, and the retention mechanism must not sustain damage requiring repair.** The payload will be fully retained throughout the entirety of the flight. All retention mechanisms will function as designed and they will not sustain damage requiring repair.

2.20.2.2. **The payload flown must be the final, active version.**The payload flown will be the final, active version

2.20.2.3. **If the above criteria is met during the original Vehicle Demonstration Flight, occurring prior to the FRR deadline and the information is included in the FRR package, the additional flight and FRR Addendum are not required.** We understand that if we complete the above criteria during the Vehicle Demonstration flight, prior to the FRR deadline the additional flight and FRR Addendum will not be required.

2.20.2.4. **Payload Demonstration Flights must be completed by the FRR Addendum deadline. No extensions will be granted.** We will complete the Payload Demonstration Flight prior to the FRR Addendum deadline.

2.21. **An FRR Addendum will be required for any team completing a Payload Demonstration Flight or NASA-required Vehicle Demonstration Re-flight after the submission of the FRR Report.**

2.21.1. **Teams required to complete a Vehicle Demonstration Re-Flight and failing to submit the FRR Addendum by the deadline will not be permitted to fly the vehicle at launch**

week. We understand that failure to complete a Vehicle Demonstration Re-Flight and failing to submit the FRR Addendum by the deadline will result in not being allowed to fly the vehicle at launch week.

2.21.2. **Teams who successfully complete a Vehicle Demonstration Flight but fail to qualify the payload by satisfactorily completing the Payload Demonstration Flight requirement will not be permitted to fly the payload at launch week.** We understand the importance of safety in the NASA Student Launch program and will follow all RSO directions should this situation arise.

2.21.3. **Teams who complete a Payload Demonstration Flight which is not fully successful may petition the NASA RSO for permission to fly the payload at launch week. Permission will not be granted if the RSO or the Review Panel have any safety concerns.** We understand the importance of safety in the NASA Student Launch program and will follow all RSO directions should this situation arise.

2.22. **Any structural protuberance on the rocket will be located aft of the burnout center of gravity.** There are no structural protuberances on the rocket.

2.23. **The team's name and launch day contact information shall be in or on the rocket airframe as well as in or on any section of the vehicle that separates during flight and is not tethered to the main airframe. This information shall be included in a manner that allows the information to be retrieved without the need to open or separate the vehicle.** The team name and contact information will be included in the rocket and in an easily accessible location.

2.24. **Vehicle Prohibitions:**

2.24.1. **The launch vehicle will not utilize forward canards.** The vehicle does not have forward canards.

2.24.2. **The launch vehicle will not utilize forward firing motors.** The vehicle does not utilize forward firing motors.

2.24.3. **The launch vehicle will not utilize motors that expel titanium sponges (Sparky, Skidmark, MetalStorm, etc.)** The vehicle does not utilize motors expelling titanium sponges.

2.24.4. **The launch vehicle will not utilize hybrid motors.** Hybrid motors are not used.

2.24.5. **The launch vehicle will not utilize a cluster of motors.** Clustered motors are not used.

2.24.6. **The launch vehicle will not utilize friction fitting for motors.** A flange mounted, thread secured motor retention system is used.

2.24.7. **The launch vehicle will not exceed Mach 1 at any point during flight.** The vehicle remains subsonic during entire flight. The maximum predicted velocity is 0.5 mach.

2.24.8. **Vehicle ballast will not exceed 10% of the total weight of the rocket.** The ballast (if used) will not exceed 10% of the vehicle weight.

2.24.9. **Transmissions from onboard transmitters will not exceed 250 mW of power.** Transmission power from the onboard transmitters will not exceed 250 mW of power. The telemetry unit uses Xbee Pro S1s which have a max transmission power of 250 mW of power.

2.24.10. **Excessive and/or dense metal will not be utilized in the construction of the vehicle. Use of light-weight metal will be permitted but limited to the amount necessary to ensure structural integrity of the airframe under the expected operating stresses.** Our rocket will neither utilize excessive nor dense metal during the construction of our vehicle. We will keep lightweight metal to a minimum if used.

3. Recovery System Requirements

3.1. **The launch vehicle will stage the deployment of its recovery devices, where a drogue parachute is deployed at apogee and a main parachute is deployed at a lower altitude. Tumble or streamer recovery from apogee to main parachute deployment is also permissible, provided that kinetic energy during drogue-stage descent is reasonable, as deemed by the RSO.** Dual deployment recovery method is used for the vehicle (drogue parachute deploys at apogee and main parachute 700 ft (or other predetermined altitude). The vehicle has two fully independent and redundant deployment circuits. The backup charges are 25% larger than primary charges to increase the chance of deployment in the event of primary charge failure.

3.1.1. **The main parachute shall be deployed no lower than 500 feet [152 meters].** The main parachute typically deploys at 700 ft and will not be deployed below 500 ft.

3.1.2. **The apogee event may contain a delay of no more than 2 seconds.** Apogee event delay will not exceed 2 seconds.

3.2. **Each team must perform a successful ground ejection test for both the drogue and main parachutes. This must be done prior to the initial subscale and full-scale launches.** Static ejection test are the standard step in our vehicle development process, starting with the subscale model and extending to the full-scale vehicle as well.

3.3. **At landing, each independent sections of the launch vehicle will have a maximum kinetic energy of 75 ft-lbf [101 joules].** The parachute sizes will be so chosen than no section of the rocket lands with kinetic energy greater than 75 ft-lbf.

3.4. **The recovery system electrical circuits will be completely independent of any payload electrical circuits.** This performance target is a standard requirement for all Madison West projects and will be satisfied.

3.5. **All recovery electronics will be powered by commercially available batteries.** All recovery electronics will be powered by 9V Duracell batteries. Batteries are installed fresh and only used for one flight.

3.6. **The recovery system will contain redundant, commercially available altimeters. The term "altimeters" includes both simple altimeters and more sophisticated flight computers.** We only use commercially available altimeters for deployment of recovery devices. Full redundancy of deployment electronics is a standard requirement for all Madison West high powered rocketry projects. This performance target will be satisfied and documented.

3.7. **Motor ejection is not a permissible form of primary or secondary deployment.** Motor ejection charges are not used for the deployment, all deployment events are triggered by barometric altimeters.

3.8. **Removable shear pins will be used for both the main parachute compartment and the drogue parachute compartment.** Removable shear pins will be used at all separation points. The shear pins will be tested during static ejection tests to assure that they will hold but not interfere with the separation of the corresponding compartment.

3.9. **Recovery area will be limited to a 2500 ft. [762 m] radius from the launch pads.** The rocket will remain within the confines of the launch area even under 20mph wind speed conditions.

3.10. **Descent time will be limited to 90 seconds (apogee to touchdown).** Descent time will be less than or equal to 90 seconds from apogee to touchdown.

3.11. **An electronic tracking device will be installed in the launch vehicle and will transmit the position of the tethered vehicle or any independent section to a ground receiver.** We will use an onboard GPS receiver transmitting its location via cellular network (Trackimo trackers).

3.11.1. **Any rocket section, or payload component, which lands untethered to the launch vehicle, will also carry an active electronic tracking device.** Target satisfied with 3.11

3.11.2. **The electronic tracking device will be fully functional during the official flight on launch day.** All tracking devices will fully operational during official flight in Huntsville and for all full-scale vehicle test launches.

3.12. **The recovery system electronics will not be adversely affected by any other on-board electronic devices during flight (from launch until landing).** There will be no interference between recovery deployment circuitry and payload or tracking circuitry. Shielding will be used as necessary.

3.12.1. **The recovery system altimeters will be physically located in a separate compartment within the vehicle from any other radio frequency transmitting device and/or magnetic wave producing device.** The recovery system altimeters are housed in a dedicated avionics bay, separate from all other electronics

3.12.2. **The recovery system electronics will be shielded from all onboard transmitting devices, to avoid inadvertent excitation of the recovery system electronics.** Shielding will be used as necessary. All electronics will be ground tested for possible interference.

3.12.3. **The recovery system electronics will be shielded from all onboard devices which may generate magnetic waves (such as generators, solenoid valves, and Tesla coils) to avoid inadvertent excitation of the recovery system.** There are no magnetic wave generators onboard.

3.12.4. **The recovery system electronics will be shielded from any other onboard devices which may adversely affect the proper operation of the recovery system electronics.** Shielding will be used as necessary. All electronics will be ground tested for possible interference.

4. Payload Experiment Requirements

4.1. **High School/Middle School Division – Teams may design their own science or engineering experiment or may choose to complete one of the College/University Division experiment options.** The Madison West Rocketry Team will be measuring air particulation in the planetary boundary layer.

4.2. **Section Not Applicable**

4.3. **Section Not Applicable**

4.4. **Section Not Applicable**

4.5. **Team-Designed Payload Requirements (High School/Middle School Division)**

4.5.1. **Team-designed payloads must be approved by NASA. NASA reserves the authority to require a team to modify or change a payload, as deemed necessary by the Review Panel, even after a proposal has been awarded.** Our payload is described in detail earlier in this document. We will comply with all NASA requests for changes (if applicable).

4.5.2. **Data from the science or engineering experiment will be collected, analyzed, and reported by the team following the scientific method.** We will thoroughly analyze and document all data collected by our payload. Post Launch Assessment Report will be sent to NASA after our final launch in Huntsville. The hypothesis and analytical methods are described earlier in this document.

4.5.3. **The experiment must be designed to be recoverable and reusable. Reusable is defined as being able to be launched again on the same day without repairs or modifications.** The payload has its own tracking capabilities (to facilitate recovery) and can be flown several times a day (the maximum payload preparation time is 2 hours).

4.5.4. **Any experiment element that is jettisoned during the recovery phase will receive real-time RSO permission prior to initiating the jettison event.** Not Applicable. No elements are planned to be ejected during the recovery phase. However, if such a situation arises, the team will receive real-time RSO permission.

4.5.5. **Unmanned aerial vehicle (UAV) payloads, if designed to be deployed during descent, will be tethered to the vehicle with a remotely controlled release mechanism until the RSO has given permission to release the UAV.** Not Applicable. No UAVs will be used.

4.5.6. **Teams flying UAVs will abide by all applicable FAA regulations, including the FAA's Special Rule for Model Aircraft (Public Law 112-95 Section 336; see https://www.faa.gov/uas/faqs).** Not Applicable. No UAVs will be used.

4.5.7. **Any UAV weighing more than .55 lbs. will be registered with the FAA and the registration number marked on the vehicle.** Not Applicable. No UAVs will be used.

5. Safety Requirements

5.1. **Each team will use a launch and safety checklist. The final checklists will be included in the FRR report and used during the Launch Readiness Review (LRR) and any launch day operations.** We will use a launch and safety checklist for each launch. The checklists will be checked and improved during each test launch. All checklists will be included in our Flight Readiness Review.

5.2. **Each team must identify a student safety officer who will be responsible for all items in section 5.3.** Matilda Carne is the team's safety officer.

5.3. **The role and responsibilities of each safety officer will include, but not limited to:**

5.3.1. **Monitor team activities with an emphasis on Safety during:**

5.3.1.1. **Design of vehicle and payload.** The safety officer will insure that the design of the vehicle and payload are safe.

5.3.1.2. **Construction of vehicle and payload.** The safety officer will insure that the construction of the vehicle and payload are sound.

5.3.1.3. **Assembly of vehicle and payload.** The safety officer will supervise assembly and insure that the vehicle and payload are assembled correctly.

5.3.1.4. **Ground testing of vehicle and payload.** The safety officer will attend ground testing and insure it is within safe standards.

5.3.1.5. **Sub-scale launch test(s).** The safety officer will be present at subscale launch tests and insure that they will be carried out safely.

5.3.1.6. **Full-scale launch test(s).** The safety officer will be present at full-scale launch tests and insure that they will be carried out safely.

5.3.1.7. **Launch Day.** The safety officer will be present on launch tests and insure that all safety precautions are kept.

5.3.1.8. **Recovery Activities.** The safety officer will insure that the team remains safe during recovery activities and that all local laws are kept.

5.3.1.9. **Educational Engagement Activities.** The safety officer will insure that educational engagement activities remain safe.

5.3.2. **Implement procedures developed by the team for construction, assembly, launch, and recovery activities.** The safety officer will contribute to, check, and approve procedures and implement them for all activities.

5.3.3. **Manage and maintain current revisions of the team's hazard analyses, failure modes analysis, procedures, and MSDS/chemical inventory data.** The safety officer will take an active leading role in managing the documents outlined above.

5.3.4. **Assist in the writing and development of the team's hazard analyses, failure modes analysis, and procedures.** The safety officer will contribute to, check, and approve the documents outlined above.

5.4. **During test flights, teams will abide by the rules and guidance of the local rocketry club's RSO. The allowance of certain vehicle configurations and/or payloads at the NASA Student Launch Initiative does not give explicit or implicit authority for teams to fly those certain vehicle configurations and/or payloads at other club launches. Teams should communicate their intentions to the local club's President or Prefect and RSO before attending any NAR or TRA launch.** The team's intentions are communicated to the host organization prior each launch. The team will abide by the launch rules set by the host organization.

5.5. **Teams will abide by all rules set forth by the FAA.** All FAA rules will be strictly followed by all team members.

Supplementary Information

Team Member Resumes

Resume For Benton

Academic Experience:
Grant Elementary school (2007-2012)
Eagle School (2012-2016)
West High School (2016-present)

Languages:
English
French (5 years)

Extracurriculars:
Madison West Rocket Club (2016-present)
Ski Team (2016-present)
Thinkpad club (founded 2018 -present)
Model United Nations (2017-2018)
Music:
Piano (2008-present)
Violin (2012-present)
Viola (2009-present)

Rocketry Experience:
TARC 2017 (finalist)
SLI 2018

Honor Classes:
US History Honors (9th grade)
Biology Honors (9th grade)
Precalculus (9th grade)
English Honors (9th grade)

AP Calculus AB (10th grade)
English 10 Honors (10th grade)
AP Statistics (10th grade)

AP Calculus BC (11th grade)
AP French 5 (11th grade)
AP Chemistry (11th grade)
Survey of American Literature Honors (11th grade)

Community Service:
Writer Workshop (2016)
Rocket Club Outreaches (2018-present)

Interests:
Computer programming, Fly Fishing, GNU/linux, Alpine Skiing, Hiking, Mountain Biking, playing piano/violin

Resume For Daniel

Academic Experience
Fern Elementary School (2007-2012)
Mill Valley Middle School (2012-2015)
Tamalpais High School (2015-2017)
Madison West High School (2017-present)

Languages
English
Korean
Spanish (2 years)

Activities
Engineering Club (2015-2017)
Programming Club (2015-2017)
Track & Field (2015-2017)
Madison West Rocket Club (2017-Present)
Varsity Math Team (2017-Present)
UW-Madison Bacteriology Research Intern (2018-Present)

Awards and Achievements
TARC Finalist 2018
Rockets for Schools First Place 2018
NHS member
Red Cross CPR & AED Certification

Honors Classes
Honors Trends in 20th Century Literature
AP Calculus BC
AP Computer Science A
AP US History
AP Biology
AP Statistics
AP Chemistry
AP Music Theory

Community Service
Rocket Outreaches
Service Trip to Mexico and Cambodia
TA for Algebra 1 and AP Calculus AB

Interests
Rocketry
Music
Computer Science
Biology

Resume For Edwin

Academic Experience
Eastover Elementary (2007-2010)
Dilworth Elementary (2010-2013)
Alexander Graham Middle School (2013-2014)
Velma Hamilton Middle School (2014-2016)
Madison West High School (2016-present)

Languages
English
Spanish (4 years)

Activities
Madison West Rocket Club (2016-present)
Student Launch 2018
Cross Country (2016)
Team America Rocketry Challenge (2017)
NASA Student Launch (2018)
Boy Scouts of America (2013-2017)

Awards and Achievements
TARC 2017 (Finalist)

Honors Classes
Algebra 1 Honors (8^{th} grade)
Geometry Honors (9^{th} grade)
AP European History (10^{th} grade)
English 2 Honors (10^{th} grade)
Algebra 2/Trig Honors (10^{th} grade)

Interests
Electrical Engineering/Circuit Building
Programming
3D Modelling
Rocketry
Aviation

- 10.6 Flight Hours Logged

Resume For Ella

Academic Experience
Midvale Elementary School (2006-2009)
Abraham Lincoln Elementary School (2009-2012)
Velma Hamilton Middle School (2012-2015)
Madison West High School (2015-present)

Languages
English (Native)
Spanish (4 years)
Japanese (1 year)

Activities

Rockетry
Madison West Rocket Club (2016-present)
Team America Rocketry Challenge (2016-2017)
Rockets for Schools (2017, 2018)
NASA Student Launch (2017-2018)

Music
Piano (2009-present)
Violin (2011-2015)

Others
Girl Scouts (9 years)

Awards and Achievements
Rockets for Schools First Place (2017, 2018)
Team America Rocketry Challenge 19th place (2017)
NASA Student Launch First Place Awards (Altitude and Best-Looking Rocket, 2018)
Honor Roll (2015-2018)

Honors Classes
Algebra Honors (8th grade)
Geometry Honors (9th grade)
Trigonometry Honors (10th grade)
Pre-calc Honors (11th grade)
English Honors (9th-11th grade)
History Honors (9th-10th grade)
Biology Honors (9th grade)

Community Service
Madison Children’s Museum (2012)
Dane County Humane Society (2016-2018)

Interests
Illustration, Biology, Chemistry, Reading, Piano

Resume For Grant

Resume For Hyun-seok

Academic Experience:

- Shorewood Elementary School
- Elm Elementary School
- Hinsdale Middle School
- Velma Hamilton Middle School
- Madison West High School

Languages:

English (Fluent), Korean (Fluent), French (5 years), Spanish (2 years)

Activities:

Madison West Rocket Club (2016 – present)

- Team America Rocketry Challenge (2017)
- Rocket For Schools (2017, 2018)
- NASA Student Launch (2018)

Boy Scouts of America (2011-present)

- Senior Patrol Leader (2017-2018)
- Leader of Eagle Scout service project (2018)
- Life Scout (2016 - present)

Model United Nations (2017-present)

- 1981 US Cabinet Simulation, Madison Model UN (2017)

Awards & Achievements

Rocket For Schools 1st place (2017, 2018)
NASA Student Launch, Altitude Award, feat. the LEMUR team (2018)
Madison Model UN Best Position Paper Award (2017)
National History Day State Labor Prize (2017)
Topik Test Level 3 (Korean Assessment test) (2012)
Honor Roll (2016-2018)

Honors & AP Classes

Algebra Honors (8th grade)
Geometry honors (9th grade)
English 1 honors (9th grade)
Biology Honors (9th grade)
US History Honors (9th grade)
Algebra 2/Trigonometry Honors (10th grade)
English 2 honors (10th grade)
AP European History (10th grade)
AP Government and Politics (11th grade)
AP Calculus AB (11th grade)
AP Chemistry (11th grade)
Math Physics (11th grade)

Community Service

CMC Meal Service and Gardening
Rocketry Outreaches
Boy Scout Service Projects

Interests: Hiking, Hobby electronics, Programming, Music, Board Games

Resume For Kabiltan

Education:

Coopertown Elementary School (2006-2011)
Shorewood Elementary School (2011-2012)
Hamilton Middle School (2012-2015)
Madison West High School (2015-Present)

Languages:

English(Fluent), Spanish(5 years), Tamil(Fluent)

Activities/clubs:

Rocketry:

Madison West Rocket Club (2017-current)
TARC 2018 (2017-2018)
Rockets for Schools (2017 – 2018)

Sports:

Madison West Soccer (2015-2017)
Madison West Cross Country (2018 – Present)
Madison West Tennis (2018 – Present)
Zoe Martial Arts School (2012 – 2016) (Black Belt)

Study Abroad:

CIEE Marine Biology and Field Work – Portugal - (2018 Summer)

Tutoring:

Peer Tutor at Madison West High School(2017 – Present)

Awards and Achievements:

Honor Roll(2012 – 2018)
National Honors Society (2018 – Present)
Spanish National Honors Society (2017-Present)
Team America Rocketry Challenge (16th place)
Rockets For Schools (1st Place)

Honors Classe/ AP Classes:

Algebra 1 honors (8th grade)
Geometry honors (9th grade)
Algebra 2 Honors (10th grade)
Biology Honors (9th grade)
AP US History (11th grade)
AP Computer Science Principles (10th grade)
AP Chemistry (12th grade)
AP Calculus AB (12th grade)
AP Spanish Language/Culture (12th grade)
AP Physics 2 (12th grade)

Interests:

Aerospace Engineering, Soccer, Cross country, Tennis, Snowboarding, Physics

Resume For Kyle

Summary

A hard working and tech-savvy employee with 6 months of experience working in food service. Skills include hosting/bussing, working cash registers, and accommodating guests' needs. Able to communicate effectively with a team and very keen to develop more professional skills, such as Rocket Design.

Education

Madison West High School
Madison, Wisconsin
Graduating June 2020

I am in my Junior year of high school, and taking classes that challenge my abilities and will lead to future career opportunities. I am currently an active member of West High Rocketry Club and could not be happier to work with my classmates on the NASA Student Launch 2019.

Employment History

Luigi's Pizza
Host & Busser
Madison, Wisconsin
June 2017 – September 2017
I learned how to greet guests, be consistently on time, and work well with coworkers. Overall it was a great experience but I ended employment to focus on my schoolwork.

Pizza Brutta
Runner
Madison, Wisconsin
May 2018 – Present
My responsibilities as a runner include working a cash register, cutting pizzas and other basic food prep, bringing food out to customers, cleaning tables and dishes, and closing the restaurant.
Hobbies & Interests

Two of my greatest interests and hobbies are Video Games and Rockets. I've been a gamer for a long time along with my two brothers, but only recently started to take an interest in rockets. Before joining Rocket Club, I had no idea there was a high school opportunity to design your own rocket and compete in a NASA competition. I hope to pursue a career in Aerospace Engineering and work with NASA or SpaceX to launch humanity to new heights.

Professional Skills

Computer Programming: Beginner
Woodworking: Intermediate
Computer Hardware: Assembly & Repair: Intermediate
Leadership Skills: Competent

Languages

English: Native
Spanish: Conversational

Resume For Mason

Academic Experience
Shorewood Elementary School
Hamilton Middle School
Madison West High School

Languages
English
Spanish (4 years)

Activities
Madison West Rocket Club (2017-Present)
Team America Rocketry Challenge (TARC) (2017-2018)
Rockets for Schools (2017-2018)
Student Research Internship, UW-Madison Department of Botany (2018)
Saxophone (2013-Present): State Solo and Ensemble and Jazz Band
Summer Camp Counselor (2016-2017)

Awards and Achievements
TARC 2018 Finalist
Rockets for Schools 2018 First Place
National Honors Society member (2016-Present)
Spanish National Honors Society (2017-Present)
Red Cross CPR & AED Certification

Honors Classes
Algebra 1 honors
Geometry honors
Algebra 2 Honors
Biology Honors
AP European History
AP US History
AP Chemistry
AP Spanish Language/Culture

Community Service
Summer Camp Counselor
Rocket Outreaches
Elementary School Soccer Coach

Interests
Ecology
Botany
Mycology
Rocketry
Music
Snowboarding

Resume For Matilda

Academic:

Wingra School (2007-2016)

Madison West High School (2016-present)

Language:

Spanish (11 years)

English (native)

Activities:

TARC 2017

SL 2018

Madison West Rocketry Club (2016-present)

Math club (2016-present)

Philosophy club (2016-2018)

Capitol east soccer club (2014-2016)

Regent soccer club (2016-present)

West High School freshman soccer (2017)

West High School Junior Varsity soccer (2018)

Wingra School Science Night exhibit table (2015, 2016)

Achievements:

TARC 2017 national finalist

Corn maze design selected for use at Treinan farm (2014)

SL altitude award (2018)

SL best looking rocket award (2018)

Interests

Vexillology, math, ceramics, contemporary art, economics, botany, soccer, reading.

Resume For Maya

Academic experience
Franklin Elementary School (2008-2011
Randall Elementary School (2011-2013)
Burgermeisterschutteschule (2013-2014)
Velma Hamilton Middle School (2014-2017)
West High School (2017-present)

Languages
English (Fluent)
German (Fluent)
Spanish (2 Years)
Hebrew (10 years)

Activities

Rocketry
Madison West Rocket Club (2017-present)
Team America Rocketry Challenge (2017-2018)
Music
Cello (2007-Present)
Flute (2014-Present)
Sports
Cross Country Running (2014-Present)
Ultimate Frisbee (2017-present)
Shorewood Swim Team (2011-2017)
Other Extracurriculars
Traditional South Indian Dance (2015-Present)
Book Bowl (2011-2017)
Future Problem Solvers (2014-2016)
Ramah in the Rockies
Midrasha

Honors Classes
Algebra Honors
English 1 Honors
U.S History Honors
Geometry Honors

Community Service
Rocketry Outreaches
Beth Israel Center teaching

Interests
Film/cinematography, engineering, hiking, reading, programming

Resume For Michael H.

Education:

- Leopold Elementary School (2007-2013)
- Cherokee Heights Middle School (2013-2016)
- WCATY: How To Lie With Numbers (2016)
- Madison West High School (2016-current)

Languages:

- English (native)
- French (3 years)

Activities/clubs:

- Boy Scouts (2013-current)
  - Patrol leader 3 years
  - Assistant senior patrol leader 1 year
  - Senior patrol leader 1 year
- Cub Scouts (2009-2013)
- Madison West Rocket Club (2016-current)
  - TARC 2017 (2016-2017)
  - NASA Student Launch 2018 (2017-2018)
- Book bowl (2012-2013)

Honors and college credit classes classes:

- Algebra 1 Honors (2015-2016)
- Geometry Honors (2016-2017)
- Biology Honors (2016-2017)
- US History Honors (2016-2017)
- PLTW Intro to Engineering (2016-2017)
- PLTW Principles of Engineering (2017-2018)
- Algebra 2/trigonometry Honors (2017-2018)

Awards and achievements:

- Boy Scout Life Rank
- Cub Scout Arrow of Light
- Honor roll (2013-2016)

Volunteering:

- Boy scout service projects (2013-current)
- Rocketry outreaches (2016-current)

Interests:

- Engineering, physics, chemistry, astronomy

Resume For Michael M.

Resume For Nicholas

Academic experience:

Eagle School (Elementary and Middle School)
West High School (Grades 9-11)

Languages:

English
French (11 years)

Activities:

Madison West Rocket Club (2017-present)
TARC (2017-18)
Volleyball (2016)
Science Olympiad (2015-16)

Awards and achievements:

TARC National Finals (2017)
Honor roll (2016-17)

Honors and AP Classes:

English 1 honors (9th grade)
US History Honors (9th grade)
Biology
English 2 honors (10th grade)
AP Calculus AB (10th grade)

Community Service:

Rocket club outreaches (2017-18)
Writing Workshop (2015-16)

Interests:

Engineering, Astronomy, Physics, Programming, Video Games, Robotics

Resume For Norlha

Academic Experience:
Glenn Stephens Elementary School (2007-2013)
Cherokee Heights Middle School (2013-2016)
Madison West High School (2016-Present)

Languages:
Tibetan (Native)
English (Fluent)
Spanish (4 years)
Hindi (8 years)

Activities:
- **Clubs**
  - Madison West Rocket Club (2016-Present)
  - Tibetan Club (2016-Present)
  - Green Club (2016-2017)
- **Music**
  - Violin(2007-2016)
  - Piano(2006-Present)
  - Guitar(2016-2018)

Awards and Achievements:
- Team America Rocketry Challenge National Finalist (2016)
- Team America Rocketry Challenge 19th Place (2017)
- Honor Roll (2016-Present)
- Spelling Bee Champion(2013)

Honors Classes:
- Geometry Honors (9th grade)
- Trigonometry Honors (10th grade)
- English 1 Honors (9th grade)
- Chemistry Honors (9th grade)

Community Service:
100+ hours, Wisconsin Tibetan Association, St James Food Service, Agrace HospiceCare

Interests:
Engineering, Math, Music, Reading, Writing

Resume For Ryley

Academic Experience

Van Hise Elementary School (2007-2013)

Velma Hamilton Middle School (2013-2016)

West High School (2016-Present)

Languages

English (Native)

French (4 Years)

Chinese (10 Years)

Activities

Rocketry

Madison West Rocket Club (2016-Present)

Team America Rocketry Challenge (2016)

Rockets For Schools (2017)

NASA Student Launch (2018)

Rockets For Schools (2018)

Music

Harp (2009-Present)

Violin (2012-Present)

WYSO (2013-Present)

SMC (Summer 2018)

Sports

Log Rolling (2011-Present)

Awards and Achievements

Honor Roll (2016-2018)

Team America Rocketry Challenge 19th Place (2017)

3rd Place Midwest Log Rolling Championships (2016)

National History Day State Finalist (2017)

NASA SL Best Looking Rocket Award (2018)

NASA SL Altitude Award (2018)

Honors Classes

Algebra Honors (8th Grade)

Geometry Honors (9th Grade)

US History Honors (9th Grade)

Biology Honors (9th Grade)

English 1 Honors (9th Grade)

Algebra 2/Trigonometry Honors (10th Grade)

English 2 Honors (10th Grade)

Community Service

Rocketry Outreaches (2016-Present)

Vilas Zoo Fun Run (2016)

Souper Bowl (2017)

Madison Marathon (2017)

Ironman WI (2018)

Resume For Sultani

Academic Experience

Franklin Elementary School (2006-09)
Randall Elementary School (2009-12)
Velma Hamilton Middle School (2012-14)
St James School (2014-15)
Madison West High School (2015-Present)

Languages

English (Native)
Japanese (3 years)

Activities

Madison West Rocket Club (2015-Present)
Future Problem Solvers (2011-13)
Girl Scouts (6 years)
Greater Madison Young Writer's Camp (2 years)

Awards and Achievements

Rockets for Schools 1st place (2016)
Rockets for Schools 1st place (2017)
Rockets for Schools 1st place (2018)
Team America Rocketry Challenge National Finalist (2016)
Team America Rocketry Challenge 19th Place (2017)
SLI Best Looking Rocket and Altitude Award (2018)
Japanese National Honors Society (2017-18)
National Honors Society (2018)
Honor Roll (2015-18)
Madison-Obihiro Sister City essay scholarship (2018)

AP Classes

AP Chem
AP Environmental Science
AP Calculus

Community Service

70+ hours, Monroe St Arts Center, St James Food Service and Folk Choir, Open Doors For Refugees

Interests

Space travel, astrobotany, marine biology, ecology, graphic design, comic art and writing

NAR Model Rocketry Safety Code

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

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

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

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

Launch Safety. I will use a countdown before launch, and will ensure that everyone is paying attention and is a safe distance of at least 15 feet away when I launch rockets with D motors or smaller, and 30 feet when I launch larger rockets. If I am uncertain about the safety or stability of an untested rocket, I will check the stability before flight and will fly it only after warning spectators and clearing them away to a safe distance. When conducting a simultaneous launch of more than ten rockets I will observe a safe distance of 1.5 times the maximum expected altitude of any launched rocket.

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

Size. My model rocket will not weigh more than 1,500 grams (53 ounces) at liftoff and will not contain more than 125 grams (4.4 ounces) of propellant or 320 N-sec (71.9 pound-seconds) of total impulse.

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

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

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

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

NAR Launch Site Dimensions

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

Table A1: NAR Launch Site Dimensions

NAR High Power Rocketry Safety Code

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

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

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

Ignition System. I will launch my rockets with an electrical launch system, and with electrical motor igniters that are installed in the motor only after my rocket is at the launch pad or in a designated prepping area. My launch system will have a safety interlock that is in series with the launch switch that is not installed until my rocket is ready for launch, and will use a launch switch that returns to the “off” position when released. The function of onboard energetics and firing circuits will be inhibited except when my rocket is in the launching position.

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

Launch Safety. I will use a 5-second countdown before launch. I will ensure that a means is available to warn participants and spectators in the event of a problem. I will ensure that no person is closer to the launch pad than allowed by the accompanying Minimum Distance Table. When arming onboard energetics and firing circuits I will ensure that no person is at the pad except safety personnel and those required for arming and disarming operations. I will check the stability of my rocket before flight and will not fly it if it cannot be determined to be stable. When conducting a simultaneous launch of more than one high power rocket I will observe the additional requirements of NFPA 1127.

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

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

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

Launch Site. I will launch my rocket outdoors, in an open area where trees, power lines, occupied buildings, and persons not involved in the launch do not present a hazard, and that is at least as large on its smallest dimension as one-half of the maximum altitude to which rockets are allowed to be flown at that site or 1500 feet, whichever is greater, or 1000 feet for rockets with a combined total impulse of less than 160 N-sec, a total liftoff weight of less than 1500 grams, and a maximum expected altitude of less than 610 meters (2000 feet).

Launcher Location. My launcher will be 1500 feet from any occupied building or from any public highway on which traffic flow exceeds 10 vehicles per hour, not including traffic flow related to the launch. It will also be no closer than the appropriate Minimum Personnel Distance from the accompanying table from any boundary of the launch site.

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

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

NAR Minimum Distance Table

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

Table A2: NAR minimum distance

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

List of Applicable Outside Resources

Electrical Data Sheets / User Manuals

PerfectFlite Stratologger CF
PerfectFlite Stratologger SL100
Trackimo 3G GPS Universal Tracker
C&K Keylock Switches

Coding Resources

Arduino Language Reference
Python Coding Standards
Python Coding Library
Python Beginner Resources
Typography Standards
Visual Studio Code Manual

West Rocketry Resources

Club Website
Facebook
Github

Safety Laws

FAR CFR 14 Chapter F Part 101 Subpart C
CFR 27 Part 55: Explosives In Commerce
NFPA 1127 (2002)

Other Info

Fin Flutter Calculations

List of Applicable Safety Data Sheets

Propulsion and Deployment

Ammonium Perchlorate
Aerotech Reloadable Motors
Aerotech Igniters
M-Tek E-matches
Pyrodex Pellets
Black Powder
Nomex (thermal protector)

Glues

Elmer's White Glue
Two Ton Epoxy Resin
Two Ton Epoxy Hardener
Bob Smith Cyanoacrylate Glue
Super-glue Accelerator
Super-glue Debonder

Soldering

Flux
Solder
Solder Braid

Painting and Finish

Automotive Primer
Automotive Spray Paint
Clear Coat

Construction Supplies

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

Solvents

Ethyl Alcohol 70%
Distilled Water
Bacto-Peptone
Liquinox
Isopropyl alcohol
Hydrochloric acid
Sodium hydroxide

Payload Materials

Aluminum
Acrylic
Polycarbonate

Payload Chemicals

Copper Sulfate
Glucose
Sucrose
Potassium Phosphate
Agar
Sodium Chloride
Sorensen's Phosphate
Calcium Chloride