MAHARISHI SCHOOL

Preliminary Design Review

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I) Summary of PDR Report

Team Summary

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Launch Vehicle Summary

- **Size and Mass:** 90.322 inches, 0.65 slugs
- **Motor Choice:** K680
- **Recovery System:** The vehicle will use redundant dual deployment for recovery and one more ejection for payload.
- **Milestone Review Flysheet:**

Payload Summary

- **Payload title:** SkyCrane
- **Summary:** The payload will be an engineering project, called a Sky Crane, that will assist in the landing of our rocket within a specified amount of time

II) Changes Since Proposal

Vehicle Criteria

- Changed diameter from 180 mm to 154.94 mm
- Changed length from 100 inches to 90.322 inches

Payload Criteria

- SkyCrane duration time and window specified

Project Plan

- No changes

III) Vehicle Criteria

Selection, Design, and Rationale of Launch Vehicle

Mission Statement

We, the No Way But Up Team, will construct and launch a rocket that will reach a mile high while deploying a payload. The rocket will include a dual deploy recovery and will remain reusable.

System Review

Several systems are required to accomplish our mission. These are shown in the diagram below (subsystems of those systems are covered in subsequent sections).

Vehicle

The vehicle is the rocket itself, it contains several subsystems: payload, recovery, and propulsion. All of these subsystems work together to create and form our project, without all of these working together our project would be incomplete and faulty. The payload was our team choice, we decide to deploy a Skycrane system to precisely control the flight duration time of the rocket. The recovery is one of the most important parts of rocket, if this is faulty the team could lose all electronics and data, the flight would be inconclusive, tragic, and poses a safety threat to the spectators. All of the recovery electronics will be located in the electronics bay, and our Skycrane system will be employed in the lower section of our rocket. The propulsion is the rocket engine. The team decided to use a K680R motor from Aerotech.

Design Details

The Rocket was designed using OpenRocket and is made up of 4 main parts. First there is the 11.41 inch long ogive nose cone with a 4 inch long shoulder. The nose cone will be attached to the upper section via shock cord. Next is the 25 inch upper section that will hold a 144 inch main parachute. There will be a triple thickness bulkhead in the the nose cone shoulder for the shock cord to attach to. There will be a shock cord that attaches to the Avionic Bay bulkhead. Then is the 15 inch Avionic Bay. The GPS system and two stratologger Altimeters will be in the Avionic Bay. There are two bulkheads on each side of the Avionic Bay. Lastly is the 35.9 inch lower airframe cone. The payload and the drogue chute, measuring 18 inches, and the motor will be in the lower airframe. The motor will be purchased commercially and some centering rings and accept a 98mm motor. Since we will be using a single use motor, our motor will use friction retention. There will be three fins equally placed around the outside of the lower section. The fins will have a root chord length of 10 inches, tip chord length of 1 inches, a sweep length of 12.2 inches, a sweep angle of 50.7_{o}, a semi span of 10 inches, and they will be 0.118 inches thick. The fins will be made out of a G10 fiberglass frame. All exposed pieces of the Rocket will be made out of fiberglass. The recovery section including the electronics and parachutes are covered in detail in section 3.2.

Component	Material	Qty	Weight (grams)	Total Weight (grams)	Length (inches)	Width (inches)	Thickness (inches)
Vehicle							
Nosecone	Fiberglass	1	794	794	24	6.1	0.125

Upper Body Tube	Fiberglass	1	1355	1355	30	6.1	0.079
Lower Body Tube	Fiberglass	1	1513	1513	33.5	6.1	0.079
Fins	Fiberglass	3	548	548	n/a	10.63	0.118
Motor Retention	Aluminum	1	45	45	1	4.1	n/a
Propulsion							
Aerotech K680 Motor	APCP, plastic	1	n/a	n/a	11.3	3.86	n/a

The final rocket is custom designed to our needs and has the following characteristics:

- Length: 90.322 inches
- Diameter: 6.0 inches
- Span: 16.0 inches
- Mass: 0.65 slugs
- Center of Gravity: 58.9 inches behind the nose tip
- Center of Pressure: 72.0 inches behind the nose tip
- Stability Margin: 2.19

Motor Choice

To select a motor we needed to have all of the details of components for the rocket (major vehicle components are in the table above, for complete list see appendix D). The total final weight from our table was 9527 grams, or 21 pounds (this varied as we loaded different motors). This corresponded closely with the weight of the individual components entered into OpenRocket using their data base. We selected several different motors made by Aerotech, since Aerotech has a reputation for being consistent and reliable. Our target altitude was just above 1 mile. From the simulations, the K680R single use motor carried our rocket to 5,327 feet – just more of the needed 5,280 feet (better to err on the high side of 1 mile) with a burn time of 3.5 seconds.

Launch System

When the team launches the rocket there's a lot that contributes to it. To launch a rocket it requires: a launch rail, a launch controller with a safety interlock system, a weather station, wire/cable, two garden tractor batteries, alligator clips, a remote relay, and a fire extinguisher. The team's rocket will use launch rail guides, thus we need a launch rail to launch. To actually launch the rocket you need a launch controller with a safety interlock system which needs a power supply which is the 12v garden tractor battery, wires/cables run out to the launch pad to a remote relay which attaches to a second 12 v battery. The launch controller closes the remote relay that provides power to the igniter. In this way, less power is lost in the long wire run from the controller to the pad. Just in case anything happens to our engine we will have a fire extinguisher on hand. Before we actually launch our rocket we need to check our weather station to make sure the wind speed is less than 20 miles an hour.

Tracking System

The tracking system will use a Trackimo 3G GPS. This device utilizes cellular towers in that area to created a connection with a mobile ground device. A cellular 2G connection is required to transmit data from transmitter (Trackimo device) to receiver (mobile phone). In almost all environments, a stable 3G connection is available, which is more than enough for this device. This GPS device removes the need for complex radio systems (or other alternatives) and provides similar accuracy at a fraction of the cost. It also provides a more convenient way to track the vehicle, since all that is required is a mobile phone instead of multiple wired devices that create unnecessary complexity.

Retrieval

The retrieval of the rocket is the most simplistic of all the system. All we need is a group of ready people (people from our team) who are willing to walk to retrieve the rocket. Hopefully they are wearing comfortable shoes that day. With the retrieval, they have to be sure that they recover all parts just in case something malfunctioned.

Subsystems

GPS Subsystem

Within the system of the Trackimo device, no further setup is required. The device is fully functional out of the box, as long as the cellular service has been paid for. The Trackimo device includes a built-in battery and all wires are internal. A holding apparatus will be built to hold the device in place and protect it from all forces. The device can be turned on well in advance due to its long battery life of 1 month.

Recovery Subsystem

The vehicle will use redundant dual deployment for recovery and one more ejection for payload. The upper section will have both a drogue and a main parachute within it. Recovery will occur in two phases – near apogee a small drogue parachute will be deployed that is designed to slow the rocket for initial descent. Much later, at an altitude of 500 feet, our upper section will deploy a larger parachute to slow the rocket down to a safe landing speed. Each half of the redundant recovery electronics will use a different sensing device. In this way, if there is a bug in the design of either device that would affect the recovery during our flight it will not be replicated in the backup electronics. Each of the two recovery electronics has its own separate battery capable of powering the electronics for a minimum of 1 hour dwell time plus flight time. That battery is disconnected through an interlock key switch accessible on the outside of the vehicle approximately 3.5 ft above the fin end of the rocket so that the electronics is unarmed and not powered until it is safe to do so (when on the launch pad).

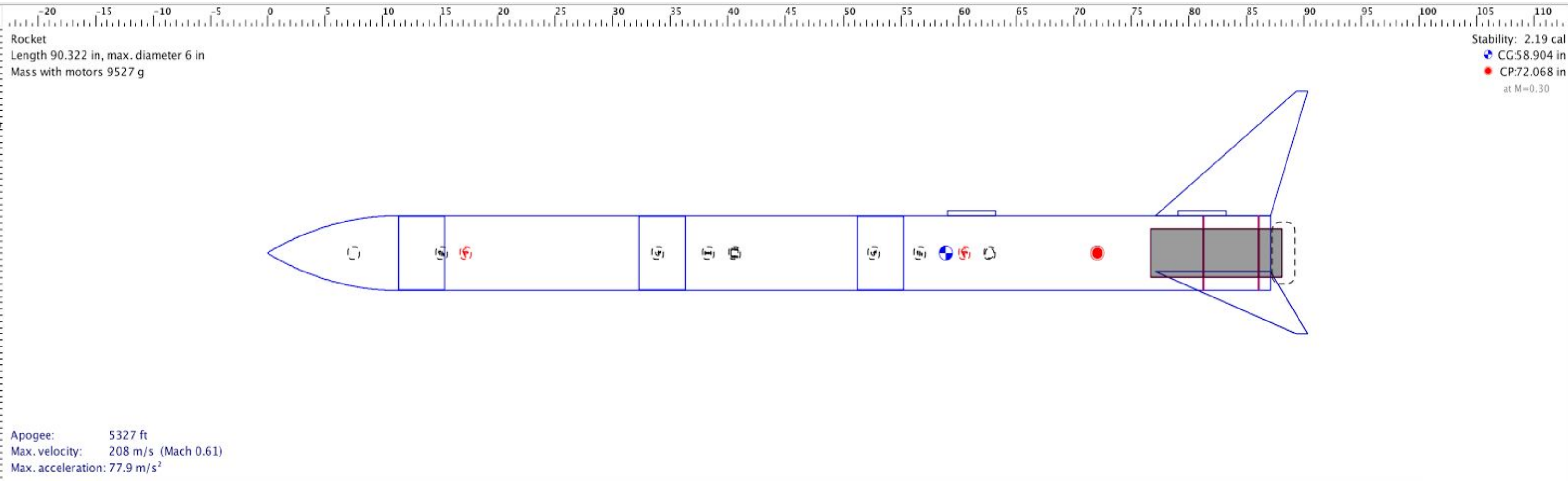
They key can be removed only when the switch is locked ON. The recovery electronics will ignite a measured portion of gunpowder using an electric match. Recovery electronics are totally independent of the payload electronics and power.

Full Scale and Full Subsystems

Our full scale model will be 90.332 inches tall and have a 98mm motor mount. We will use an Aerotech K680 single use to propel the rocket up to approximately 5280 ft. we will deploy a drogue at apogee, and our main parachute at 500 ft.

Mission Performance Predictions

The drawing below is the whole rocket with measurements listed and locations of where different components are located.



Length: 96.322 in

Diameter: 6 in

Mass with motors: 0.65 slugs

Stability: 2.19 cal

CG: 58.904 in

CP: 72.068 in

Apogee: 5,327 ft

Max. Velocity: 208 m/s (Mach 0.61)

Max. Acceleration: 77.9 m/s^2

IV) Safety

Risk Ranking Matrix

Probability	4 -Catastrophic	3 - Critical	2 - Marginal	1 - Negligible
Frequent - 5	High Risk	High Risk	High Risk	Low Risk
Probable - 4	High Risk	High Risk	Moderate Risk	Low Risk
Occasional - 3	High Risk	Moderate Risk	Moderate Risk	Minimal Risk
Remote - 2	Moderate Risk	Moderate Risk	Low Risk	Minimal Risk
Improbable -1	Low Risk	Low Risk	Low Risk	Minimal Risk

Severity Rankings Table

Description	Value	Personnel Safety & Effect on Health	Facility and Equipment	Environmental Hazards	Effect on the Mission
Catastrophic	4	Loss of a life or permanent disabling injury	Loss of facility, systems or associated hardware	Major irreversible sever environmental damage	Complete failure of a mission related system
Critical	3	Severe injury of occupational related illness	Major damage to facilities, systems,or equipment.	Major reversible environmental damage	Partial failure of a non-mission related system
Marginal	2	Minor injury or occupational - related illness	Minor damage to facilities, systems,or equipment	Minor mitigatable environmental damage	Complete failure of a non-mission related system
Negligible	1	First aid injury or occupational related illness	Minimal damage to facility, systems,or equipment	Minimal environmental damage	Partial failure of a non-mission related system

Likelihood Rankings Table

Description	Qualitative Definition	Quantitative Definition
Frequent- 1	High likelihood to occur immediately or expected to be experienced continuously	Probability is> 0.1
Probable- 2	Likely to occur through expected to occur frequently within time	.1≥Probability >0.01
Occasional- 3	Expected to occur several times or occasionally within time	0.01≥Probability>0.001
Remote- 4	Unlikely to occur, but can be reasonably expected to occur at some point within time	0.001 ≥ Probability > 0.000001
Improbable- 5	Very unlikely to occur and an occurrence is not expected to be experienced within time	0.000001≥Probability

Hazards Table

Failure/Hazard	Probability	Severity	Mitigation
Avionics Failure	3	4	Create a preflight checklist with these items: check voltage on batteries, check all connections, arm altimeters,and ensure altimeters start up as expected.Use two different brands of altimeters to decrease the possibility of any brand-specific errors.
Air Brake Failure	3	2	Do many preliminary tests of the air brakes. Check functionality of air brakes before each launch.
Ejection Charge/ Ignition Failure	1	3-4	Verify continuity of each igniter upon connection to altimeter. Dual charges lower severity if igniter fails.
Attachment Point Failure	1	2	We will be using strong hardware (U bolts). We will also be checking

			our attachment points before flight.
Parachute Entanglement	1	3	Our parachutes will be carefully and completely be packed and each pack will be checked by multiple team members along with our mentor and safety officer.
Recovery System Protection Failure	3	2	Kevlar deployment bag will be used to shield the main parachute from the ejection charge. Al other parachutes will be protected by fireproof wadding or a parachute and/or parachute protector
Airframe Failure	1	4	Couplers, bulkheads and other structural supports will be checked to see if they are in place. We will also inspect the air frame prior to launch.
Fin Attachment Failure	1	4	We will use the appropriate epoxy while attaching fins and double check

			before launch.
Center Ring and/or Motor Mount Failure	1	4	We will use the appropriate epoxy while attaching motor mounts and centering ring and we will also double check before launch.
Motor Retention Failure	1	3	We will make sure to use the correct motor retention and inspect it before flight
Frame Superstructure Failure.	1	4	We will ensure that all the joints of the rocket are secure on the site launch pad construction
Rail actuator binds to rail.	1	4	We will use linear bearings which will prevent actuator binding
Launch rail flexion	1	4	1”x3” launch rail will provide enough rigidity to support itself and the rocket along its length.
Motor Failure	1	3	We will ensure motors don’t operate above their torque limit
Shock Failure	1	3	Verify all shock seals and valves are fully

			functional before use

Personnel Health Hazards Table

Hazard	**Probability**	**Severity**	**Mitigation**
Cuts/scratches from sharp tools such as knives, blades etc.	3	1-4	All team members involved in rocket construction will be required to complete training for all tool and general safety.
Burns or cuts caused by drills, sanders, and other power tools	3	1-4	All team members working with tools will wear protection such as goggles, gloves, ear muffs, etc. Only members that have been properly trained will be allowed to operate machinery and other power tools.
Skin Irritation caused by skin exposure to chemicals like epoxies, etc.	3	1-4	All team members be trained in knowing the dangers of epoxies and other chemicals, and in how to use them. Everyone will also wear the

			proper skin protection.
Lung Irritation caused by exposure to chemicals like epoxies, etc.	1	1-4	All team members will be required to wear masks for proper breathing protection and know the dangers of epoxies and other chemicals. The place of work will also be properly ventilated.
Eye Irritation caused by exposure to chemicals like epoxies, etc.	1	1-4	All team members will be required to wear goggles for proper eye protection and will also know the dangers of epoxies and other chemicals.
Electrical Shock	1-2	1-4	All team members will be required to use the proper equipment when handling electrical devices. They will also be trained to make sure they do so,

Environmental Effect Hazards Table

Hazard	**Probability**	**Severity**	**Mitigation**
Debris that's left on the site of the launch field during launch prep.	3	1	Finish all launch preparation before arriving at launch site, and do any preparation that needs to happen on the launch site on a table and throw all waste in a recycle bin.
Destruction of crops due to excessive foot traffic on the launch field which is corn field	3	3	Only required team members will arm the rocket on the launch field - all other members will stay behind
Excess metal goes and other construction material going to waste.	1	1	Recycle metal and/or other construction materials or set aside to reuse for future projects.
Batteries going to waste.	1	3	

Project Management Risks Table

Risks/Delays	Probability	Severity	Mitigation
Enough time to work on and complete all	3-4	4	All team members will meet twice a week on the

aspects of the project and meeting all deadlines, since there will be no more in class time for our project until February.			weekends for two hours each time and will attend all day launches/construction if necessary
Not having enough money to spend on rocketry equipment, tools, engines, travel, etc.	1	3	Baking and selling baked goods in places around town. Also emailing all local companies for donation requests.
Weather will be a large barrier since we only have one available launch site on the third sunday of every month and weather could affect our ability to launch.	3	3	We will actively look at forecast and be prepared for the worst so we can plan accordingly and adjust the launch schedule, We will also be looking out for other potential launch sites, preferably in areas that have different, more suitable weather conditions.
Functionality and Scope of the project may become too complex and inhibit us from completing the project (payload) as currently	2-3	1-2	The biggest scope concern is the payload of our project, though it's simple it has rarely been done before. In the case that payload becomes too

envisioned.			difficult to construct and operate at a maximum level of quality we will revert to a backup payload idea. This payload will be simpler in design and functionality, lighter in weight and able to run more autonomously.

Launch Operations Risk Assessment Table

Black Powder Accidentally Ignited during canister loading	Medium	High	Onboard switches turn off altimeters during loading- include in checklist	Two rotary switches mounted and item included in checklist to ensure they are switched off
Launch preparations exceed allotted time	High	Medium	Run multiple dry run preparations of rocket assembly excluding ejection canister loading and make	Full Scale Launch

			notes of operations that need to be slimmed down	
Missing parts to the rocket (i.e. insufficient amount of rivets/shear pins, etc.)	Low	Low	Do an inventory check before leaving for Huntsville and the day before launch.	Included in Travel and Launch pre checklist
Batteries are not fully charged for the launch day	Low	High	Charge batteries before launch day - include in Pre-Launch checklist	Included in Pre-Launch checklist
Improper launch procedures (Checklist not followed)	Low	High	Stress importance of checklist. Checklists divided up amongst relevant sub team leads with overseers that verify and check off items from the checklist	Roles delegated out to the sub team leads
Pre-ignition	Low	High	The ignitor to our rocket will be held away from the motor until the	Await full scale launch

			rocket is positioned in its “take off” stance. The motor used to insert the ignitor has a shield that will act as a Faraday cage	
Structural Malfunction	Low	Low-High	The welds to the AGSE will all be inspected thoroughly by our team to ensure that they hold up to the task. The rig will also be tested before hand to make sure it is structurally sound.	Inspect upon AGSE completion
Rocket Gets Stuck on the Launch Rail	Low	High	We will make sure that the launchlugs are properly aligned. This will minimize friction between the launch rail and	Await full scale launch

			the launch lugs on the rocket.	

Launch Operations Environmental Concerns Table

Hazard	**Probability**	**Severity**	**Mitigation**
Debris that’s left on the site of the launch field during launch prep.	3	1	Finish all launch preparation before arriving at launch site, and do any preparation that needs to happen on the launch site on a table and throw all waste in a recycle bin.
Destruction of crops due to excessive foot traffic on the launch field which is corn field	3	3	Only required team members will arm the rocket on the launch field - all other members will stay behind
Excess metal goes and other construction material going to waste.	1	1	Recycle metal and/or other construction materials or set aside to reuse for future projects.
Batteries going to waste.	1	3	

V) Payload Criteria

5.1 Selection, Design, and Rationale of Payload

The objective of the payload is to hit our target flight duration with the highest precision possible. We will specify the rocket to be in the air for a certain time with a small tolerance, and program our payload to make certain adjustments depending on given inputs of altitude and duration. The arduino board of our payload will be programmed to receive input from the altimeter and use this information to operate the motor effectively. A successful experiment is one that is within x seconds of our target duration set before our launch. Currently, our target duration is x seconds. If our rocket touches the ground during this window of time and stays undamaged once all parts of the rocket have landed, the experiment is successful. The key components of this design include an arduino board, altimeter, winch, and shock cord. Each of these items have been selected because of their ease of use and practicality. There are not many alternatives for the systems used in the payload due to the specificity of the task at hand.

5.2 Payload Subsystems Overview

Design Component	Alternative to Design Component	Pros of Alternative Design Component	Cons of Alternative Design Component
Arduino	Raspberry Pi	+Powerful +Multiple programs at once +Multipurpose	-Poor portability -Requires constant power source -Too powerful for our needs
RC4WD Z-S1079 1/10 Warn 9.5cti Winch	DC Motor	+Fast +Customizable +Easier to configure with Arduino	-Inconvenient to design/create -No guarantee of success
Battery	N/A	N/A	N/A
Altimeter			

5.3 Justification for Subsystems

Each item used in this system was chosen by analyzing its effectiveness in the experiment. Before choosing an item, we discussed any possible better options and considered any drawbacks or side effects these parts might bring, along with its overall efficiency and compatibility with the design we desired.

5.3.1 Arduino

The brain of the payload will be an Arduino 101 board. The Arduino was selected for its power, speed, and ease of use. The Arduino on board will receive data from the altimeter and determine whether or not the rocket is too high/low based on flight time and control the winch accordingly.

Arduino alternative: Raspberry Pi. Although the Raspberry Pi is the more powerful computer, the Arduino is a more compact version and better suits our needs. The Arduino is also simpler and easier to work with. Arduino also has better documentation and is more user friendly. In order to use an Arduino, we will need adequate knowledge and skills in C/C++. Portability is also an issue with the Pi, as the Pi requires a steady power supply. With the Arduino, as soon as you provide power, it begins to execute code. The Pi requires setting up and is not nearly as automated as the Arduino. Even if the power drops on the Arduino, you won’t end up with corruption or other errors. It will simply just start running code when it’s plugged back in.

5.3.2 Winch

The winch we have selected is the RC4WD Z-S1079 1/10 Warn 9.5cti Winch. This winch was selected for its compact design and ability to deadlift around 6 lbs. of mass. The winch is also programmable and compatible with Arduino boards, which will enable it to communicate with the Arduino 101 on board our rocket.

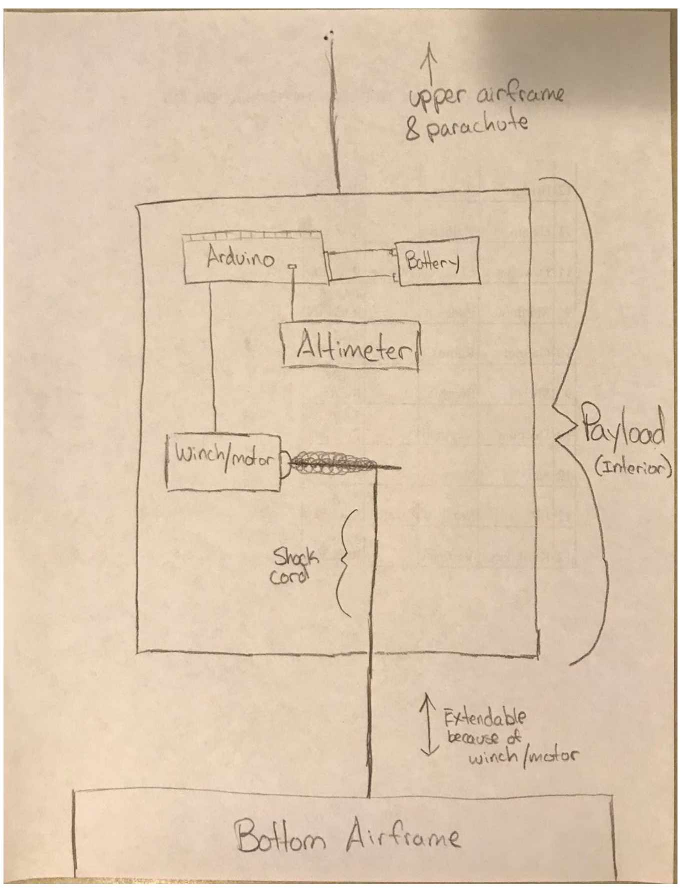
Winch alternative: DC Motor. We will be using the RC4WD Z-S1079 1/10 Warn 9.5cti Winch which will allow us to control the descent of our rocket to a manageable degree. If the winch is not compatible with an arduino control, we will have to use a standard DC Motor based system which we will design and create. A DC Motor system may also be lighter, more customizable, and easier to program.

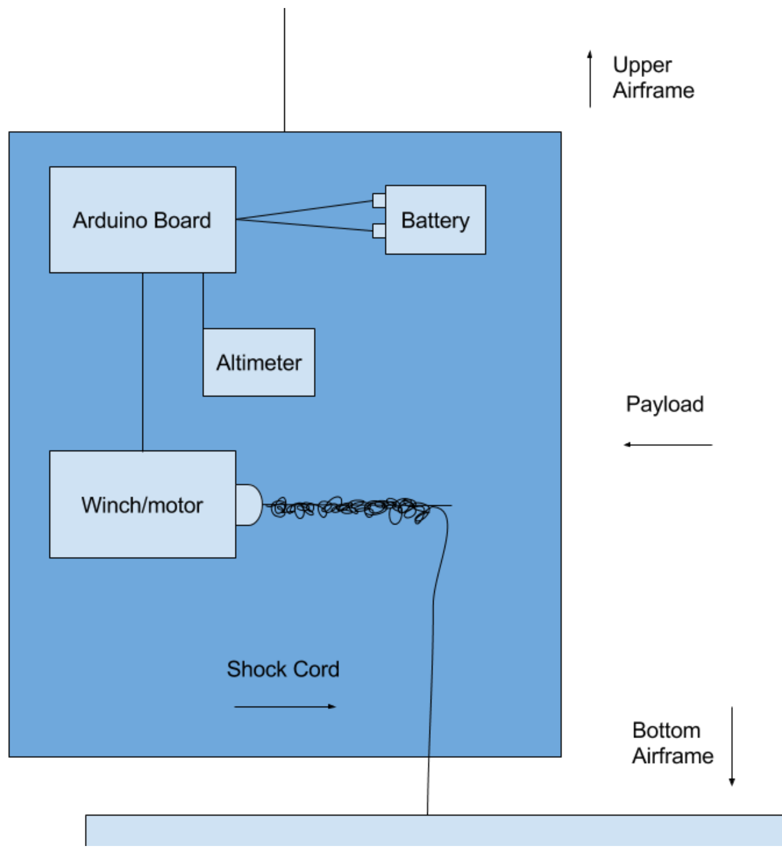
5.3.3 Shock Cord

We have elected to use the same shock cord material that we will be using in our rocket to eliminate confusion and promote simplicity. Because it has been designed for the use in rockets, the shock cord is a good choice in its strength, ability to withstand abuse, and flexibility.

Shock cord alternative: Fishing line. Although fishing line is lightweight and a lot of it can be coiled around a winch, we are worried about the durability/strength of it. If fishing line or an alternative that is similar to it that is strong enough can be found, we may change to that.

5.4 Payload Illustrations





5.5 Interface Between Payload and Vehicle

Interface between bottom airframe and payload:

- Option 1: An altimeter will be placed in the bottom airframe. it will wirelessly send altitude information to the arduino on the payload so it can make precise adjustments as it descends.
- Option 2: An altimeter will be placed in the payload. Certain calculations will be made to determine how many inches per rotation of cord will be let out. This will allow wired connections between the altimeter and arduino with the loss of certainty and precision.

VI) Project Plan

Requirements Verification

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). Our mentors will use inspection to verify the authenticity of our team's work and to make sure that the specified requirements are done by the team.
   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. We will demonstrate the requirements in the project plan section of our review documents (PDR, CDR, FRR, etc.)
   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 team has identified all foreign national team members in the FN form in the PDR.

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.
  The entire team is required to remain working on this project throughout its duration.

  1.4.2. One mentor (see requirement 1.14).
  Rick Rudloff is the team mentor.

  1.4.3. No more than two adult educators. The team will include a final list of all team members (who meet the above requirements) by the Critical Design Review.

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 Educational Engagement Activity Report, by FRR. An educational engagement activity report will be completed and submitted within two weeks after completion of an event. A sample of the educational engagement activity report can be found on page 30 of the handbook. To satisfy this requirement, all events must occur between project acceptance and the FRR due date. We will ensure that our educational outreach activities will be recorded, documented, and updated appropriately in the activity report.

1.6. The team will develop and host a Web site for project documentation. Our team's website is already up and running with minimum functionality. However, we will continue to update the layout and features of the site to make it as visually appeasing as possible.

1.7. Teams will post, and make available for download, the required deliverables to the team Web site by the due dates specified in the project timeline. The website documentation will be updated by each deliverable deadline.

1.8. All deliverables must be in PDF format. Our team members will make sure that each document is in PDF form upon submission.

1.9. In every report, teams will provide a table of contents including major sections and their respective sub-sections. We will strive our best to make each deliverable as organized as possible and easy to navigate by including sections and headers.

1.10. In every report, the team will include the page number at the bottom of the page. Every report will use page numbers on the bottom right of each page to ensure easy navigation.

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 ensure that we are prepared for each teleconference by testing our equipment beforehand.

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, and 8 and 12 ft. 1515 rails available for use. Our launch site at Indianola, Iowa will provide the necessary launch rail systems in order to launch both subscale and full scale models of our rockets. Other than those launches, our final launch at Huntsville will be using Student Launch's launch service provider.

1.13. Teams must implement the Architectural and Transportation Barriers Compliance Board Electronic and Information Technology (EIT) Accessibility Standards (36 CFR Part 1194).

1.13.1. Subpart B-Technical Standards (http://www.section508.gov):

1.13.1.1. 1194.21 Software applications and operating systems.

1.13.1.2. 1194.22 Web-based intranet and Internet information and applications. Our team will ensure that we are in full compliance with NASA's and the government's rules and regulations at all times during the project.

1.14. 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 2 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. 5 We have two highly qualified team mentors who not only meet but exceed these minimum requirements. Refer to Team Summary on page 3 under mentors.

2. Vehicle Requirements

2.1. The vehicle will deliver the payload to an apogee altitude of 5,280 feet above ground level (AGL).
We will be using an online, rocket design simulation called Rocksim 9, for the overall design of our rocket. The data provides an approximate number of the apogee, based on the changes we make to our rocket. The purpose of the full-scale test will determine what mass adjustments are needed, to verify that our apogee will not overly exceed 5,280 feet. Having an estimated apogee beforehand, will improve the quality our launch, and make it easier to meet our requirements.

2.2. The vehicle will carry one commercially available, barometric altimeter for recording the official altitude used in determining the altitude award winner. Teams will receive the maximum number of altitude points (5,280) if the official scoring altimeter reads a value of exactly 5280 feet AGL. The team will lose one point for every foot above or below the required altitude.
Our team decided to use the Perfectflite StratoLogger as the altimeter of our rocket, which serves the purpose of deploying the drogue and main parachutes. Another option we had was to use the trackimo device. This will work as a gps to ensure accurate results of our flight.

2.3. 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.
The arming switch will be accessible from the exterior of the rocket. This is because the centering ring is in our design it is

placed where. It will be placed on the part that is showing between the upper and lower body.

2.4. Each altimeter will have a dedicated power supply.
The altimeter will be located in the altimeter bay where it will be powered by a 9 volt battery.

2.5. Each arming switch will be capable of being locked in the ON position for launch (i.e. cannot be disarmed due to flight forces).
The arming switch will be securely locked by a spring which will keep the altimeter in place.

2.6. 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.
We will make sure of this by designing our rocket in a way that is both strong and sturdy with reusable parts that do not need to be replaced every launch.

2.7. 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. In our design we only have four sections. So we do not exceed four.

2.8. The launch vehicle will be limited to a single stage.
Our rocket will stay tethered to itself the entire time.

2.9. The launch vehicle will be capable of being prepared for flight at the launch site within 3 hours of the time the Federal Aviation Administration flight waiver opens.
Our design was created in a way so that everything including set up is efficient. We did this by planning how everything was going to be assembled and in what order.

2.10. The launch vehicle will be capable of remaining in launch-ready configuration at the pad for a minimum of 1 hour without losing the functionality of any critical on-board components.
Our rocket is designed to last a long time without having to be touched or messed with.

2.11. 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 Range Services Provider.
Our design will allow us to launch on a standard 12-volt direct current firing system. We will have also tested it on this beforehand.

2.12. The launch vehicle will require no external circuitry or special ground support equipment to initiate launch (other than what is provided by Range Services).
All of our circuitry is on the inside of the rocket. We have designed our rocket to not need extra ground support systems then what will be provided.

2.13. 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).
We will be using a K680 rocket motor to propel our vehicle.

2.13.1. Final motor choices must be made by the Critical Design Review (CDR).
We have already chosen our final motor.

2.13.2. 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.
If for some reason we do change our motor, we will make sure to get it approved.

2.13.3. Pressure vessels on the vehicle will be approved by the RSO and will meet the following criteria:
We will not be using pressure vessels.

2.13.4. 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.

2.13.5. 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.

2.13.6. 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.

2.14. The total impulse provided by a Middle and/or High School launch vehicle will not exceed 2,560 Newton-seconds (K-class).
Our motor is in K-class.

2.15. 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.

Our stability is above 2.0 and this number is provided to us by our online simulation.

2.16. The launch vehicle will accelerate to a minimum velocity of 52 fps at rail exit.

2.17. 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.

A subscale launch was completed on November 19th.

2.17.1. 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.

We will design a subscale model that will not act as our full scale model. The subscale rocket will only meet the requirements that were assigned to the subscale model, and will not exceed those boundaries. We will launch our sub-scale model during our first flight and not use the full-scale model as a replacement.

2.17.2. The subscale model will carry an altimeter capable of reporting the model's apogee altitude.

We will use the Perfectflite Stratologger as our altimeter, and it will be placed in the bottom airframe. The altimeter will wirelessly send altitude information to the arduino on the payload so it can make precise adjustments as it descends. We will incorporate these ideas to the design of our subscale model

2.18. 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:

We will put our best effort into ensuring that our rocket is well prepared for the final launch. We will revise and test the consistency of our rocket multiple times. We will use the test launches to our advantage to make any needed changes as well as improving the quality of our flight.

The vehicle and recovery system will have functioned as designed.

The simulation we use will provide accurate results based on the design of the rocket. We will also follow precautions and safety concerns related to vehicle and recovery system. We will also have test launched many times to make logical prediction of our results and have the knowledge to fix any dysfunctions.

The payload does not have to be flown during the full-scale test flight. The following requirements still apply:

We intend that our payload will be used during the full-scale test flight so we can test all aspects of our rocket before the final launch. This way we can see how our rocket is functioning as whole. Our payload also acts as a device that controls landing which will be useful in recovering the rocket during each launch.

2.18.1.1. If the payload is not flown, mass simulators will be used to simulate the payload mass.

If for any reason we are not able to use our payload we will calculate an approximate mass as ballast in our rocket.

2.18.1.1.1. The mass simulators will be located in the same approximate location on the rocket as the missing payload mass.

The mass replacement will be in the same location as the payload. We will make these adjustments not only in the physical model of our rocket, but also incorporate this to our design on the simulation to get better results.

2.18.2. 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.

Our payload doesn’t change the external surfaces of the rocket.

2.18.3. The full-scale motor does not have to be flown during the full-scale test flight. However, it is recommended that the full-scale motor be used to demonstrate full flight readiness and altitude verification. If the full-scale motor is not flown during the full-scale flight, it is desired that the motor simulates, as closely as possible, the predicted maximum velocity and maximum acceleration of the launch day flight.
We plan to use the full scale motor on the full scale test flights.

2.18.4. 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.
We will make sure our full scale test flight is fully ballasted, and to not use additional ballast without a re-flight of the full-scale.

2.18.5. 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).
We plan to not have further modification after our full scale test flight. If for some reason we are encountered by a significant problem, then all changes after full scale tests will be informed to NASA RSO.

2.18.6. Full scale flights must be completed by the start of FRRs (March 6th, 2018). If the Student Launch office determines that a re-flight is necessary, then an extension to March 28th, 2018 will be granted. This extension is only valid for re-flights; not first-time flights.
Our full scale model will be ready to launch by March 6, 2018.

2.19. Any structural protuberance on the rocket will be located aft of the burnout center of gravity.

2.20. Vehicle Prohibitions

2.20.1. The launch vehicle will not utilize forward canards.
Our vehicle does not include canards.

2.20.2. The launch vehicle will not utilize forward firing motors.
Our vehicle does not include forward firing motors.

2.20.3. The launch vehicle will not utilize motors that expel titanium sponges (Sparky, Skidmark, MetalStorm, etc.)
We will be using an Aerotech K680. We will not be using motors that expel titanium sponges.

2.20.4. The launch vehicle will not utilize hybrid motors. We will be using an Aerotech K680 motor. Therefore, we are not using a hybrid motor.

2.20.5. The launch vehicle will not utilize a cluster of motors. We will only be using only one motor.

2.20.6. The launch vehicle will not utilize friction fitting for motors.
We will be using a motor retainer to keep the motor from falling out

2.20.7. The launch vehicle will not exceed Mach 1 at any point during flight.
The vehicle's maximum velocity is Mach 0.6.

2.20.8. Vehicle ballast will not exceed 10% of the total weight of the rocket. Our design verifies that the vehicle ballast will be less than 10% of the total weight of the rocket.

3. Recovery System

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.
Our rocket will include a stratologger perfectflite altimeter to deploy the drogue and main parachutes. We have designed and created our altimeter bay, which has been tested in our subscale rocket. The system successfully deployed the parachutes at the correct altitudes, as programmed.

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.
The subscale model was launched at Indianola Launching Grounds on the 19th of November. It reached an altitude of 2301 feet. Before this, the drogue and main parachutes were tested and

successfully ejected. The same will be done before the official launch.

3.3. At landing, each independent sections of the launch vehicle will have a maximum kinetic energy of 75 ft-lbf.

The parachute designed is large enough where the speed of the rocket will never allow the kinetic energy to go above 75 ft-lbf.

3.4. The recovery system electrical circuits will be completely independent of any payload electrical circuits.

The recovery system electronics bay has been designed and created. There is no overlap whatsoever with the payload electronics bay.

3.5. All recovery electronics will be powered by commercially available batteries.

The electronics bay is powered by a Duracell 9-volt battery.

3.6. The recovery system will contain redundant, commercially available altimeters. The term “altimeters” includes both simple altimeters and more sophisticated flight computers.

We are using a StratologgerCF Perfectflite Altimeter.

3.7. Motor ejection is not a permissible form of primary or secondary deployment.

The design includes manually placed black powder for parachute ejection. The motor ejection charges will not be used in the deployment of the parachutes.

3.8. Removable shear pins will be used for both the main parachute compartment and the drogue parachute compartment.

Shear pins will be placed on both the top and bottom parts of the airframe to keep the rocket intact until the ejection charges are fired.

3.9. Recovery area will be limited to a 2500 ft. radius from the launch pads.

To ensure that the rocket does not travel too far during its descent, the drogue parachute will be deployed at apogee but the main parachute will be deployed at a much lower altitude (500 ft). Also, we will only launch in ideal wind conditions.

3.10. 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.

A Trackimo GPS device will be placed inside the rocket. This device will transmit its location a to mobile phone on the ground.

3.10.1. Any rocket section, or payload component, which lands untethered to the launch vehicle, will also carry an active electronic tracking device.
No parts of the design will have planned separation from the rocket.

3.10.2. The electronic tracking device will be fully functional during the official flight on launch day.
The GPS tracking device will be tested many times, including before the official launch. The device will be also be fully charged before the launch.

3.11. The recovery system electronics will not be adversely affected by any other on-board electronic devices during flight (from launch until landing).
All recovery system electronics will act independently from other on board electronics, such as the payload electronic bay. They will act self-sustainably so that if an error would occur, it would affect only that system.

3.11.1. 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 altimeter bay will be located in a separate compartment from other electronics on board. Each electronics bay will be enclosed in its own container and placed in different part of the rocket.

3.11.2. The recovery system electronics will be shielded from all onboard transmitting devices, to avoid inadvertent excitation of the recovery system electronics.
Recovery system electronics will be properly shielded from all electronic transmitting devices by using proper shielding material and separating the devices far apart.

3.11.3. 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.
The electronics will be placed inside its own container bay to allow physical separation from other electronics. In addition, other on board electronics will be properly shielded and placed distant from the recovery system.

3.11.4. The recovery system electronics will be shielded from any other onboard devices which may adversely affect the proper operation of the recovery system electronics. The recovery system electronics will be enclosed in a separate electronic bay which will not interfere with other devices or electronics with proper shielding and distance from devices.

3.11.5. While the devices are in transport (not ready to launch), items will be disconnected from power sources and placed in faraday bags.

4. Experiment (payload)

4.1. The launch vehicle will carry a science or engineering payload. The payload may be of the team's discretion, but 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 launch vehicle will carry a science or engineering payload. Students will inspect the final design to insure that the payload is incorporated into the rocket. Our proposal has already been approved by NASA, but we acknowledge NASA reserves the authority to require us to modify or change a payload, even after a proposal has been awarded. Our plan to verify this requirement is to work closely with the payload team to insure that a payload is created and implemented within the rocket.

4.2. Data from the science or engineering payload will be collected, analyzed, and reported by the team following the scientific method. Students on the team will collect and analyze data collected from the engineering payload through the elements of testing and analysis. We will then report the data collected following the scientific method through demonstration. Our plan to verify this requirement is to launch several test flights and gather data from each one.

4.3. Unmanned aerial vehicle (UAV) payloads of any type will be tethered to the vehicle with a remotely controlled release mechanism until the RSO has given the authority to release the UAV. Inspection will be required to verify this requirement. Our current design does not incorporate UAVs of any kind, so our plan is to stick with our current design.

4.4. Any payload element that is jettisoned during the recovery phase, or after the launch vehicle lands, will receive real-time RSO permission prior to initiating the jettison event. Inspection will be required to verify this requirement. Our current design does not incorporate a jettisoned payload, so our plan is to stick with our current design.

4.5. The payload 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. Tests and demonstrations are required to verify this requirement. Our plan is to create a payload that is able to withstand multiple launches without requiring maintenance.

Team Derived Requirements

General

- Our goal for the educational outreach part of this project is to outreach to at least 250 people.

Payload

- Our engineering payload will allow us to meet the team derived requirement of being able to land our rocket within the time window of 60-65 seconds. To meet this requirement, the team will need to employ the element of testing to insure that the rocket will be able to accomplish the restriction. This restriction is meaningful because it imitates the real life conditions of aeronautics where time is of essence, and is not always unlimited.

Budgeting

Overall Project Cost

	Cost
Rocket(s)	$2,936.38
Educational Outreach Budget	$500.00
Travel to Des Moines, IA	$277.50
Travel Expenses to Huntsville, AL	$3,225.00
Total Operating Budget	**$6938.88**

Overall Rocket Cost

	Price per Unit	# Needed	Total Price
Arduino Microcontroller + IMU	$30.00	2	$60.00
Construction Cost per Rocket pair (sub/main)	$1,909.00	1	$1,909.00
Reloadable Rocket Motors	$200.00	2	$400.00
Reloadable Rocket Motors-subscale	$32.00	4	$128.00
H Rocket Motor Casings	$40.00	2	$80.00
K Rocket Motor Casings	$260.00	1	$260.00
Altimeters	$49.69	2	$99.38
Total Rocket Cost			**$2936.38**

Rocket Parts Cost

Parts	Cost
Body Tube1 - Fiberglass	$225.00
Body Tube2 - Fiberglass	$225.00
Kevlar Shock Cord	$30.00
Nose Cone	$85.00
Fins	$100.00
Motor Retainers	$100.00
Glue	$20.00
Parachutes	$140.00
Paint	$20.00
Payload	$400.00
GPS tracking system	$214.00
Dual Deployment	$150.00
Subscale Rocket	$200.00
Total	**$1909.00**

Travel to Des Moines, IA

Gas Price	$2.50	222 miles	10 miles/gallon	5 times	**Total: $277.50**

Travel to Huntsville, AL

Description	**Number**	**Days/Nights**	**Cost/unit**	**Total**
Hotel Rooms	3	5 days	$80.00	$1,200.00
Gas Price	10 miles/gallon	1500 miles	$2.50	$375.00
Meals	3 meals/day	5 days	$10 / person = $110	$1,650.00
				$3,225.00

Funding Plan

As of November 3rd, Team No Way But Up has raised $4,500 by fundraising as a team in our local community by selling home baked goods. This is around 65% of our total estimated cost for this project. We have also sent a proposal for a grant of $3,400 to Omron Foundation and are waiting to hear back from them. Our team plans to not only meet our budget funds, but exceed them, so that we have room for extra emergency expenses.

Timeline