University of South Florida

NASA Student Launch

Proposal

September 30, 2016

Society of Aeronautics and Rocketry

14247 Les Palms Circle, Apt. 102

Tampa, Florida 33613

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1. General Information

1.1 Educator Information

Dr. Manoug Manougian

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1.2 Safety Officer

Brooke Salas

Junior Undergraduate

Mechanical Engineering Major

1.3 Student Team Leader

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1.4 Web Presence

facebook.com/usfsoar

usfsoar.com

1.5 Project Organization

Figure 1 depicts the hierarchy of each leadership position and overall team structure.

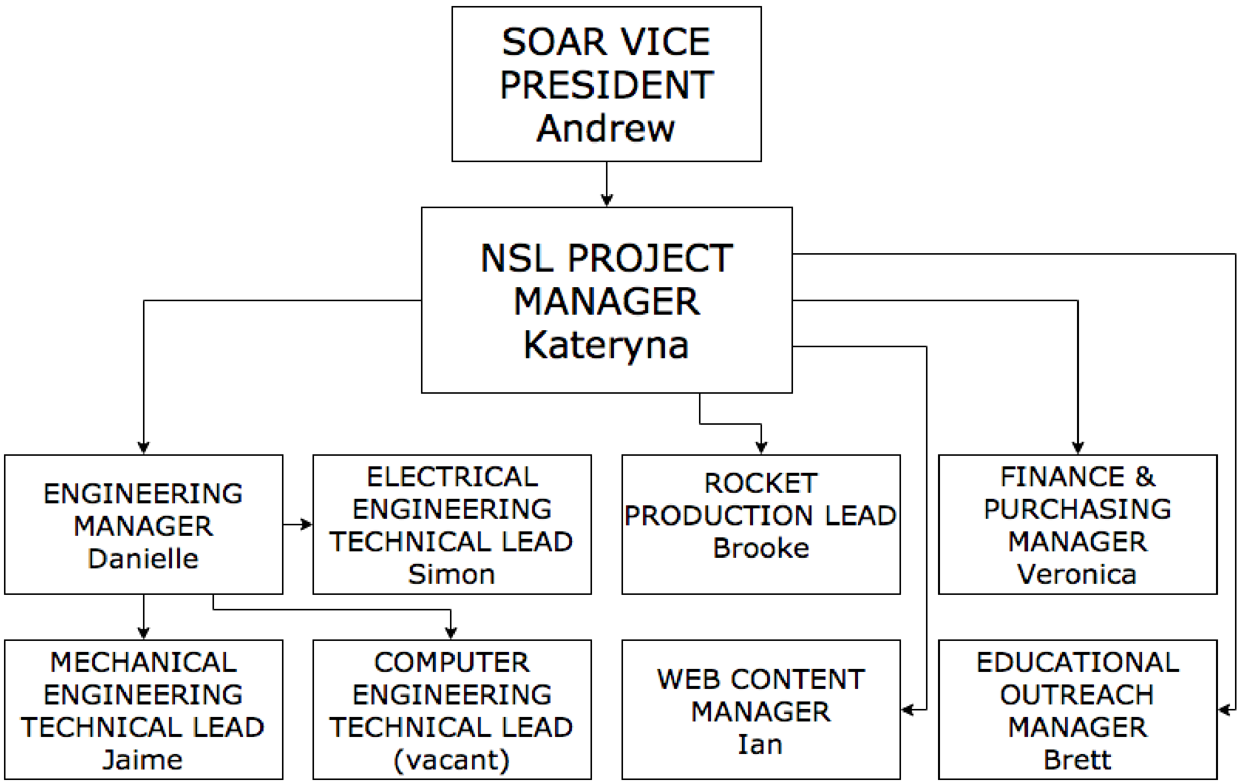


Figure 1. Project Organization Chart

1.6 NAR/TRA Sections

The Society of Aeronautics and Rocketry at the University of South Florida Team will utilize the nearby rocketry sections as a source of mentoring, launch assistance, and reviewing. The local Tampa Tripoli Rocketry Association (prefecture #17) will be the high powered launch sites. In addition, the TTRA location has an altitude waiver of 12,000 feet.

2. Facilities & Equipment

2.1 Facilities/Equipment

USF Design for X Labs

An engineering lab space dedicated to providing space and tools for engineering organizations and students. This location contains work tables, laser cutters, 3D printers, and small hand tools. Construction and planning will happen at this location.

Equipment:

- Small Hand Tools
- 3D Printers
- Laser Cutters
- Lathe

Hours: 7:00am - 5:00pm Monday - Friday

CUTR 102

A classroom reserved for weekly general body meetings and individual sections of the rocket team.

Equipment:

- White Board
- LCD Projector

Hours: 5:00pm - 7:00pm

Offsite Workshop

Equipment:

- Lathe/Mill
- Power Tools

Varn Ranch (Plant City)

Varn Ranch is the official Tampa Tripoli Rocket Association launch site, and also where SOAR has launched most of its rockets. This will be the primary site for our test launches. The site has a 10,000ft ceiling, allowing enough overhead for test launches of the goal altitude. Though we have much of the equipment we need to launch, there is also equipment available on site to use as well.

Equipment:

- Launch Rails
- Dedicated Launch System

2.2 Personnel

Dr. Manoug Manougian

Dr. Manougian is Director of the University of South Florida's STEM Education Center and a distinguished Professor of Mathematics. Dr. Manougian is the organization's advisor, serving the students as a reference for rocket design, construction, and launching of rocket propulsion systems. He also serves as a role model and scientific inspiration for the entire student body.

Jim West

Jim West is an experienced member of the hobby rocketry community and local Tampa TRA. He oversees launches at Varn Ranch on Tripoli launch days and has acted as a mentor in terms of design and manufacturing of our rockets, particularly high powered designs.

2.3 Computer Programs

2.3.1 Communication

Outside of regular meeting times, team communication is achieved primarily through the Slack messaging app and also by email, our website, and texting among the officers and team members. An updated roster on USF's campus engagement network "Bullsync" will consistently keep the email list up to date and ensure that everyone knows the status of the ongoing project.

2.3.2 Design/Analysis

Our team will utilize the 3D rendering software SolidWorks 2015-2016, which is provided free of charge by the University of South Florida to all students through the application gateway. ANSYS Simulation Software is another resource that will be employed, and it is also available to all students. These softwares will allow the team to draft feasible mechanical models as well as engineering analysis simulations.

The USF application gateway also provides students with access to MATLAB, a resource that will prove invaluable for data processing and mathematical modelling.

Additionally, for precision rocket prediction and simulation we will use a combination of RockSim, a well-known commercial design and simulation program and OpenRocket, a java-based open-source, free-to-use program designed for model rocket analysis. Correlation between these programs will provide a model of best fit.

2.3.3 Document Development

For document development, as well as data storage, our team intends to use our pre-existing organizational cloud storage, the SOAR Google Drive. This database allows us to instantaneously communicate and work collaboratively on documents and presentations.

2.4 Supplies

2.4.1 Rocket Supplies and Materials

- Nose cone Public Missiles - FNC-6.00 - Fiberglass nose cone, Material: Fiberglass
- Body tube - Custom, Material: Fiberglass
- Main Parachute b2 Rocketry - CERT-3 XLarge - SkyAngle, Material: 1.9 oz. Ripstop Nylon (SkyAngle)
- Altimeter Bay - Custom, Material: Fiberglass
- Tube coupler - Custom, Material: Kraft phenolic
- Altimeters and Batteries - Custom, Material: Custom
- Bottom Drogue Parachute b2 Rocketry - CERT-3 Drogue - SkyAngle, Material: 1.9 oz. Ripstop Nylon (SkyAngle)
- Drogue Parachute b2 Rocketry - CERT-3 Drogue - SkyAngle, Material: 1.9 oz. Ripstop Nylon (SkyAngle)
- Fin set - Custom, Material: G10 (PML 0.062")
- Body tube Public Missiles Ltd. - KS-3.0-GIANT - Giant KwikSwitch MMT 75mm, Material: Kraft phenolic

- Bulkhead - Custom, Material: 1/8 Aircraft Plywood
- Removable Bulkhead - Custom, Material: 1/8 Aircraft Plywood
- Quicklink, Material: Steel
- Shock Cord, Material: Kevlar
- Forged Eye-Bolts, Material: Steel

3. Safety

Safety is paramount in the Society of Aeronautics and Rocketry and the University of South Florida in its entirety. While our Safety Officer actively ensures the well-being of members and property, our entire team is expected to maintain constant vigil. We brief all members of the potential hazards in our projects and encourage them to voice any concerns.

3.1 Safety Plans

3.1.1 Safety and Hazard Analysis

Careful observation regarding the team members, rockets, payload components, and work and launch environment has been done and any hazards observed have been addressed. Each potential hazard has received a risk assessment level using the risk assessment matrix found on page 56 of the NASA Student Launch Handbook. Risk levels are determined by the severity of the potential situations and the probability the hazards will occur.

The severity of each potential risk is determined by comparing the possible outcome to criteria based on human injury, vehicle and payload equipment damage, and damage to environment. Severity is based on a 1 to 4 scale, 1 being the most severe. The severity criteria is provided below in Table 1.

Severity		
Description	Value	Criteria
Catastrophic	1	Could result in death, significant irreversible environmental effects, complete mission failure, and/or monetary loss greater than $5000
Critical	2	Could result in severe injuries, significant reversible environmental effects, partial mission failure, and/or monetary loss between $500 and $5000
Marginal	3	Could result in minor injuries, moderate reversible environmental effects, and/or monetary loss between $100 and $500
Negligible	4	Could result in insignificant injuries, minor reversible environmental effects, and/or monetary loss of less than $10

Table 1: Severity criteria.

The probability of each potential risk has been assigned a level between 1 and 5, 1 being the most certain. The scale of probabilities is determined by analyzing the risks and estimating the possibility of the accident to occur. Table 2 depicts the levels of probability for each risk.

Probability		
Description	Value	Criteria
Almost Certain	1	Greater than 90% chance of occurrence
Likely	2	Between 50% and 90% chance of occurrence

Moderate	3	Between 25% and 50% chance of occurrence
Unlikely	4	Between 1% and 25% chance of occurrence
Improbable	5	Less than 1% chance of occurrence

Table 2: Probability scale

Risk assessment levels are then assigned based on the severity and probability levels. By following the given risk assessment matrix, each hazard has been assessed and further observation into each hazard is being considered. For each risk, mitigation has been detailed. Throughout the progression of the project, new risks will arise, and will be considered. Completed risk assessments are found below in Table 3.

Hazard	Severity of Risk	Probability of Risk	Risk Level	Mitigation
Using power tools	3	3	Low	1. All individuals to use tools with be trained on each tool. No individual will attempt to learn how to use the tool on their own and no individual will use the tool who is not trained on that tool. Safety glasses will be worn at all times within the lab and workshop. Lab and workshop will be kept clean and cleaned after each use to ensure no debris is left that may cause injury 2. Any additional PPE will be worn as instructed by the tool

				manufacturer or as required. All individuals will be instructed on proper use of PPE
Working with chemical components	3	4	Low	1. MSDS documents will be readily available at all times for all chemicals. MSDS documents will be reviewed before each use of chemicals. Gloves and safety goggles designed for chemical splash will be worn at all times by all personnel when working with and/or near hazardous chemicals 2. When working with chemicals that will generate fumes all work is to be done in a well-ventilated area. All personnel will minimize inhalation by wearing appropriate PPE which may include vapor masks when there is a risk of serious fume inhalation
Motor ignition failure	1	3	Moderate	1. Follow TRA safety code and wait a minimum of 60 seconds before approaching the rocket to ensure that the motor is not just delayed in launching. 2. If there is no activity after 60 seconds, the safety officer will check the ignition system for a lost connection or a bad igniter. 3. In the event of a faulty ematch, the safety officer or

				project manager will remove the ignition system from the rocket motor, retrieve the motor from the launch pad and replace the motor with a spare.
Motor explodes upon ignition on the launch pad	1	4	Moderate	1. Assure that all team members are a safe distance away from the launch pad upon ignition of the rocket.Wait a specified amount of time before approaching the pad after a catastrophe. All fires will be extinguished when it is safe to approach the pad.
Separation of rocket at apogee and/or 500ft does not occur	1	3	Moderate	1. Separation sections of rocket will be designed to ensure that the black powder charges provide enough force to cause the pins to shear. Ground test will be done to ensure the correct amount of black powder is used 2. Couplings between components will be sanded to prevent components from sticking together. Fittings will be tested prior to launch to ensure that no components are sticking together

				In the event that the rocket does become ballistic, all individuals at the launch field will be notified immediately
Parachute does not deploy	1	3	Moderate	1. The packing of each parachute will be checked by our mentor prior to launch to ensure proper packing. In addition the parachute size has been selected to fin within the body tube but not so tightly as to become stuck due to the size of the parachute. In the event that the rocket does become ballistic, all individuals at the launch field will be notified immediately
Altimeter and/or e-match failure	1	4	Moderate	1. We will have a redundancy by including two altimeters each with their own e-matches and black powder charges, wired in series. In the event that the rocket does become ballistic, all individuals at the launch field will be notified immediately

Table 3: Risk Assessment and Mitigation

3.1.2 Safety Officer Responsibilities and Duties

As mentioned, all members are expected to maintain awareness of the potential dangers. However, we have nominated Brooke Salas to be our official Safety Officer. Brooke has earned this role through constant dedication to our organization as well as consistent procedural vigilance. When the safety officer is not available, we will turn to our Student Team Leader to oversee the maintenance of safety.

The roles and responsibilities of the safety officer include, but are not limited to:

A. Monitor all team activities with an emphasis on safety, including:

- Design of launch vehicle
- Creation of launch vehicle
- Set-up of launch vehicle
- Exhaustive ground testing of launch vehicle
- Subscale launch test(s)
- Full-scale launch test(s)
- Competition activities and launch
- Recovery activities
- Educational engagement activities

B. Coordinate and implement the safety procedures outlined by the organization for the design, creation, set-up, launch, and recovery of the launch vehicle.

C. Finding the relevant Material Safety Data Sheets (MSDS), sharing them with organization, and maintaining the appropriate folder in the organization's Google Drive, Material Safety Data Sheets. The Safety Officer will also ensure proper and safe conditions of materials during storage, transport, and implementation.

D. Analyze and record the team's hazard analysis tests, failure mode analysis, simulations, experimental data, and other relevant information sources for failures and potentially hazardous trends. As well as coordinating the compliance with safety procedures and improvements to reduce risk.

E. Assist in the management and development of the team's hazard analysis, failure mode analysis, safety simulations, safety procedures, and guidelines.

F. Maintaining responsible and appropriate organizational behavior at all stages of design, development, test, travel, and launch.

G. Finally, the safety officer is expected to familiarize herself with all local, state, and federal laws, rules, customs, and regulations which apply to the use and transportation of motors, propellants, and other sources of risk. Based on this familiarity, the safety officer is expected to ensure compliance with the aforementioned regulations.

3.2 NAR/TAR Personnel

The following launch procedure will be followed during each test launch. This procedure is designed to outline the responsibilities of the NAR/TRA Personnel and the members of the team.

1. A level 2 certified member and an NAR/TRA Personnel will oversee any test launch of the vehicle and flight tests of the vehicle.
2. The launch site Range Safety Officer will be responsible for ensuring proper safety measures are taken and for arming the launch system.

3. If the vehicle does not launch when the ignition button is pressed, then the RSO will remove the key and wait 90 seconds before approaching the rocket to investigate the issue. Only the Project Manager and Safety Officer will be allowed to accompany the RSO in investigating the issue.
4. The RSO will ensure that no one is within 100 ft. of the rocket and the team will be behind the RSO during launch. The RSO will use a 10 second countdown before launch.
5. A certified member will be responsible for ensuring that the rocket is directed no more than 20 degrees from vertical and ensuring that the wind speed is no more than 5 mph. This individual will also ensure proper stand and ground conditions for launch including but not limited to launch rail length, and cleared ground space. This member will ensure that the rocket is not launched at targets, into clouds, near other aircraft, nor take paths above civilians. Additionally, this individual will ensure that all FAA regulations are abided by.
6. Another certified member will ensure that flight tests are conducted at a certified NAR/TRA launch site.
7. The safety officer will ensure that the rocket is recovered properly according to Tripoli and NAR guidelines.

3.3 Safety Briefing

3.3.1 Hazard Recognition

The team Safety Officer will orchestrate all potentially hazardous activities, as well as brief the members who may participate in such activities on proper safety procedures, and ensuring that they are familiar with any personal protective equipment which must be worn during those activities. If a member fails to abide by the safety procedures, he/she will not be permitted to participate in the potentially hazardous activities. In addition to briefing the members on safety procedures, the team Safety Officer must remain in the immediate vicinity of the hazardous activity as it is occurring, so as to mitigate any potentially dangerous incidents and answer any safety questions which may arise.

3.3.2 Accident Avoidance

It will be the duty of the team Safety Officer to verify, in advance, that procedures planned for testing or construction of materials by team members satisfy safety requirements. In the event that the Safety Officer judges a planned procedure to be unsafe, said procedure will thus be revised or eliminated.

3.3.3 Launch Procedures

At the team meeting most closely preceding the launch, the Safety Officer will be given time to help the members review launch safety and precautionary measures. Topics discussed at this time include but are not limited to: laws and regulations mandated by the Federal Aviation Administration (FAA), the National Fire Protection Association (NFPA), and Florida State Statutes; prohibited launchpad activities and behaviors; maintaining safe distances; and safety procedures pertaining to any potentially hazardous chemicals which will be present during the launch. All team leaders must be in attendance at this briefing, and they are obliged to address the other members with any further safety concerns they are aware of that were not mentioned by the Safety Officer. At this time, launch procedures will be scrutinized, paying special attention to the parts involving caution.

3.4 Caution Statements

Any potential safety hazards or concerns that may arise throughout the course of this project will be documented where relevant. To minimize risks the design verification process will include a comprehensive investigation to ensure safety in manufacturing, testing, and launching of our rocket. The Safety Officer and Project Manager will present at all design verification meetings.

3.5 Legal Compliance

The Safety Officer and Project Manager have read all relevant laws and regulations that apply to this project in order to ensure compliance with these laws. As well, the team members will also be briefed on these laws as they apply to the project. The material reviewed includes:

- 14 CFR: Aeronautics and Space, Chapter 1, Subchapter F, Part 101, Subpart C: Amateur Rockets
- 27 CFR: Part 55: Commerce in Explosives
- Florida Statute: Title XXV: Aviation, Chapter 331: Aviation and Aerospace Facilities and Commerce
- Florida Statute: Title XXXIII: Regulation of Trade, Commerce, Investments, and Solicitations, Chapter 552: Manufacture, Distribution, and Use of Explosives
- NFPA 1127 "Code for High Power Rocket Motors"

3.6 Purchase/Transportation/Storage of Motor

The motor will be purchased and stored by one of our organization's mentors. This person is certified for the purchase of high powered rocket propellent and well versed in storage. The propellent will be stored in an off-campus garage, where several other rocket components have been stored carefully. There will be a clear indication that there is propellent in the room, by large lettering on the magazine and yellow/black cautionary tape. There will also be a clear indication to keep away, in addition to warning about fire in the area. Our mentor shall maintain primary access to the propellent upon storage and shall prep it for transportation. It will be secured carefully within a vehicle, bound down to avoid unnecessary motion and without the risk of any other object resting or falling on top of it.

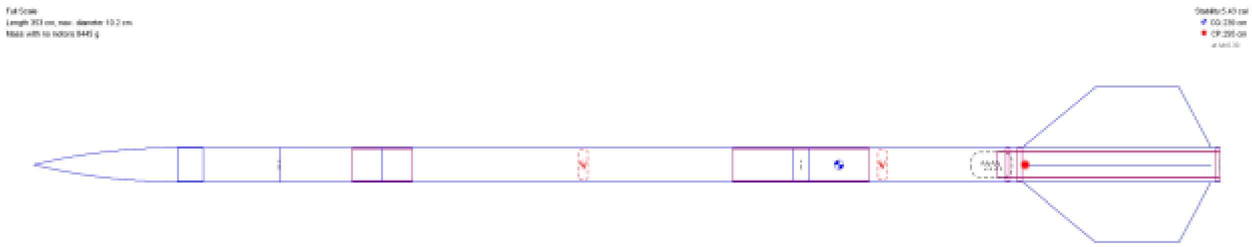
3.7 Written Statement of Compliance

All members of the team agree to abide by all relevant laws and regulations set forth by the FAA, NFPA, and NASA. The team agrees to have the launch site Range Safety Officer perform a safety inspection before each flight and to comply with the determinations from the RSO's safety inspections. All members recognize that the RSO will determine all final decisions regarding rocket safety and that this individual has the right to deny the launch of any rocket for safety reasons. As well all members recognize that noncompliance with the RSO's requests will result in the team being unable to launch the rocket.

4. Technical Design

4.1 Vehicle Specifications

The proposed design is shown below. It is 145 inches in length and 6 inches in diameter. The body tubes are made out of fiberglass with kraft phenolic motor mount. The fins are G10 fiberglass. We chose fiberglass because of it's high tensile and compressive strengths as well as its availability.



To construct the rocket we will begin with the fin can. We will epoxy the fins onto the motor mount with chopped carbon fiber in the epoxy for added strength. Once that is complete we will cut slits in the outer tube and slide the fin can into the aft fiberglass tube. We will add fillets with epoxy on the outer and inside of the outer tube for increased stability of the fins. A bulkhead will be added to the end of the motor mount to hold the motor mount in place. Above this bulkhead is where the landing mechanisms will be placed. Above the mechanisms will be a removable bulkhead with a forged eyebolt on it to attach to the parachutes.

4.2 Projected Altitude

The projected altitude is 5,400 feet on an L class motor. Simulations of launch data was completed using Rocksim. We have found that the weights for the rocket components in Rocksim are lower than what it will actually be. This is because we, as an organization, usually add more epoxy for safety reasons. This will, in theory, lower our projected altitude. The rocket was modeled in Rocksim and several different motors were tested on it up to an L class motor. Once each part of the rocket is built we can update the mass of our rocket to get a more approximate model of ascent and apogee.

4.3 Projected Parachute System

At apogee the altimeter will blow the bottom section of the rocket off with two drogue parachutes. It will push out the parachute for the bottom section and the drogue for the rest of the rocket. The bottom section will be separate from the rest of the rocket and this section will be the one to land on the target. The bottom section's parachute will be attached to a forged eyebolt in the bulkhead. The other section of the rocket will have the parachute and shock cord attached to a forged eyebolt in at the altimeter bay. At 800 feet the main parachute with shock cord will deploy to slow descent and land safely.

4.4 Projected Motor

The motor selected is a L1100 from Animal Motor Works. The motor has a 75 mm diameter and a length of 72.8 cm. The average thrust is roughly 1100 N, and the total impulse is roughly 2600 N-s with a 2.3 second burn time.

4.5 Projected Payload

The teams projected payload will consists of a flap design, designated to detect the projected landing platform on descent and land vertically upright. The flap system will be located on the lower stage of the rocket for vertical landing purposes. Our system will consist of four flaps, four servo motors, a pixy color sensor and an accelerometer. The system will communicate with an arduino to accomplish the experimental goal.

Flap Design Structure

The structure will include four identical flaps equally offsetted from the lower fins and hinged to the structure of the rocket. The flaps will sit flush with the structure of the rocket during ascent to insure that no protuberance will occur before the burnout center of gravity. Each flap opening will include an internally mounted shield to prevent airflow to the internal components when each flap is in operation. There will be a small notch on the top of the shield to direct the airflow to the parachute and allow maneuverability. There will also be a small hole near the bottom edge of the flap to prevent turbulent flow.

Flap Design Operation

A pixy color sensor will be operated on decent to designate the specified target and create a projected landing path. The pixy will communicate with an arduino to operate the servos. A delay will be created in the program to allow the accelerometer to communicate with the arduino and operate the servos once again. The accelerometer will be used to stabilize the rocket vertically on descent. The flaps will be actuated by four independently operated servos. Each servo will use a two link rod to allow a greater extension of each flap. The servos will communicate with an arduino for maneuverability. Once the rocket is at a relatively low altitude, and is directly above the desired target, all four flaps will be fully extended to reduce the velocity as much as possible. This will aid in increasing the ability of the rocket to land properly.

4.6 Requirements

4.6.1 Launch Vehicle Requirements

The launch vehicle will need to meet the following requirements:

- Launch from 5 degree from vertical
- Fly straight with minimal drifting
- Attain an apogee of 5,280 feet

4.6.2 Recovery System Requirements

The recovery system will need to meet the following requirements:

- Deploy all parachutes at the correct altitude
- Deploy fully and have the parachutes open quickly
- Allow for minimal drift
- Slow descent rate to attain a safe landing

4.6.3 Payload Requirements

The payload system will need to meet the following requirements:

- Design an onboard camera system on a section of the rocket
- Employ a logic system to differentiate between the three colored target zones
- Deploy flaps to reduce descent velocity and correct upright orientation
- Produce a controlled landing with reasonable proof

4.7 Major Technical Challenges and Solutions

Vehicle

One of the challenges involves the containment of the three parachute design, ensuring all parachutes come out properly and do not tangle. The solution to this is making sure the correct amount of black powder is used by the altimeter bay and carefully packing the parachutes, ensuring correct deployment.

Another challenge is ensuring the removable bulkhead for the landing mechanism is easy to remove, yet strong enough to maintain its hold. A solution to this is to implement metal inserts in the bulkhead allowing the bulkhead to be mounted and removed.

Payload - Mechanical

The landing detection and upright landing experiment will induce a challenge when it comes to the mechanical system's design, functionality and safety factors. In order to pursue the experimental goal, a stress and strain simulation will be performed using a Fundamental Element Analysis (FEA) program. The recorded data will then be used to determine the correct selection of mechanical components and flap design. In order for this all to be accomplished, the proper programming must be implemented, which will possibly present the greatest challenge with this design. At any given time, the rocket will need to recognize its orientation in flight, and autonomously adjust itself at a precise magnitude to avoid drastic changes in its flight pattern.

Payload - Electrical

This project will give us a unique new challenge for handling signal transmission to our rocket. We will be working to ensure we get consistent communication with our onboard systems, reducing latency and maintaining a design for our altimeter/electronics bay that befits proper signal transmission.

5. Educational Engagement

SOAR will conduct educational engagement activities with as many local schools as possible. Two charter schools have been contacted already to initiate planning of activities. We expect to have several students visit the schools after their dismissal and work with the students who a part of the after-school programs. In this setting, we'd be able to give the students the attention they need to learn the material we teach.

We also have plans to participate in USF's Engineering Expo which is the largest annual engineering event on campus. In February, the event will host thousands of elementary, middle, and high school students with demonstrations by student engineering organizations, USF research labs, and engineering companies. In this setting, we'll engage a large amount of students during the two-day event actively with hands-on activities and passively with information about rocketry.

6. Project Plan

6.1 Schedule

Task	Deadline
Proposal	9/30/2016
Initial Design:	
Rocket	
Engineering Systems	10/15/2016
Establish Budget	10/20/2016
PDR Report	10/31/2016
Prototype of eng systems	11/30/2016
Subscale fabrication	11/30/2016
Prototype testing	12/15/2016
Subscale test launch	12/17/2016
Final Design	
Rocket	
Engineering Systems	12/20/2016
CDR Report	1/13/2017
Fullscale fabrication	2/11/2017
Final fabrication of eng systems	2/15/2017
Fullscale test launch	2/18/2017
FRR Report	2/28/2017

Initial testing	3/3/2017
Final testing	3/30/2017
PLAR	4/24/2017

Table 4. Projected Schedule for Project Duration

6.2 Budget

Budget Item	Projected Cost
Rocket	$3,000
Payload	$2,000
Travel	$4,500

Table 5. Projected Budget for Project Duration

6.3 Funding Plan

To complete this project our organization shall rely primarily on funding allocated to us through the University of South Florida Student Government and fundraising activities completed throughout the year.

6.4 Sustainability

This will be the second time an organization at USF will be participating in this competition. SOAR has been a growing organization at USF since 2013, and as we move forward, we are establishing several traditions that will be carried on by aspiring engineers and scientists after our current leadership has graduated.

Every year our organization gains new members who are willing to take on leadership positions and help SOAR grow to be more effective.

As a student organization, we have developed a strong relationship with student government based on a history of fiscal responsibility and adherence to procedure. Our budget is consistently awarded annually due to our attention to detail and a good relationship with the administration. Student Government appreciates our organization's purpose and supports it. In addition to the university connections, our organization has long lasting relationships with our mentors, who have supported us since the formation of the club.