SEPTEMBER 18, 2019

PROJECT LUNAGATOR

NASA STUDENT LAUNCH - PROPOSAL

SWAMP LAUNCH ROCKET TEAM

UNIVERSITY OF FLORIDA

Department of Mechanical and Aerospace Engineering

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1. General Information

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4th Year Aerospace Engineering

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1st Year Electrical Engineering

1.6 Organization Structure

Pictured below is the organizational structure the Swamp Launch Rocket Team will follow (Fig. 1).

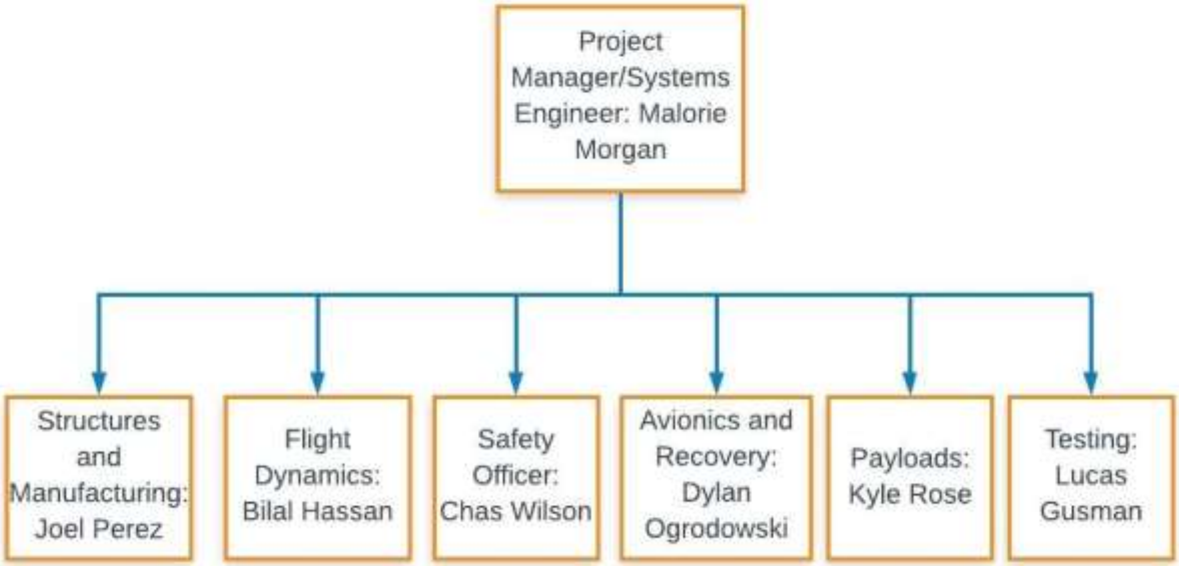

Figure 1 Flow chart of the Swamp Launch Rocket Team's organization.

1.7 NAR/TRA Sections

The team will have access to two launch sites that are only two hour drives away from the university. The Tampa Tripoli Rocketry Association (prefecture #17) and the Northeast Florida Association of Rocketry (NEFAR) (#563) will be used to launch both our full-scale vehicle and sub-scale vehicles. These two launch sites will provide the team with two launch opportunities per month. The team will also be receiving mentoring from Jimmy Yawn. Yawn is a level 3 certified member of NEFAR. He will be assisting us with his wealth of knowledge in high power rocketry.

2. Facilities and Equipment

2.1 Facilities

2.1.1 UF MAE Student Design Center

Description

The Swamp Launch Rocket team has a workspace specifically for the team in the Student Design Center. In this space, the team stores all materials, tools, and machinery. This location is primarily used for rocket construction and testing of the rocket. The rocket construction is conducted inside of the building in the team's designated bay. This includes epoxying, machining, and painting. The testing is conducted outside of the building in an open area to prevent any harm to the public or building (Fig. 2).

Hours of Accessibility and Necessary Personnel

The facility is available twenty-four hours a day, seven days a week. Along with a design lead needing to be present, if any construction is being done with the machinery, the team requires a safety steward to be present to ensure safety to our team members. The team currently have two safety stewards on the team, our Safety Officer Chas Wilson and a general member Christopher Thomas.

Equipment

The tools that the team has access to at this facility that requires supervision from a safety steward include hand tools, power drills, hand and table saws, drill press, sanding belt, circular saw, plasma cutter, MIG welders, and TIG welders.

Figure 2 MAE Student Design Center [1].

2.1.2 UF MAE Student Manufacturing Lab (MAE-C 150)

Description

This facility is used primarily for precision manufacturing and to conduct meetings. The team has access to a manufacturing workshop that is run by one of the professors at the university. The manufacturing workshop will be used for manufacturing parts of the rocket that require precision and large-scale equipment. On the other side of the manufacturing workshop, the team has a meeting area where the team can run design team meetings, discuss designs, and manufacturing processes (Fig. 3).

Hours of Accessibility and Necessary Personnel

The meeting area of the facility is available for use Monday through Friday exclusively to the Swamp Launch Rocket Team after 6 pm. The manufacturing area of the facility is available during these times as well as long as a Safety Steward, professor (Mike Braddock or Sean Niemi), or a Design and Manufacturing Lab Teaching Assistant is supervising. The professors Mike Braddock and Sean Niemi run the manufacturing lab.

Equipment

The tools available to the team in this facility include mill machines, lathes, band saws, a welding station, white boards, water jet cutting machine, sanding belts, large tables, and seating.

Figure 3 Picture of some of the machines and layout of the student manufacturing lab [2].

2.1.3 UF Classroom (CSE E222)

Description

This classroom is in the Computer Science Engineering building on the University of Florida Campus. It is used on a weekly basis to hold general body meeting and general education meetings. The room has a seating capacity of 80 people (Fig. 4).

Hours of Accessibility and Necessary Personnel

The room is available for the team every Wednesday from 7pm-9pm. While there are no personnel needed to use this room, it is preferred that the executive board of the team is present.

Equipment

The equipment available in this room includes a projector, document camera, windows PC, BYOD connections, DVD player, and chalk boards.

Figure 4 Picture of the room CSE E222 at the University of Florida [3].

2.1.4 UF MAE Rapid Prototyping Lab

Description

The team will be using the rapid prototyping lab available to all students in the MAE department. The lab is in MAE-B 313 on the UF campus (Fig. 5). The lab has the capability of producing parts made from ABS plastic, nylon, or polycarbonate.

Hours of Accessibility and Necessary Personnel

The lab is available for use via an online submission forum. Any part can be submitted to the forum to be printed. The team members themselves are not authorized to operate the machines, but MAE students trained to use the machines can.

Equipment

The equipment offered at the lab include an additive rapid prototyping machine, a subtractive rapid prototyping machine, and a 3D scanner.

Figure 5 Picture of the Mechanical and Aerospace Engineering Department's Rapid Prototyping Facility and the machines [4][5].

2.4 Required Supplies

2.4.1 Manufacturing Equipment

The team will be using many manufacturing tools that the University of Florida Mechanical and Aerospace Engineering Department offers the students to use, including the following:

- Additive Rapid Prototyping machine – Stratasys Dimension 1200 es, Fortus 360mc
- Subtractive Rapid Prototyping machine – Roland MDX-540

The following tools can only be used if the students have the proper training learned in the Design and Manufacturing Lab Course:

- Lathe Machines
- Milling Machines
- Abrasive Water Jet
- CNC Mill Machine
- Vertical Bandsaw
- Hand Drills

2.4.2 Testing Supplies

The team will be using many tools and supplies to perform all necessary tests including the following:

- Safety Glasses
- Impervious Rubber Gloves
- Black Powder
- Precision Gram Scale
- Accelerometer
- Electric Matches
- Remote Igniter
- Highspeed Camera (Smartphone)
- Fireproof Cellulose Insulation
- Timer
- Gridded Plate of Non-Flammable Material
- Voltmeter
- Masking Tape
- Fireproof Tissue
- Static Motor Test Stand

The team already has access to all the above supplies.

2.4.3 Computer Software

MATLAB

The team will be using the computer programming software called MATLAB for purposes of flight simulations and numerical analyses. UF maintains a license for professional versions of MATLAB with a full suite of toolboxes that every student can access.

OpenRocket

The team will be using the software OpenRocket to model the launch vehicle and run flight simulations (Fig. 6). This tool is helpful in determining how the launch vehicle will perform under certain launch conditions and will help determine the most efficient and safest designs for the vehicle. The program is free to download for the public.

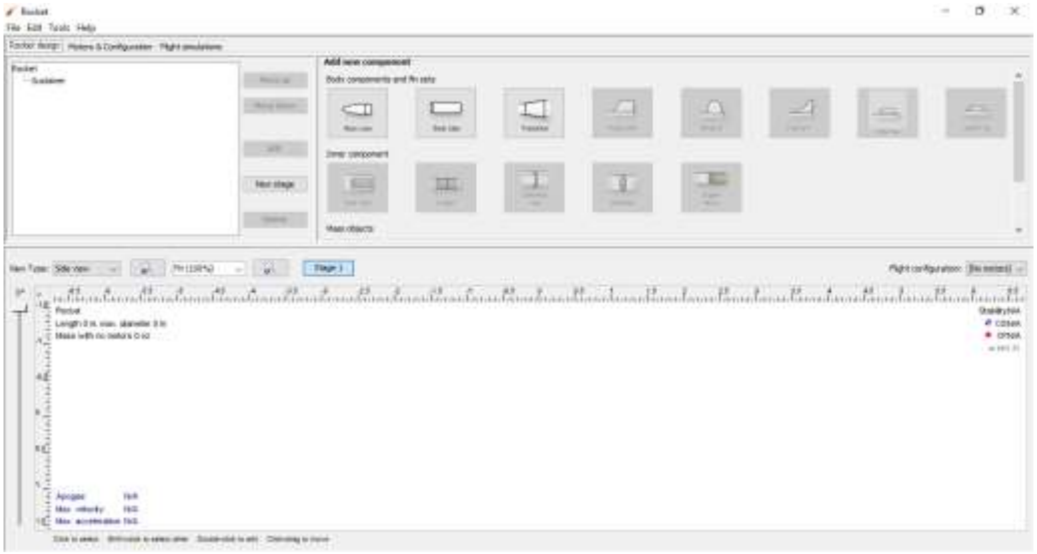

Figure 6 Visual of the OpenRocket software the team will be using.

SolidWorks

The team will use the computer aided design software SolidWorks for purposes of modeling the payload designs, avionics designs, and launch vehicle. The team will also use SolidWorks to perform finite element analyses on the systems to determine if the structures are safe to use and will not fail. UF maintains a license for professional versions of SolidWorks with a full suite of toolboxes that every student can access.

Slack

The team will be using the communication application called Slack for purposes of announcing meetings, keeping general members involved, communication amongst each other, and collaboration when members cannot meet in person. Slack is available to download for free onto any smartphone and can also be viewed on their website (Fig. 7). To ensure everyone has access to the team's Slack channel, we provide the information for it at every general body meeting and it is available on the team's social media.

Figure 7 Visual of the team's Slack channel.

Microsoft Teams

The team will be using Microsoft Teams for document sharing and task lists. Microsoft Teams can send messages to others in the database, create a schedule, task lists, share Microsoft Word, Excel, and other applications (Fig. 8). The team will primarily use the software for sharing Microsoft documents, following a schedule, and creating task lists. UF maintains a license for Microsoft with a full suite of toolboxes that every student can access.

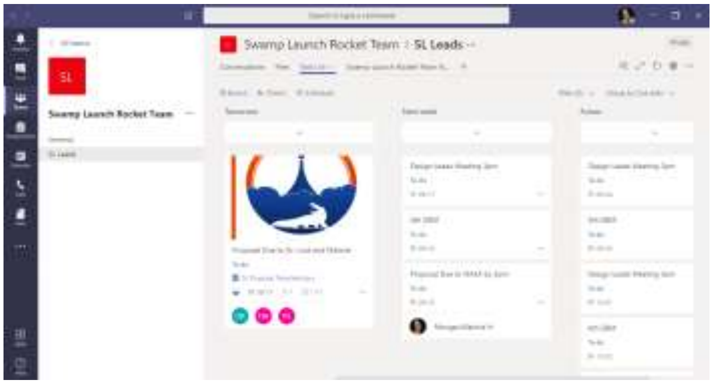

Figure 8 Visual of the Microsoft Teams database the team will utilize.

3. Safety

The Swamp Launch Rocket Team at the University of Florida holds the safety and well-being of its members as the highest priority. The oversight of responsibility for safety falls to the Safety Officer and Project Manager. Additionally, each member of the team is tasked with having the skills and knowledge to identify potential hazards and use the appropriate safety procedures to mitigate them.

3.1 Safety Plan

The team will maintain a safety plan throughout the project to ensure safety measures are properly followed:

1. Responsibilities will be assigned as an authority for oversight for our safety procedures.
2. The team will identify hazards and characterize all mitigation strategies.
3. The team will formulate rigorous procedures for all testing, manufacturing, and launches.
4. Extensive testing of components will be done.
5. The design will incorporate robustness with methods such as:
    a. Uncertainty analyses
    b. Monte Carlo simulations
    c. Surrogate modeling
    d. Parameter updating of simulations based on sub-scale launch

3.1.1 Risks and Mitigations Assessment

A risk assessment for the materials and facilities that will be used was completed. A proposed mitigation approach is provided.

Table I RAC

Probability	Severity			
	1 Catastrophic	2 Critical	3 Marginal	4 Negligible
A – Most Likely	1A	2A	3A	4A
B – Very Likely	1B	2B	3B	4B
C – Likely	1C	2C	3C	4C
D – Less Likely	1D	2D	3D	4D
E – Not Likely	1E	2E	3E	4E

Table II Probability Parameters

A – Most Likely	Highest chance the hazard will occur
B – Very Likely	Higher chance the hazard will occur
C - Likely	Moderate chance the hazard will occur
D – Less Likely	Low chance but possible to occur
E – Not Likely	Nearly no chance the hazard will occur

Severity Parameters	Conditions (If any or all occur)
1 - Catastrophic	• Death, permanent disability • Destruction of launch vehicle • Loss of mission, no chance of future completion
2 – Critical	• Injury requiring transport to medical facility • Permanent damage to vital component • Loss of mission, opportunity to attempt again
3 - Marginal	• Injury requiring First Aid • Component damaged but repaired or replaced quickly • Partial mission loss, or mission endangered but possible to complete
4 – Negligible	• No injury • Component not damaged or easily fixed • Mission unaffected

Table III Personnel Hazard Analysis

Event	Hazard	Cause	Probability	Severity	RAC Score	Mitigation
Rocket motor fails to ignite on launchpad	Delayed firing hurts people, potential mission loss	Damaged motor Ignitor lost continuity	Less Likely	Marginal	3D	RSO removes safety interlock, and the team waits 60 seconds to approach the rocket
Rocket ignites while team member is holding it to transfer to launchpad	Rocket launches horizontally and hits someone at the launch site	Static electricity prematurely ignites the loaded motor	Not likely	Critical	2E	Rocket is never pointed at spectators during prep, and members stay out of line of fire.
Rocket has no separation events and comes down ballistic	People directly below rocket risk being hit by ballistic projectile, rocket destroyed	Altimeters do not have continuity, E-matches do not ignite	Not likely	Catastrophic	1E	Test and verify electrical components have continuity at launchpad, Test E-matches
Rocket turns and flies toward spectators	Severe injury due to projectile, mission loss	Safe exit velocity not achieved, Launch angle not adjusted for windspeed	Not likely	Critical	2E	Adjust launch rail angle to point against the wind, Verify safe exit velocity possible with selected motor and rail provided
Viewer attempts to catch rocket during recovery	Injury due to falling rocket debris, Mission objective incomplete	Rocket recovery occurring over spectators	Likely	Marginal	3C	Angle launch rail away from wind, abide by NAR minimum personnel distance code
Injury sustained during manufacturing of rocket components	Lacerations due to cutting edges, Skin or eye irritation due to material debris	Machine safety guidelines not followed	Less Likely	Marginal	3D	Proper training on machine and supervision, Use of PPE

Parachute cords come untied	Injury from falling debris, Complete or partial mission loss	Correct knots used to tie parachute cords	Less Likely	Critical	2D	Safety Officer visually confirms correct type of knots have been used

Table IV Failure Modes and Effects Analysis

Event	Hazard	Cause	Probability	Severity	RAC Score	Mitigation
Drogue and main chute deploy in the wrong order	The rocket drifts far due to the larger drag force at apogee from main parachute	Altimeters trigger the wrong black powder charges	Less Likely	Marginal	3D	Label correct of orientation blasting caps, visually confirm altimeters will trigger correct black powder charges
Fins fly off body tube during launch	Damaged components Mission Loss	Unreliable attachment of fins to body tube	Less Likely	Critical	2D	Design fin attachment to maximize rigidity, justify with calculations
Motor falls out the bottom of the rocket on launchpad	Armed motor in open space not restrained by rocket motor mount, Mission endangered	Motor retention failure	Not likely	Marginal	2E	Test motor retention with empty casing before launch, verify rigidity of retention part attachment
Motor “chunks” and sputters during launch	Trajectory thrown off Mission Loss	Motor is old, propellant has clumped together inside	Less Likely	Critical	2D	Check that a new motor purchase is in the budget
Altimeter batteries drain during launch	Recovery system does not work, no separation events, Rocket destroyed	Altimeters left on too long, batteries not brand new	Less Likely	Catastrophic	1D	Check that new batteries are in budget, Only create continuity in electronics on launchpad
Parachutes are damaged by propellant	Parachute failure,	Insufficient use of fire-resistant wadding,	Less likely	Marginal	3E	Verify age/quality of wadding,

	Component damaged by landing	Not fire-resistant				Visually confirm enough wadding is added inside rocket
Separation event during liftoff	Sudden drag force on rocket damages components Mission Loss	Altimeter triggers black powder charge too soon, apogee calculated incorrectly	Remote	Critical	2D	Run simulations to accurately determine apogee, confirm altimeter is set to that altitude
Nosecone does not separate during black powder charge	Component damaged by high velocity landing Mission Loss	Interference fit between nosecone and body tube too tight	Not likely	Critical	2E	Design rocket with a body tube that can fit an off-the-shelf nosecone, test for excessive resistance or friction between surfaces
Launch vehicle is not assembled properly before launch	Safety concerns causing failure of range safety inspection Complete mission loss	Team did not coordinate productive group work on rocket	Not likely	Critical	2E	Pre-launch checklist is worked on by whole team so no task goes unfinished
Launch vehicle assembly not completed in time	Project work stops Complete mission loss	Enough time was not allotted to assemble the rocket	Less likely	Catastrophic	1D	GANTT chart provides a timeline for team to follow

Table V Environmental Hazards Analysis

Event	Hazard	Cause	Probability	Severity	RAC Score	Mitigation
Precipitation at the launch site	Water damage to components Mission Loss	Unpredictable weather at the launch site	Likely	Critical	2C	Bring a canopy to cover launch prep area, bring waterproof storage for electronics
Rocket lands in a	Submerging can ruin electronics	Launch site chosen too close to	Less likely	Critical	2D	Minimize drift, angle launch rail away from wind,

body of water	and warp airframe	water or rocket drifts over boundaries				ensure drogue chute comes out at apogee, verify rocket is stable
Rocket is caught in a tree or power line	Dangerous for team members to retrieve	Launch site chosen with obstacles sitting to close	Likely	Marginal	3C	Choose a launch site that has no trees or power lines in proximity
Rocket ignition causes surrounding grass to catch fire	Open fire is generated at the launch site	Dry grass was sitting within the minimal cleared distance of the launchpad	Not likely	Marginal	3E	Follow NAR minimum cleared distance code and remove sitting dry grass around launchpad
Rocket flies into a cloud	Water damages recovery system Mission Loss	Liftoff occurred without waiting for a clear sky	Not likely	Catastrophic	1E	Do not launch the rocket if the sky is not sufficiently clear

3.1.2 NAR/TRA Procedures

The following guidelines are in accordance with the High-Power Rocket Safety Code [6].

- Only team members who are active NAR/TRA members with a certification of Level 2 or higher will be permitted to handle the high-powered rocket motor and perform launch preparation or launch initiation activities once the motor has been loaded into the project vehicle.
- Material use will be limited to lightweight materials such as wood, plastic, or composite materials like fiberglass. Ductile metals such as copper will be permitted only if non-metallic, lightweight material cannot be substituted without compromising the vehicle's function.
- Motors used in the vehicle will be certified and commercially available. These motors will not be modified for any reason by any member of the team. Motors will also be kept at least 25 meters away from any source of heat, smoke, or open flame always.
- The vehicle will be launched using an electrical firing system with an ignitor. The ignitor will not be loaded into the vehicle until the vehicle is set up on the launchpad. Loaded energetics and the electrical firing system will always be inhibited except when the vehicle is in launch position. A safety interlock will be installed in series with a launch switch when the vehicle is ready for launch and the switch will disarm when it is released.
- If the vehicle does not launch when the electrical firing system is activated, the Range Safety Officer (RSO) will remove the safety interlock. 60 seconds must pass after the last launch attempt before the vehicle can be approached to investigate the issue.
- The RSO will initiate a 5-second countdown before launching the rocket. Only the Safety Officer and required certified team members will be present at the launchpad to arm the vehicle's electrical firing system and altimeters. During launch, all team members will stand behind the RSO at the minimum personnel distance, according to the NAR Safety Code.

- The stability of the vehicle will be confirmed to be an acceptable value by the team before arriving at the launch site. The team will confirm that the project vehicle can reach a safe rail-exit velocity when loaded with the selected motor, and that a launch rail of enough length is available at the launch site, or a longer rail if the windspeed exceeds 5 mph. The vehicle will sit on the launchpad angled within 20 degrees of vertical. A blast deflector will be used, and dry grass will be cleared according to the minimum cleared area required from the NAR Safety Code.
- The project vehicle will not contain a motor or combination of motors with a total impulse totaling more than 40,960 N-sec (9208 pound-seconds). The vehicle will also not weigh more than one-third of the certified average thrust of the selected high-powered motor at liftoff.
- A certified team member will verify that the planned trajectory of the vehicle will keep it within the boundaries of the launch site and not directly above the spectators. The vehicle trajectory will also avoid high-altitude hazards such as clouds and airplanes. The team will follow the Federal Aviation Administration regulations regarding the launch site altitude limit, and a certified member will scrub the launch if the windspeed exceeds 20 mph. The team will design the vehicle payload such that it has no explosive or flammable components.
- The team will only perform launches at sites where there is wide open space away from trees, power lines, occupied buildings, or people not participating in launch activities. The launch site will be at least a half-mile wide on its smallest dimension.
- The launchpad of the vehicle will be located at least the minimum personnel distance away from any launch site boundary. The launcher will also be at least 1500 feet away from occupied buildings or public highways with traffic flow exceeding 10 mph.
- The team will design and assemble the project vehicle with a recovery system consisting of a main parachute and drogue parachute to safely return all components to the ground undamaged. The vehicle must be able to be flown again for the recovery to be considered safe and successful. Only flame-resistant or fireproof wadding will be inserted into the recovery system.
- The Safety Officer and other certified members will ensure that no team member attempts to recover the vehicle from a dangerous place such as in a tree or tangled in a power line. If the vehicle is likely to recover in spectator populated areas or outside the boundaries of the launch site, then the launch will be scrubbed, or the risk will be mitigated. No team member will attempt to recover the vehicle by catching it before it touches the ground.

3.1.3 Safety Briefing

All members of the team will be briefed on hazard recognition and accident avoidance through mandatory safety orientation sessions conducted at the Student Design Center and through safety briefings conducted in the Design and Manufacturing Lab on campus. A separate pre-launch meeting will be held prior to each planned test launch to brief team members on the regulations and safety codes that must be followed at the launch site.

3.1.3.1 Safety Steward Responsibilities

Safety stewards are team members who will be authorized to supervise team members and enforce safety guidelines after passing a written and oral examination conducted by the lab manager, Mike Braddock.

The following items represent the procedures that all Safety Stewards strictly adhere to in order to prevent accidents and equipment damage in the Student Design Center.

1. Enforce all protocols outlined in the Rules for Facility Use document. This includes policies for personal safety; equipment uses; facility cleanliness, organization, and respect; proper language; use of the Material & Tool List and Broken / Lost Tooling List; and all other miscellaneous policies.

2. Have a strong understanding of each machine at the SDC. You can't effectively train students in proper equipment use unless you possess a solid understanding of each machine and process. You will also be ineffective at proactively identifying and preventing mistakes that cause injury or damage.

3. Train students on machines, administer knowledge quizzes, and sign authorization sheets. If a student requests machine training, it is your responsibility to train him/her to the standard expected and outlined in the safety protocols. After training, administer the knowledge quiz to assess their understanding of the safety protocols for the specific machine. If the student passes the quiz, add their name to the approved list of users for that machine so (s)he can use the machine with steward supervision in the future.

4. Verify students are trained and authorized on each machine they use. Your primary responsibility is to ensure students are trained and authorized on each machine they use by referencing the lists of authorized users located by each machine. Students using machines on which they are not authorized lose facility use privileges, effective immediately.

5. Setup each approved equipment user each time (s)he works on a new part. Two trained users should catch more mistakes, so always setup team members each time they use facility equipment. For example, if a team member wishes to use a bandsaw to cut a piece of 4130 alloy steel tubing, check its hardness with a file to ensure it is soft enough to cut with a bandsaw, select the appropriate bandsaw, change the blade so its pitch matches the material thickness, and watch the student make the first cut. If the following day another student desires to cut a piece of steel flat bar, the same checks need to be made with a safety steward. Even if the same student desires to cut more 4130 alloy tubing another day, the same checks will need to be made, which require the presence of safety steward.

6. Keep watch of powered machinery as it is being used. Accidents can happen to the best trained users. Therefore, even though all users of powered machinery must be trained to be allowed to use them, safety stewards should keep a watchful eye to make sure that machinery is being used safely and correctly. Do not hesitate to interject if a student is making a mistake on the machines.

7. Manage common use tools access. Common use facility tools like sanders and grinders can be checked out using the Material & Tool Use List and must be returned after use each work session so all users have equal access to them. During checkout, a student must ask a safety steward to retrieve the item from its storage location. Upon return, a safety steward must check that the tool has been respectfully cleaned by the user and that it functions properly prior to returning it to its storage location. Users who fail to clean and return tools each session will lose use privileges.

8. Ensure students clean machines after each use and accept responsibility for stations not up to SDC cleaning standards. Machine stations should always be left cleaner than they are found. Holding students to this expectation helps keep the SDC an efficient facility by preventing premature deterioration of machines, floors, and work surfaces. If a student cannot clean their workstation(s) properly, facility use privileges should be revoked. That said, safety stewards will also be held accountable for dirty stations, so ensure users properly clean each station immediately after use (not at the end of each work session, at which time cleaning will be easily or conveniently forgotten).

9. Ensure students keep bays neat and clean. A clean SDC communicates professionalism and appreciation. Teams should adhere to the cleanliness policies outlined in the Rules for Facility Use document and your job is to ensure they do. This includes spills, general trash, the strict no-food policy, as well as general tidiness. Balance being respectful yet stern.

10. Safety stewards are never required to assist other student groups. This might sound odd at first, but we are never requiring safety stewards to assist other student groups using the facility. The first reason is accountability: if a mistake occurs it's more difficult to assign responsibility. The second reason is that each group using the facility should care enough to put forth responsible members from their team for training who have completed EML2322L instead of burdening other groups' safety stewards. That said, please feel free to help other student groups on occasion if they do not have their own steward present, but we ask that you do not make a habit of doing so for the reasons mentioned.

11. Report concerns, problems, or suggestions for improvement to the lab manager (prestond@ufl.edu) in an e-mail with SDC in the subject line.

3.1.3.2 Hazard Recognition

Activities of team members that are potentially hazardous must be assessed by the Safety Officer prior to starting. The Safety Officer will be in constant communication with team leads to remain up to date on the facilities being used and processes being performed on a weekly basis throughout the project. Operations that have well-established risk mitigation methods accessible through documentation, such as the use of machinery in the Student Design Center, will require safety steward supervision. More unique and less frequent operations, such as experiment payload testing or static fire motor testing, will require a meeting between the Safety Officer and team lead to review the procedure and determine any possible hazards.

3.1.3.3 Accident Avoidance

Safety Orientation Sessions- Meetings will held at the Student Design Center that will educate members on the safe and proper use of the machinery, tools and other resources that the team has at its disposal. Members will also be instructed on how to use Personal Protective Equipment (PPE) to properly mitigate risks present at the SDC. All PPE equipment will be provided by the facility. The Safety Officer and Safety Stewards will conduct these mandatory meetings.

Design and Manufacturing Lab- Certain machinery is not accessible through the Student Design Center, but certified Safety Stewards and the Safety Officer will be able to utilize machines in the Design and Manufacturing Laboratory. Occasional training sessions will also be provided by the teaching assistants of the lab to refresh team members on the safety protocols used in the workspace. Both the laboratory and SDC are managed by Mike Braddock and Daniel Preston, who certify the safety stewards.

3.1.3.4 Launch Procedures

Pre-Launch Briefings- All team members attending a launch must be present at the pre-launch briefing, which will be conducted by the Project Manager and Safety Officer. This meeting will cover the NAR High Power Rocketry Safety Code, the Federal Aviation Regulations 14 CFR, Subchapter F, Part 101, Subpart C; Amateur Rockets, Code of Federal Regulation 27 Part 55: Commerce in Explosives, and the NFPA 1127 "Code for High Powered Rocket Motors". Team leads will use this time to verify with the Project Manager and Safety Officer that the vehicle and all members will be compliant with these requirements.

The following checklist will be used to ensure all launch preparation activities have been performed completely and accurately.

Table VI Launch Preparation Checklist

Tasks to be Completed Prior to Launch Date	
Task	*Personnel to Complete Task*
Disassemble launch vehicle and separate into aft section, middle section, and forward section.	Any team members

Pack payload and avionics bays separate from main rocket to protect sensitive components and electronics.	Avionics and payloads sub-team members
Measure and verify lengths of shock cord required.	Any team members
Measure and verify parachute and drogue chutes diameters required.	Avionics team members
Perform an electronic-match ignition test to confirm altimeters and E-matches are working.	Testing and Avionics team members
Pack required tools and replacements for required fasteners.	Any team members
Pack black powder and verify the container is sufficiently insulated from heat or static electricity.	Safety Officer or Avionics Lead
Pack an electronic scale to weigh the launch vehicle and a smaller scale to weigh black powder.	Any team members
Pack a canopy and tarp in case of rain at the launch site	Any team members
Pack a table and horizontal rocket stand for preparation area	Any team members
Perform a complete inventory of the launch vehicle to confirm all components are present.	Project Manager, Safety Officer, and all team Leads
Tasks to be Completed at the Launch Site	
Task	*Personnel to Complete Task*
Set up preparation area (Put up canopy and set up table)	Any team members
Verify the altitudes set for separation events using Open Rocket	Modeling and Simulation team members
Load new power sources into payload and avionics bays and test altimeters for continuity	Avionics and payload team members
Prepare black powder charges, use the electronic scale to weigh correct quantities of black powder	Safety Officer and Avionics/Payload team Leads
Connect E-matches to payload and avionics bays, set correct altitudes for separation events	Avionics team members
Insert E-matches into the bay blasting caps, load in black powder charges, tape over and label	Avionics team Lead
Fold main parachute and drogue chute and tie to shock cord	Any team members
Connect main launch vehicle sections and bays with shock cord	Any team members
Pack in parachutes, parachute protectors, and fire-resistant wadding in the correct orientation into the body tube.	Avionics/Payload team Leads
Insert payload and avionics bay into the launch vehicle, verify they are in the correct orientation.	Safety Officer Avionics/Payload team Leads
Install shear pins to fasten launch vehicle sections together.	Any team member
Weigh the launch vehicle without the motor loaded.	Modeling/Simulation and Propulsion team Lead

Purchase the high-powered motor from an onsite vendor.	Team mentor and Safety Officer
Load the motor into the launch vehicle and verify motor retention method keeps it in place.	Safety Officer or level 2 certified member
Weigh the launch vehicle with the motor loaded.	Safety Officer and level 2 certified team members
Perform a simulation in Open Rocket using measured weight to confirm apogee is sufficiently close to predicted altitude.	Modeling/Simulation and Propulsion team members
Submit launch vehicle for Range Safety Inspection	Project Manager and Safety Officer
Set up launch vehicle on launch rail.	Safety Officer and level 2 certified members
Load the ignitor into the motor and wire it to the launch switch on the RSO table.	Safety Officer
Turn on the altimeters while the rocket is on the stand.	Avionics team Lead
Take photographs of each component AS IT WAS WHEN IT LANDED.	All team Leads
Retrieve components, analyze altimeters, and analyze other data acquisition from the payload	All team leads and members

3.1.3.5 Testing Procedures

Table VII Testing Procedures

Test #	Test Name	SOW item and description	Methodology	Safety Protocol (if necessary)
1	Launch Rehearsal	#2.6 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.	Fully dress rocket for launch excluding real motor.	Negligible safety risk
2	Battery Life Check	#2.7 The launch vehicle and payload will be capable of remaining in launch-ready configuration on the pad for a minimum of 2 hours without losing the functionality of any critical on-board components.	Turn on battery, ensure it lasts more than 3.5 hours.	Negligible safety risk
3	Static Motor Test	#2.10.1 Final motor choices will be declared by the CDR milestone (See also: 2.10, 2.10.2, 2.12).	Use the static motor test stand to generate a thrust curve and verify it against the manufacturing thrust curves. Or generate an original one in the case of the sugar motors.	Team members will be a safe distance away. Team mentor will handle motor
4	Subscale Demonstration Launch	#2.17 All teams will successfully launch and recover a subscale model of their rocket prior to CDR.	Launch a subscale prototype of rocket design to ensure the full-scale design is feasible.	Team members will abide by all rules set by local NAR/Tripoli

				Range Safety Officer
5	Vehicle Demonstration Flight	#2.18.1 All teams will successfully launch and recover their full-scale rocket prior to FRR in its final flight configuration.	Launch the full-scale rocket that is intended to be launched at competition. Ensure all systems operate as intended and are safe.	Team members will abide by all rules set by local NAR/Tripoli Range Safety Officer
6	Payload Demonstration Flight	#2.18.2 All teams will successfully launch and recover their full-scale rocket containing the completed payload prior to the Payload Demonstration Flight deadline.	This will be concurrent with the Vehicle Demo Flight. This will verify that the payload will perform how it is designed.	Team members will abide by all rules set by local NAR/Tripoli Range Safety Officer
7	Black Powder Charge Ejection Test (Avionics separation from payloads)	#3.2 Each team must perform a successful ground ejection test for both the drogue and main parachutes.	Wire e-matches to properly loaded black powder charges. Wire e-matches to proper altimeter. Set altimeter to ejection altitude. Ensure ejection happens.	Team members will be a safe distance away. Altimeters will not be manipulated until the test
8	Black Powder Charge Ejection Test (Avionics Separation from aft)	#3.2 Each team must perform a successful ground ejection test for both the drogue and main parachutes.	Wire e-matches to properly loaded black powder charges. Wire e-matches to proper altimeter. Set altimeter to ejection altitude. Ensure ejection happens	Team members will be a safe distance away. Altimeters will not be manipulated until the test
9	Black Powder Charge Ejection Test (Main chute deployment)	#3.2 Each team must perform a successful ground ejection test for both the drogue and main parachutes.	Wire e-match to tender descender. Load small amount of black powder into tender descender. Wire e-match to payloads altimeter. Set altimeter to main chute deployment altitude. Ensure deployment happens.	Team members will be a safe distance away. Altimeters will not be manipulated until the test
10	Shock Resistant Drop Test	#3.3 Each independent section of the launch vehicle will have a maximum kinetic energy of 75 ft-lbf at landing.	Release independent sections of rocket at a height such that it lands with the equivalent amount of kinetic energy it will during launch. This will ensure the sections are recoverable.	Team members will stand at a safe distance
11	Fin Material Strength Test	#2.4 The launch vehicle will be designed to be recoverable and reusable. Reusable is defined as being able to	Secure ends of fin and apply force in the middle until failure occurs. This will be done to ensure the fin	Team members will be at a safe distance to ensure no

		launch again on the same day without repairs or modifications.	material can withstand forces experienced during landing of the aft section.	inhalation of fiberglass materials or wear respirators

3.1.4 Caution Statements

Any potential hazards that may arise during the project will be identified in plans, procedures, and any other documents in which they are relevant. To ensure that no potential hazards have been overlooked, the design verification process includes a detailed investigation ensuring safe manufacturing, testing, and launching practices. The Safety Officer is present at all Design Verification meetings. He will be cognizant of potential hazards caused by use of all building/manufacturing materials. In addition to the Safety Officer being able to ensure that safety is always first, the Safety Stewards that have been certified as members of the team are also taught that safety is more important.

3.1.5 Legal Compliance

The Safety Officer and Project Manager have read through and understand the relevant laws and regulations governing the launching of high-powered rockets. They will ensure the team remains in legal compliance with all federal, state and local statutes for the entirety of the project. As mentioned previously, team members will be briefed on laws and regulations established by the Federal Aviation Administration, the National Fire Protection Association, and the State of Florida that relate to high-powered rocketry and any additional activities performed by the team throughout the project.

3.1.5.1 Federal

The following statutes were obtained from the Code of Federal Regulations regarding amateur rocketry [7]. All information is confirmed up to date in 2019.

Subpart A—General

101.1 Applicability.

A) This part prescribes rules governing the operation in the United States, of the following:

(iv) Uses a rope or other device for suspension of the payload that requires an impact force of more than 50 pounds to separate the suspended payload from the balloon.

(5) Any model aircraft that meets the conditions specified in §101.41. For purposes of this part, a model aircraft is an unmanned aircraft that is:

1. Capable of sustained flight in the atmosphere;
2. Flown within visual line of sight of the person operating the aircraft; and
3. Flown for hobby or recreational purposes.
4. For the purposes of this part, a *gyroglider* attached to a vehicle on the surface of the earth is considered to be a kite.

[Doc. No. 1580, 28 FR 6721, June 29, 1963, as amended by Amdt. 101-1, 29 FR 46, Jan. 3, 1964; Amdt. 101-3, 35 FR 8213, May 26, 1970; Amdt. 101-8, 73 FR 73781, Dec. 4, 2008; 74 FR 38092, July 31, 2009; Docket FAA-2015-0150, Amdt. 101-9, 81 FR 42208, June 28, 2016]

§101.3 Waivers.

No person may conduct operations that require a deviation from this part except under a certificate of waiver issued by the Administrator.

[Doc. No. 1580, 28 FR 6721, June 29, 1963]

§101.5 Operations in prohibited or restricted areas.

No person may operate a moored balloon, kite, amateur rocket, or unmanned free balloon in a prohibited

or restricted area unless he has permission from the using or controlling agency, as appropriate.
[Doc. No. 1457, 29 FR 46, Jan. 3, 1964, as amended at 74 FR 38092, July 31, 2009]

§101.7 Hazardous operations.

1. No person may operate any moored balloon, kite, amateur rocket, or unmanned free balloon in a manner that creates a hazard to other persons, or their property. No person operating any moored balloon, kite, amateur rocket, or unmanned free balloon may allow an object to be dropped therefrom, if such action creates a hazard to other persons or their property.

(Sec. 6(c), Department of Transportation Act (49 U.S.C. 1655(c)))
[Doc. No. 12800, 39 FR 22252, June 21, 1974, as amended at 74 FR 38092, July 31, 2009]

3.1.5.2 State

The following statutes were obtained from the Florida Senate archive of state laws and regulations. All information has been confirmed as up to date in 2019.

Title XXXIII Chapter 552.12

No person shall transport any explosive into this state or within the boundaries of this state over the highways, on navigable waters or by air, unless such person is possessed of a license or permit; provided, there is excepted from the effects of this sentence common, contract and private carriers, as mentioned in the next succeeding sentence. Common carriers by air, highway, railroad, or water transporting explosives into this state, or within the boundaries of this state (including ocean-plying vessels loading or unloading explosives in Florida ports), and contract or private carriers by motor vehicle transporting explosives on highways into this state, or within the boundaries of this state, and which contract or private carriers are engaged in such business pursuant to certificate or permit by whatever name issued to them by any federal or state officer, agency, bureau, commission or department, shall be fully subject to the provisions of this chapter; provided, that in any instance where the Federal Government, acting through the Interstate Commerce Commission or other federal officer, agency, bureau, commission or department, by virtue of federal laws or rules or regulations promulgated pursuant thereto, has preempted the field of regulation in relation to any activity of any such common, contract or private carrier sought to be regulated by this chapter, such activity of such a carrier is excepted from the provisions of this chapter.

Title XLVI Chapter 790.001 Subsection 4

(4) "Destructive device" means any bomb, grenade, mine, rocket, missile, pipe bomb, or similar device containing an explosive, incendiary, or poison gas and includes any frangible container filled with an explosive, incendiary, explosive gas, or expanding gas, which is designed or so constructed as to explode by such filler and is capable of causing bodily harm or property damage; any combination of parts either designed or intended for use in converting any device into a destructive device and from which a destructive device may be readily assembled; any device declared a destructive device by the Bureau of Alcohol, Tobacco, and Firearms; any type of weapon which will, is designed to, or may readily be converted to expel a projectile by the action of any explosive and which has a barrel with a bore of one-half inch or more in diameter; and ammunition for such destructive devices, but not including shotgun shells or any other ammunition designed for use in a firearm other than a destructive device. "Destructive device" does not include:
(a) A device which is not designed, redesigned, used, or intended for use as a weapon;
(b) Any device, although originally designed as a weapon, which is redesigned so that it may be used solely as a signaling, line-throwing, safety, or similar device;
(c) Any shotgun other than a short-barreled shotgun; or

(d) Any nonautomatic rifle (other than a short-barreled rifle) generally recognized or particularly suitable for use for the hunting of big game.

(5) “Explosive” means any chemical compound or mixture that has the property of yielding readily to combustion or oxidation upon application of heat, flame, or shock, including but not limited to dynamite, nitroglycerin, trinitrotoluene, or ammonium nitrate when combined with other ingredients to form an explosive mixture, blasting caps, and detonators; but not including:

(a) Shotgun shells, cartridges, or ammunition for firearms;

(b) Fireworks as defined in s.791.01;

(c) Smokeless propellant powder or small arms ammunition primers, if possessed, purchased, sold, transported, or used in compliance with s.552.241;

(d) Black powder in quantities not to exceed that authorized by chapter 552, or by any rules adopted thereunder by the Department of Financial Services, when used for, or intended to be used for, the manufacture of target and sporting ammunition or for use in muzzle-loading flint or percussion weapons.

3.1.5.3 Local

National Fire Protection Association

The NFPA 1127 code applies to the design, construction, limitation of propellant mass and power, and reliability of high-power rocket motors and their components. This code also addresses the design and construction of vehicles propelled by high power rocket motors and the launch of high-power rocket vehicles.

3.1.6 NAR/TRA Mentor Purchase, Storage, Transportation, and Use of Motors and Energetics

The Team Mentor, Jimmy Yawn, who is an active NAR member with a Level 3 certification, will purchase the selected high-powered rocket motor for the team. The motor, once purchased, will be kept in a Type 4 magazine which is painted red with “EXPLOSIVE, KEEP FIRE AWAY” written in white, 3-inch-tall letters. The magazine will be stored in the Student Design Center and kept away from any heat sources, open flames or smoke in accordance with the NAR High Power Rocketry Safety Code. This safety rule will be enforced by informing other design teams who share the SDC space of the 25-meter rule, as well as performing any tests or procedures that generate excessive heat or sparks completely outside the SDC building. While travelling to Huntsville, the high-powered motor will always be stored in the magazine and kept inside the car. A kingpin locking system will be used to constrain the magazine when the car is left unattended. The magazine will be in the trunk of the automobile, constrained to the body of the car using duct tape. Nothing will be permitted to be stored on top of the magazine. The 25-meter rule will be enforced for the entirety of the trip.

3.1.7 Written Statement of Compliance for Safety Regulations

The team has read and understood the following safety regulations and will be compliant with them through the life of the project.

1. The team agrees to have the project vehicle submitted for a range safety inspection conducted by the RSO. The team will also comply with the determination of the safety inspection.
2. The team agrees that the RSO has the final word on all safety issues associated with the project vehicle. The team therefore acknowledges the right of the RSO to deny permission to launch due to safety concerns.
3. The team agrees that the Team Mentor is ultimately responsible for the safe flight and recovery of the project vehicle. The team accepts that the Mentor will conduct a review of the project vehicle design and assembled build. The team will not launch the vehicle until the Team Mentor conducts this review and is satisfied that it meets the safety guidelines.

4. The team agrees that if it does not comply with safety requirements, it will not be allowed to launch the vehicle.

4. Technical Design

4.1 General Vehicle Description

The designed launch vehicle will deliver an unmanned aerial vehicle (UAV) as a payload to collect simulated lunar ice. To house the payload, a nominal diameter of 5.5 inches is required, with a total vehicle length of 114 inches. The launch vehicle will consist of three sections: forward airframe, avionics bay, and aft airframe. A dual deploy recovery system will be used, featuring a drogue and main parachute.

The forward airframe consists of the nose cone, forward body tube, and payload bay. Stored in the nose cone will be a GPS to track the vehicle for recovery. Housed within the forward body tube is the main parachute and shock cord, which connects the forward airframe to the avionics bay with a bulkhead and U-bolt.

The avionics bay acts as a coupler to connect the forward airframe and aft airframe. The avionics bay is joined to the forward and aft airframe by shear pins; which will shear upon deployment of the parachutes. Shock cord tethers all three sections with the use of U-bolts connected to bulkheads on both ends of the avionics bay. Within the avionics bay is an altimeter and battery.

The aft airframe houses the drogue parachute, shock chord, motor assembly, and fins. Shock cord tethers the avionics bay to an eyebolt on the motor tube. Three fins are connected through the body tube to the motor tube. The fins will be secured to the airframe with epoxy. The motor assembly within this section is connected to the aft airframe by centering rings and a thrust plate. The thrust plate transfers the forces from the motor, L-850W, to the airframe while the centering rings help to align the motor with the body tube so that thrust is directed along the center line of the rocket.

An OpenRocket model of the vehicle is shown (Fig. 9). The Center of Gravity (CG) and Center of Pressure (CP) are depicted by the blue and red circles respectively. The CG is 67.44 inches from the nose cone and the CP is 83.47 inches from the nose cone. The forward airframe section is denoted by red, avionics bay in blue, and aft airframe in green.

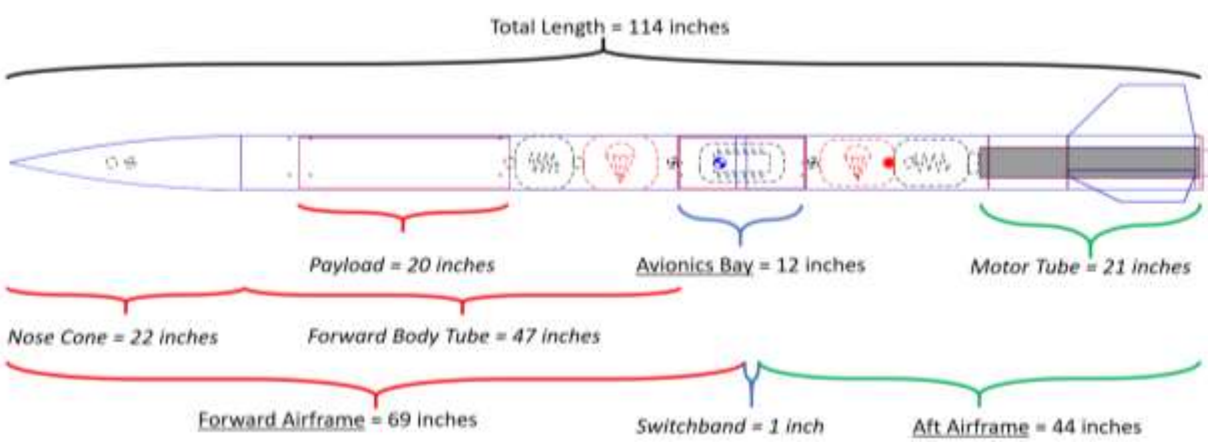

Figure 9 OpenRocket model of the vehicle.

4.1.1 Vehicle Dimensions

The launch vehicle is 114 inches long and has a nominal diameter of 5.5 inches. The nose cone is a 4:1 Ogive design and is 22 inches long with a shoulder length of 5.5 inches to meet the required shoulder length of at least ½ diameter. The avionics bay coupler will be 12 inches long, allowing for at least 5.5 inches of the coupler and airframe shoulder to be secured. Three trapezoidal fins are mounted through-the-wall to best share the load distribution between shear, tension, and compression experienced during flight. They have a root chord of 12 inches, tip chord of 6 inches, and are 5.25 inches in height. The total weight of the launch vehicle with motor is approximately 17.9 pounds (Table VIII).

Table VIII Launch Vehicle Dimensions.

Component	Weight (lb)	Length (in)	Center of Gravity (in)	Center of Pressure (in)
Launch Vehicle	47.62	216.00	67.44	83.47
Forward Airframe	17.90	69.00		
Nose Cone	3.90	22.00		
Forward Body tube	6.50	47.00		
Payload	7.50	*20.00*		
Avionics Bay	4.28	1.00		
Coupler	2.34	*12.00*		
Switch band	1.94	1.00		
Aft Airframe	17.31	44.00		
Aft Body tube	7.01	44.00		
Motor Tube	0.63	21.00		
Fins	1.54	12.00		
L-850W	8.13	*20.90*		

4.1.2 Material Selection and Justification

The nose cone will be made from G12 fiberglass. The material of the nose cone is limited by the availability of commercial off the shelf parts for the selected 5.5-inch diameter. G12 will also protect the nose cone from getting easily damaged so that it can be reused for future launches.

The airframe and couplers will be made from G12 fiberglass because this material provides enough strength to withstand the forces experienced during launch and recovery. Other materials do not provide the reliability of fiberglass through repeated use. G12 also requires less preparation work than other materials such as Blue Tube which needs to be sanded and sealed to optimize performance. The motor tube will be made from G12 fiberglass and the thrust plate from aluminum. An aluminum thrust plate will transfer thrust from the motor to the airframe without material failure; preventing the centering rings from breaking under shear stress, thus allowing the centering rings to be constructed out of weaker materials.

The fins and centering rings will be made from G10 fiberglass. G10 will be used instead of G12 because it has higher shear strength and is available in sheets which can be cut into the required shape.

Bulkheads will be made from Type II PVC because it has high impact, corrosion, and chemical resistance, making it ideal for acting as a barrier between the ejection charges and the avionics bay. The forward bulkhead in the avionics bay will also be wrapped in aluminum foil to shield internal components.

4.1.3 Construction Methods

Manufacturing

The rapid prototyping lab will be used to print unique parts that otherwise cannot be manufactured. CAD models are sent to the lab and go through a queue to be printed. 3D printed parts will include the entire UAV structure.

The abrasive water jet (AWJ) will be used to manufacture parts made from G10 fiberglass; fins and centering rings. Use of the AWJ will decrease manufacturing time spent in the student design shop while increasing the precision of manufactured parts and allowing for odd shapes such as circles or curves to be cut. Table saws will be used to cut G12 body tubes to size.

Epoxy will be used to permanently join pieces of fiberglass. Fiberglass must be prepared prior to application of epoxy; the surface must be sanded and cleaned with acetone. Sanding the surface will increase the surface area to which the epoxy can bind to, maximizing the strength of the bond. Once applied, the part will be set to dry to allow for the bond to cure.

4.2 Projected Altitude and Calculation Method

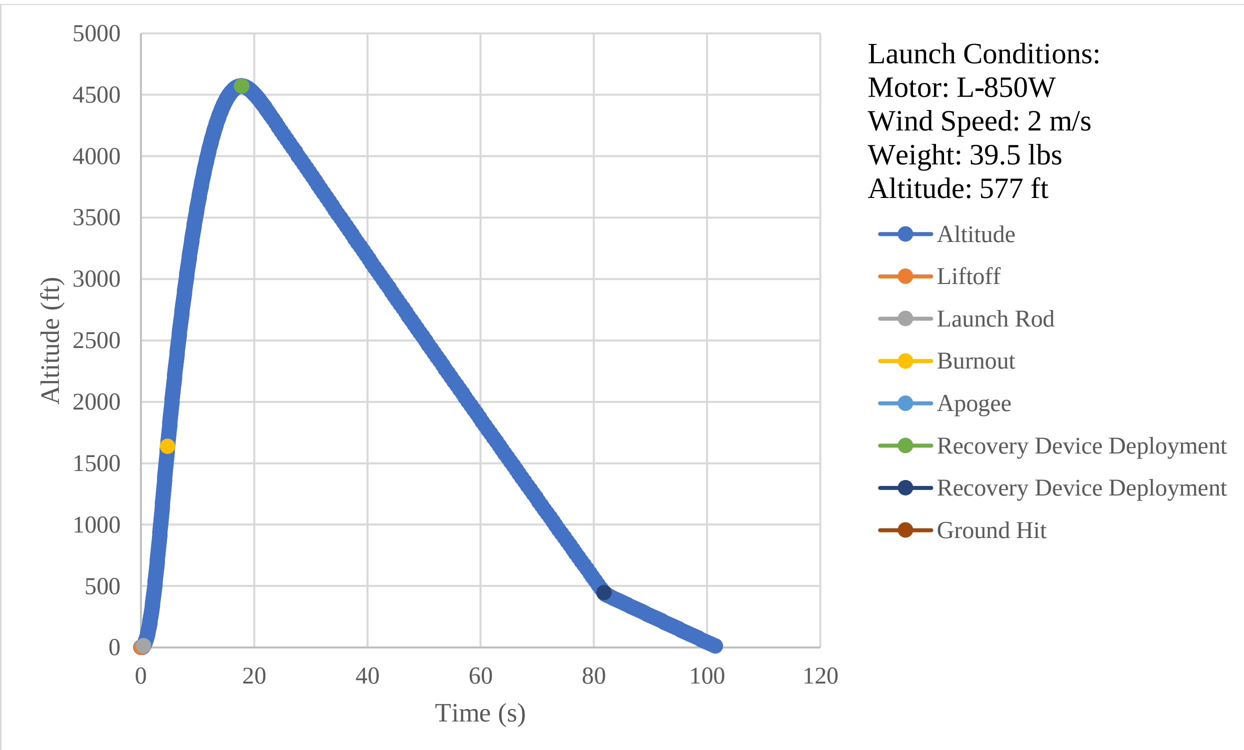

Figure 10 Altitude vs. Time plot including events.

Simulations using OpenRocket predict the rocket will reach an altitude of 4570 ft (Fig. 10). The rocket will reach a Mach number of 0.48. Using a 12-foot rail, the rocket will have a stability margin of 2.0, and a velocity off the rail of 64.6 fps, a safe margin above the required 54 fps. While wind conditions would be impossible to simulate at this stage, the flight was simulated at the same altitude and location as the launch site in Huntsville, Alabama.

The 4:1 Ogive shape was chosen for its low cost. At the maximum velocity the rocket will reach, the reduction in drag would not be significant enough to justify the more drag efficient Haack/Von Karman series nose cone. Three fins were chosen, instead of four, for a lower weight, which results in a higher altitude. The design of the fins as described in Section 4.1.1 ensure the rocket's stability margin is above the required 2.0 calibers (Fig. 11).

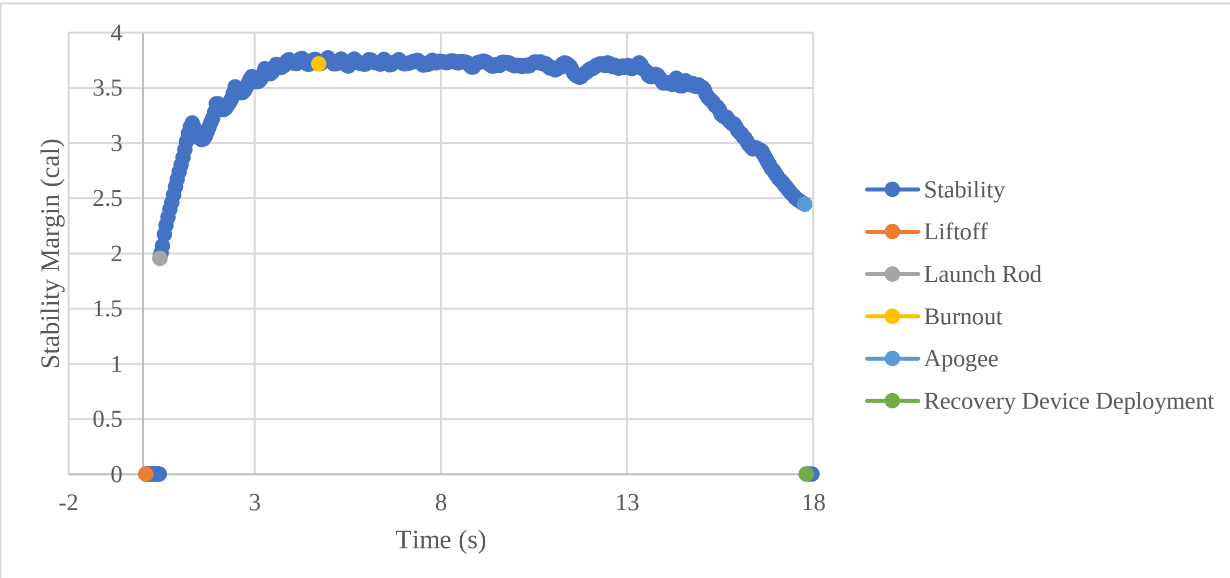

Figure 11 Stability versus time plot of the projected flight.

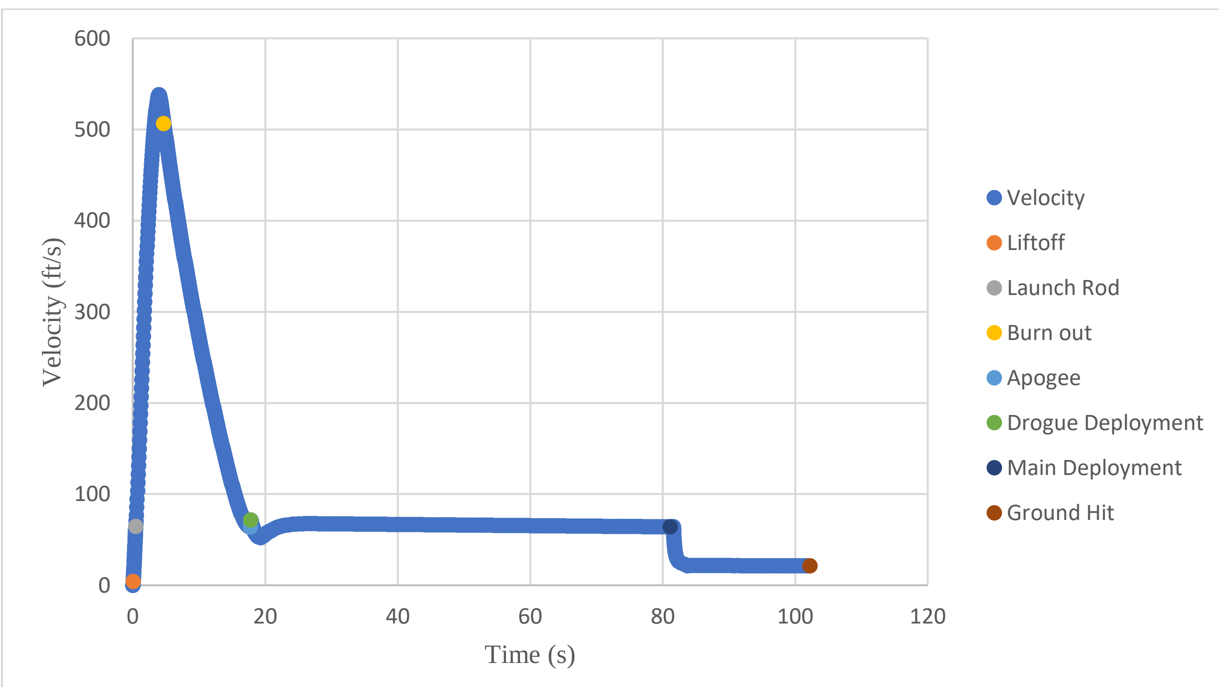

Figure 12 Velocity versus time plot of the projected flight.

4.3 Projected Recovery System Design

Figure 13 Recovery system layout.

Figure 14 Avionics Internal Structure

The rocket will separate into three sections upon decent (Fig. 13). The first separation, for drogue deployment, will occur at apogee at the joint between the avionics bay and aft airframe. The second separation will occur at the joint of the avionics bay and forward airframe and will happen at an altitude of 550 feet for main parachute deployment. Payload deployment will occur upon landing via a remote mechanical separation of the nose cone.

The forward and aft airframes will each be tethered to the avionics bay via 25 feet of 9/16" nylon shock cord. Each attachment point, shown on the above diagram (Fig. 14), will consist of a U-bolt connected to a quick link, except for the aft airframe, which will utilize an eye bolt threaded into the forward motor enclosure.

The rocket will utilize a 78" diameter LP-78 rip-stop nylon main parachute with a 30" diameter nylon drogue parachute to slow the rocket down to a projected 21.7 feet/s ground hit velocity. At ground hit, the kinetic energy will be approximately 780 J.

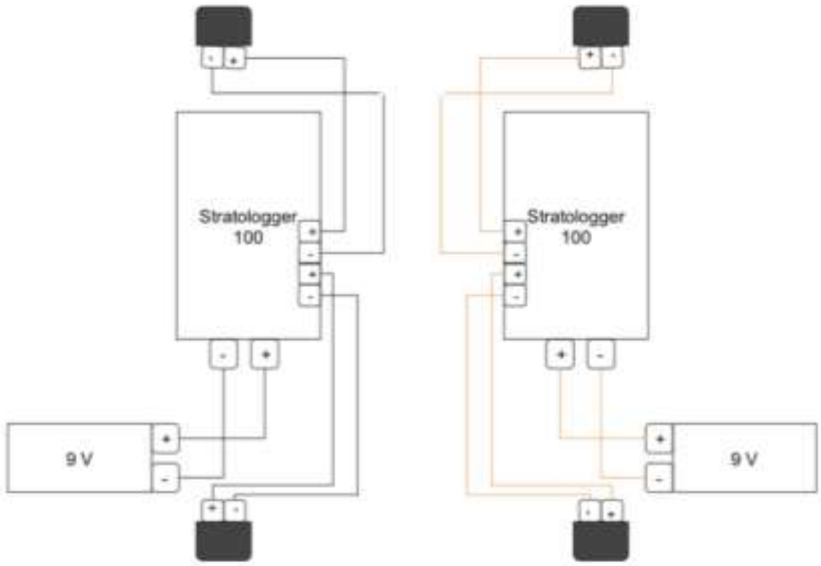

Figure 15 Avionics electronic wiring diagram.

Deployment of the main and drogue parachutes will be controlled by two independently powered and operating StratoLogger SL100 altimeters utilizing four black powder ejection charges (Fig. 15). The primary altimeter will ignite ejection charges for the drogue parachute and main parachutes at apogee and 550 feet from the ground respectively. The secondary altimeter will ignite a larger backup charge for the drogue parachute 1 second after apogee and will ignite the main parachute's backup ejection charge at 500 feet. The delayed backup charges will ensure that the main and drogue parachutes are both deployed in the event of a failed or partial ejection from the primary charges. All avionics electronics will be shielded from any interference from payload and tracking electronics using a layer on aluminum foil on the forward bulkhead.

4.4 Projected Motor Brand and Designation

The motor was selected with a goal altitude of 4,500 ft in mind. The goal altitude was selected as it is the middle of the required altitude range, 3,500 ft – 5,500 ft. Priority was given to motors that would propel the rocket above 4500 because wind conditions could possibly push the rocket further down, so it is safer to go over then under. As well as the altitude goal, the team favored motors that are smaller in diameter and length for a smaller weight of the whole rocket. A lightweight motor is preferable. Three motors came closest to these parameters: L1150, L-850W, and L1520T.

The motor that best meets the conditions is the L-Class Aerotech L-850W. The L-850W propels the rocket to an altitude of 4570 ft with a total impulse of 3,695 Ns. However, the L1150 does not reach the same altitude, only reaching 4250 ft, despite having the same weight and dimensions of the L-850W. Meanwhile, the L-850W motor case is 8 oz less than the L1520T. The motor uses 2,095 g of propellant to achieve a total impulse of 3,646.2 Ns for a burn time of 4.4 seconds. The high thrust, 1,016 N, at ignition allows the rocket to have a high velocity off the rail of 63.2 ft/s, a safe margin above the required velocity, 54 fps. During the rocket's ascent, it will achieve a maximum velocity of 537 ft/s or Mach 0.48. Overall, the motor was favored for being the closest to the altitude target, while being compact and lightweight.

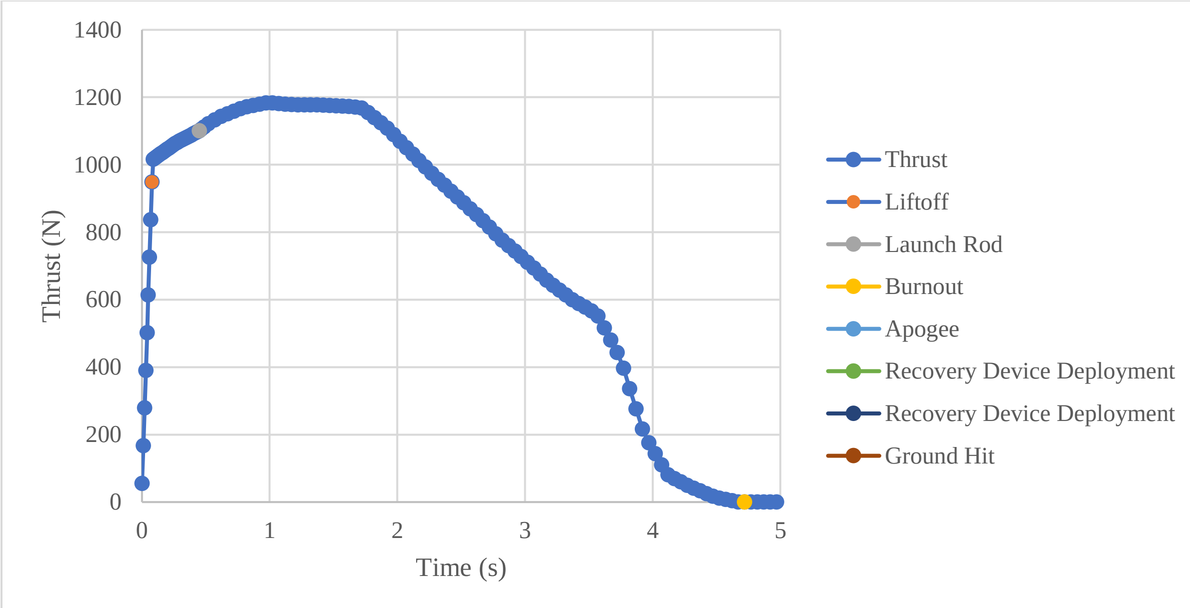

Figure 16 Thrust versus time plot of the L850W motor.

4.5 Project Payload Detailed Description

4.5.1 Payload Overview

The payload will consist of two systems: one remote controlled quadcopter unmanned aerial vehicle (UAV) and a rail/rack and pinion-based deployment and retention system. The payload will require approximately 20" of the rocket's body length. The payload will deploy after the rocket has safely landed and will come out of the front of the rocket after remotely removing the nose cone.

4.5.2 UAV And Lunar Ice Sample Acquisition Method

The task presented in the request for proposal (RFP) is to locate and acquire 10 mL of simulated lunar ice, then fly an additional 10 ft. The team decided that using a flying vehicle would be the best way to quickly and easily locate and travel to the ice patches because the locations of the lunar ice may be relatively small and far apart, and ground flatness conditions are unknown. A semi-cylindrical sample acquisition device (Scooper) utilizing a servo motor that will rotate the semi-cylinder 180 degrees, will be used to scoop and retain the acquired sample (Fig. 17, Fig. 18).

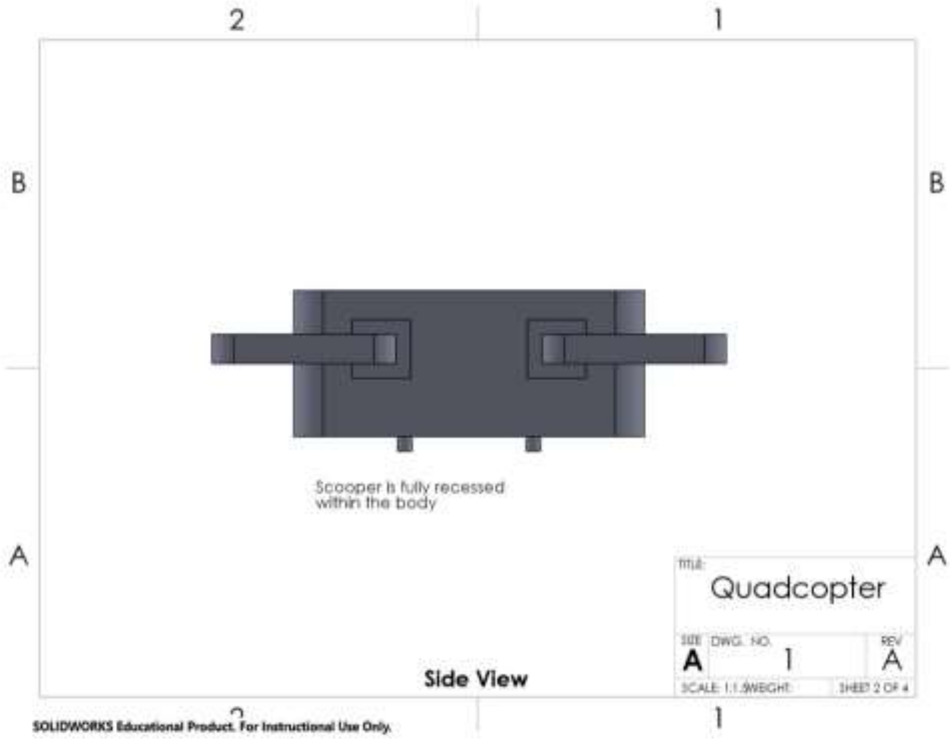

Figure 17 Quadcopter before the sample collection.

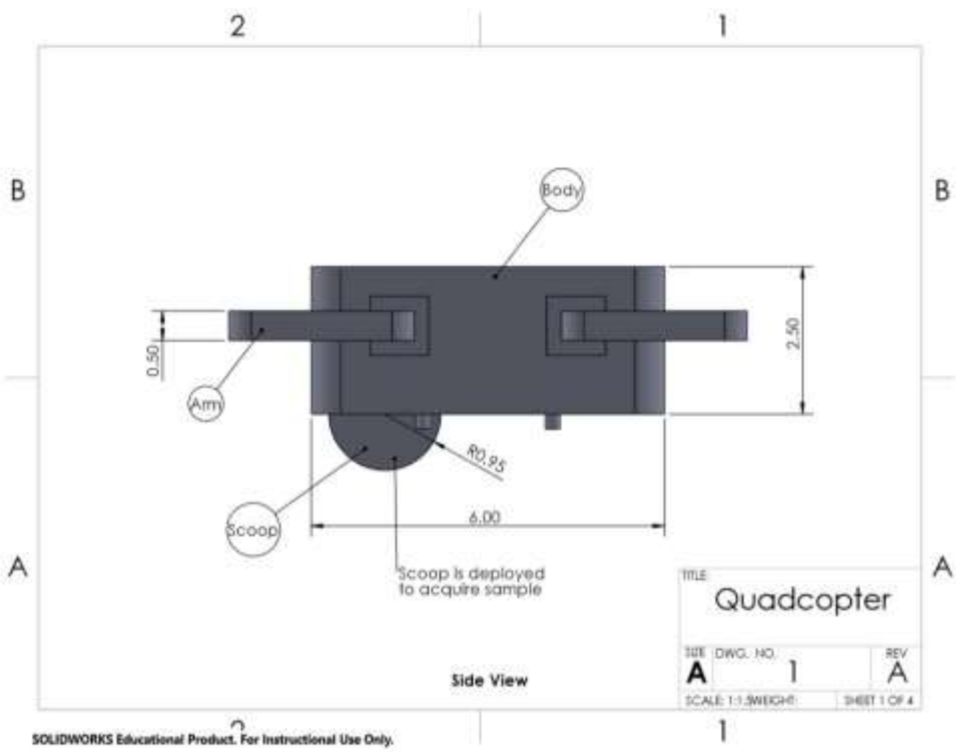

Figure 18 The quadcopter after the sample collection.

The chosen method was selected because of its simplicity and ease of operation. Another design option was using a fixed scoop. The fixed scoop option would sweep up ice as the UAV flew over the ice, but these types of maneuvers invited too much risk of user error and the possibility of crashing the UAV or losing the sample.

The team's preliminary design of the UAV has a 9.55" wheelbase and a height of approximately 4'' after deployment. While inside the airframe, the UAV will have a total length of approximately 14'' because the arms of the quadcopter will fold lengthwise (Fig. 19, 20, 21) so the quadcopter can fit into the 5.5'' diameter rocket body. The arms will unfold once they get outside the rocket body because there will be springs pushing them outwards. The arms will lock into correct position using tabs that will engage at the required angle. The 6'' propellers in the preliminary design play a large role in this length, since the propellers need 3' extra inches past the motor base of its respective arm.

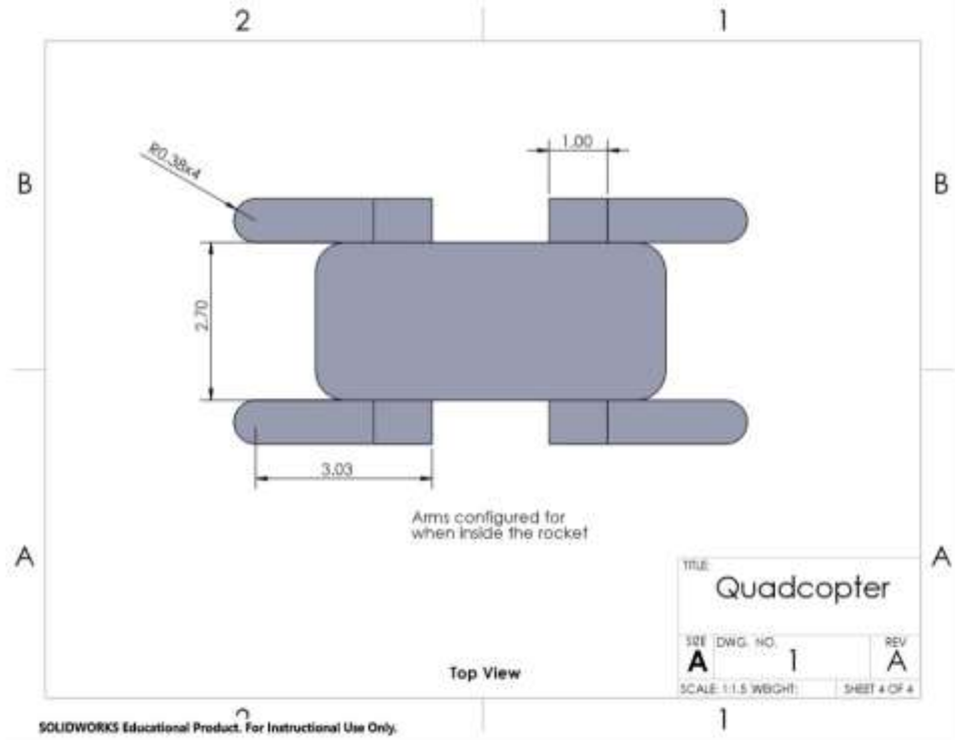

Figure 19 Quadcopter during rocket flight

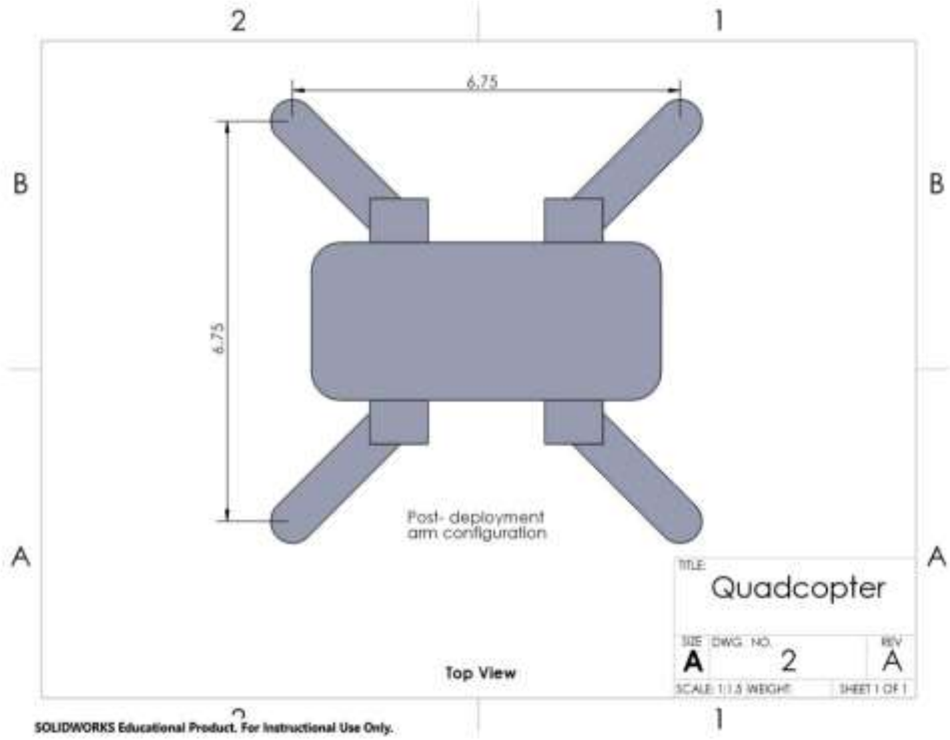

Figure 20 Quadcopter after deployment

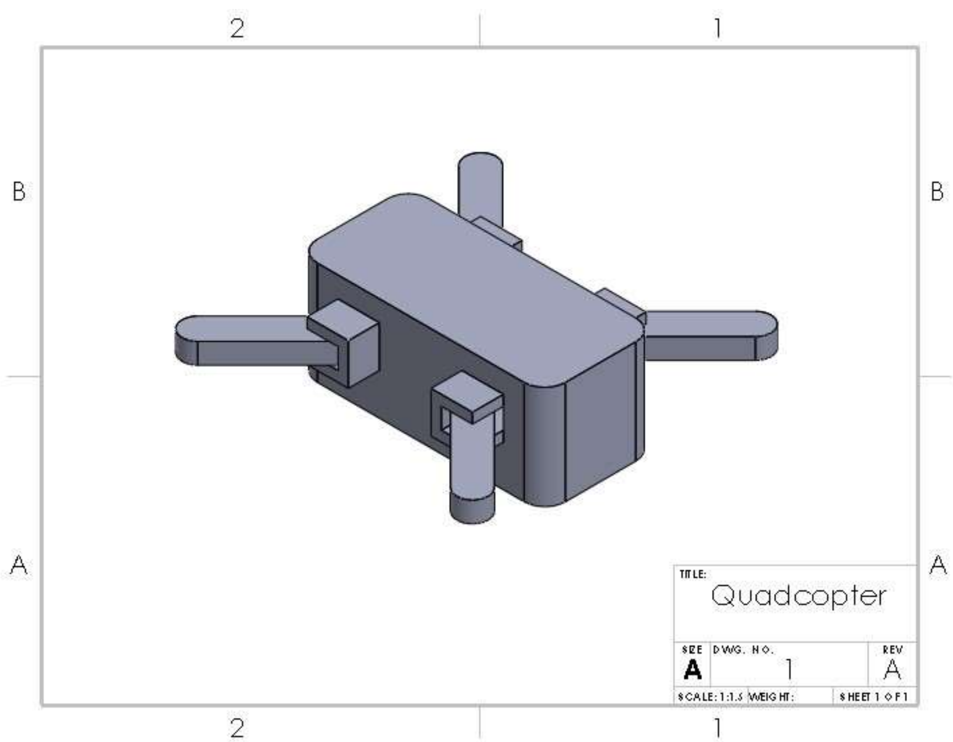

Figure 21 Isometric drawing of quadcopter

The required electronics for the rover are:

- 4 electronic speed controllers – controls power to motors based on flight controller
- Flight Controller (PixHawk 4 Mini)- allows easy control of the UAV
- GPS module - to fulfill competition requirement of needing GPS on non-tethered components
- 4 DC motors- for the propellers
- 1 servo motor- makes the scoop rotate 180 degrees to gather sample
- 1 radio transmitter and receiver- used to control the flight remotely
- 1 audio/video transmitter and receiver- to navigate remote controlled flight by sight
- 1 camera – captures video of the UAV flying
- 1 LiPo battery- powers the UAV
- 1 Battery elimination circuit (BEC) module – needed to ensure clean power output to servo motor

The wiring diagram for the quadcopter (Fig. 22) is shown below. Note that the diagram only shows one ESC connected to keep the diagram organized. There will be three other ESCs connected similarly to the one shown, for a total of four ESCs. Also not shown are the ESCs connections to their respective motors, but that is a simple connection.

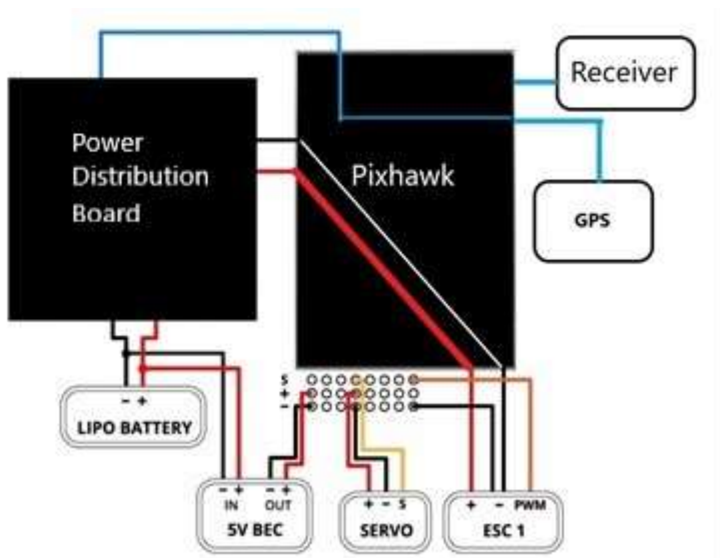

Figure 22 Wiring diagram for the quadcopter

4.5.3 Retention and Deployment System

The payload is designed for a ground deployment, and to preserve stability, the motion of all payload components should be restricted during flight. This required the design of a retention system that could limit every degree of freedom until time for deployment. The retention/deployment system (Fig. 23, Fig. 24) consists of:

- 1 smooth rail (outer rail)- used for guidance and support of the payload
- 1 rail with gear teeth (another outer rail)- used for guidance and support of payload, and part of rack and pinion system
- 1 sled- holds UAV
- 2 bearings- allow rotation of the sled to proper orientation for UAV takeoff
- Drive Gear- part of rack and pinion system when coupled with toothed rail

- 2 Retention walls with slide rails- used to hold sled to rails, allow linear motion when block is disengaged
- High strength elastic band (not pictured) - connects the hook on the UAV to the sled, so the UAV is fixed in place
- Stepper motor – makes drive gear turn, moving deployment system linearly out of rocket
- Servo motor with block – prevents linear motion along rocket length while engaged
- Altimeter (microcontroller compatible)- records the elevation, so deployment can occur at proper time
- Arduino Uno microcontroller- controls the autonomous deployment system
- 2 batteries- power the deployment system
- Driver board – used to control the stepper motor
- UAV acts as part of retention system- hook attaches to elastic band while in rocket

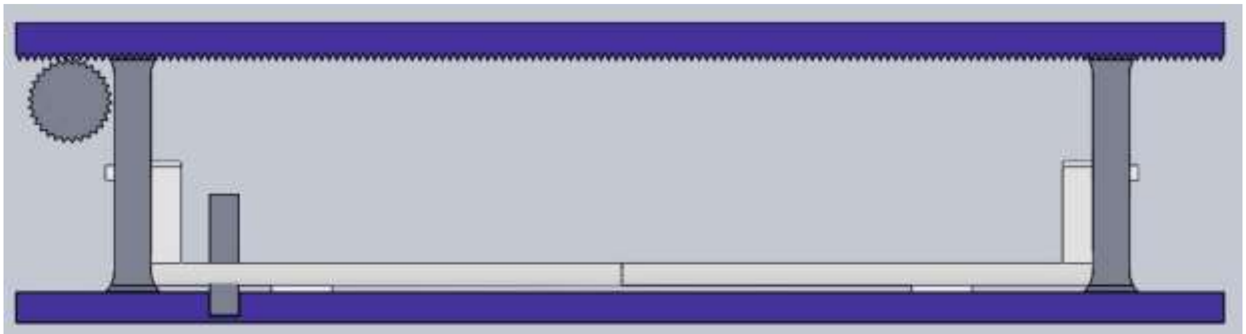

Figure 23 Side View of a Simplified retention system while locked down.

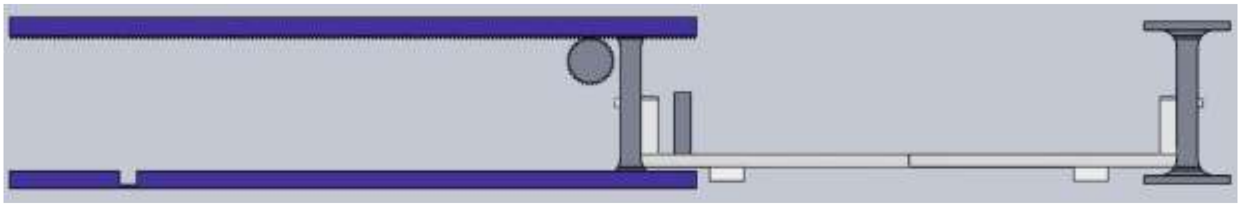

Figure 24 Retention system after deployment.

Retainment System

The two outer rails (blue) will be fixed to the rocket body, likely attached using epoxy. The slide rails fit within the outer rails to allow the inner rails to slide in and out of the outer rails. The rail system works together to restrict motion of the entire system towards the walls of the rocket body and restricts rotation of non-sled components inside the body. The sled has fins that go shallower into the smooth outer rail to restrict its rotation while inside the rocket body. Motion along the length of the rocket body will be restrained using a servo motor to insert a solid block into the smooth rail's gap until landing. The UAV is restrained to the sled using a hook inside the sample container (Fig. 25) and an elastic band attached to the hook and the sled.

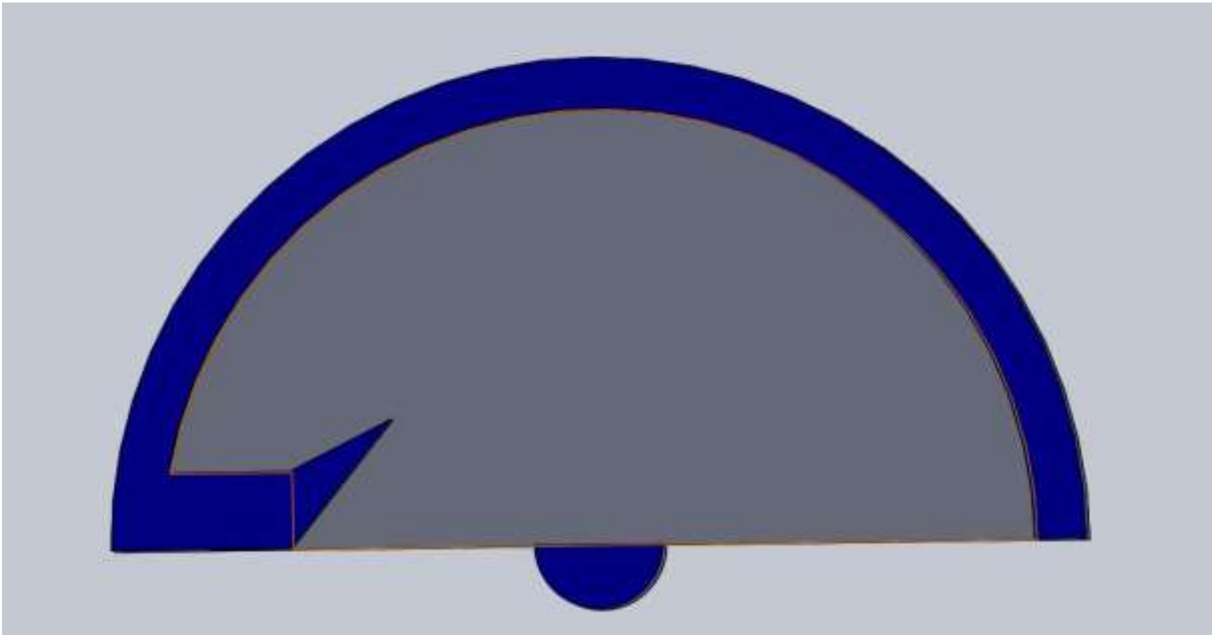
Figure 25 Section cut view of sample container, tests will be done to optimize the angle needed between the hook and the vector from hook to where the band is fixed to the sled.

Deployment Procedure

The Arduino Uno, altimeter, stepper, and servo motor are responsible for autonomously deploying the sled from the rocket body (Fig. 26). The first step begins at ground level before the rocket deploys. The altimeter is armed and calibrated for the ground height at the launch location. Upon reaching a certain altitude and then dropping back to a small distance above ground height (in case the rocket lands on a hill and can't return all the way down to original position) a countdown is initiated to ensure the rocket body has enough time to reach the ground and settle. At the end of the countdown, the servo removes the block from the rail, allowing lengthwise motion to occur. The stepper motor then drives the gear, which pushes against the toothed rail, propelling the sled and retention walls toward the nose cone side of rocket. The moving system pushes against the nose cone, causing the shear pins holding the nose cone to snap, pushing the nose cone out of the body tube. Once the sled gets both fins past the rails, the bearings allow the sled to spin so that the UAV is right side up (there will be a center of gravity significantly below the axis of rotation to ensure it will be prone to spinning). Lastly, the UAV is controlled such that the scooper is turned enough so that the elastic band will fall off the hook, allowing the UAV to move freely.

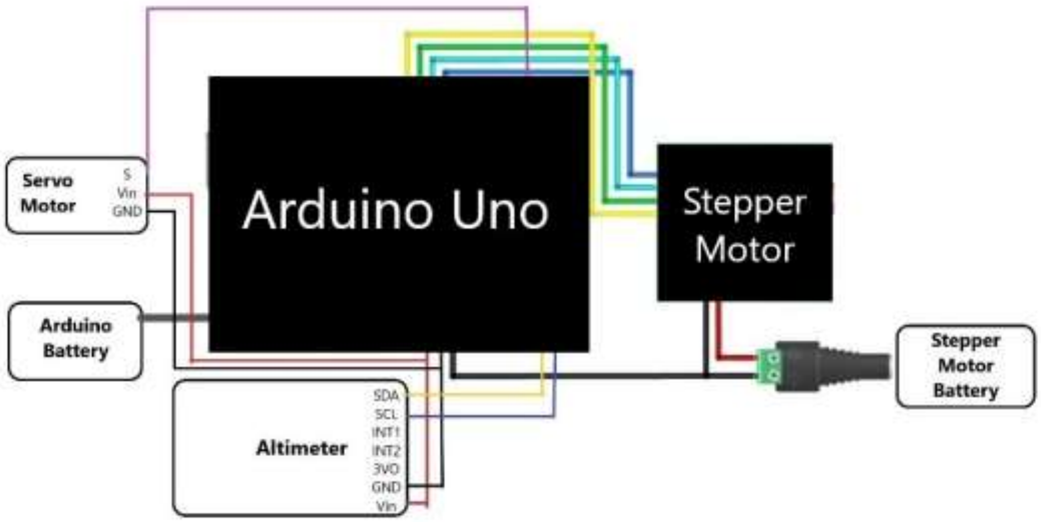

Figure 26 Wiring diagram of the deployment system.

4.6 Requirements and Plans of Attack

4.6.1 General Requirements

1.1 The students on the team will do 100% of the writing, construction, simulations, presentations and design. The team will rely on our mentor for handling black powder, motor assembly, ejection charges, and installing electric matches.
1.2 The team will use Microsoft Teams and Slack to maintain a project plan. The team will also have weekly design lead meeting and general member meetings to ensure everyone stays on track.
1.3 The team will ascertain the citizenship status of all team members attending launch week competition.
1.4. The team will identify all team members attending launch week by the CDR. They will be actively engaged in the project throughout the year and include our mentor Jimmy Yawn and an adult educator.
1.5. The team will work with local educators in the Alachua County School District and local nonprofits for educational engagement in the team's community. For more information see section 5.
1.6. The team has established a social media presence to inform the public about team activities. The team currently has an Instagram account (@SwampLaunch), Facebook (Swamp Launch Rocket Team), and Twitter (@SwampLaunch).
1.7. The project manager for the team will email all deliverables to the NASA project management team by the deadline specified. A link will be included if the file is too large.
1.11. The team will reserve a conference room on the University of Florida campus that has a computer system, video camera, speaker telephone, and internet connection.
1.12. The team will design the launch vehicle around the launch pads provided by Student Launch.
1.13. The team identifies their mentor as Jimmy Yawn.

4.6.2 Vehicle Requirements

2.1. The vehicle will deliver the payload to an apogee altitude of 4650ft using a L-850W motor.
2.2. The team will predict their target altitude goal at the PDR milestone by running many simulations on the rocket using OpenRocket.

2.3. The vehicle will include a Stratologger SL100 altimeter to record the official altitude. A second Stratologger SL100 will be used for backup parachute ejection purposes only.
2.4. The team will run simulations and use strong enough materials to ensure that the vehicle is recoverable and reusable.
2.5. The launch vehicle will have three (3) independent sections.
2.5.1. The team will verify that coupler/airframe shoulders located at in-flight separation points will be one body diameter in length (5.5 inches) prior to construction
2.5.2. The team will verify that nose cone shoulders located at in-flight separation points will be ½ body diameter in length (2.75 inches) prior to purchase
2.6. The team will ensure the vehicle will be ready for flight within 2 hours by having a checklist prepared for launch day.
2.7. The launch vehicle and payload will be capable of remaining in launch ready configuration for a minimum of 2 hours by ensuring our electronics have backup battery packs. The team will verify this by running multiple test beforehand.
2.8. The team will only use a motor configuration that can be ignited with a 12-volt direct current.
2.9. The team will not create a design that requires external circuitry or special ground support.
2.10. The launch vehicle will use an Aerotech L-850W solid rocket motor.
2.10.1. The team will declare final motor choices by the Critical Design Review (CDR) milestone after completing many simulations on the vehicle using OpenRocket.
2.10.2. The team will seek approval of the NASA Range Safety Office (RSO) if the motor is changed after CDR only if the change is for the sole purpose of increasing the safety margin.
2.11. The launch vehicle is one stage.
2.12. The total impulse of the launch vehicle is 3694.98 Ns.
2.13. The team will not be using pressure vessels on the vehicle.
2.14. After running simulations on the current design of the launch vehicle, the vehicle has a static stability of 2.0 at the point of rail exit.
2.15. The team will only place structural protuberances of the rocket aft of the burnout center of gravity.
2.16. The team ran simulations to determine that the launch vehicle will accelerate to a velocity of 63.2 fps at rail exit.
2.17. The team will launch and recover a subscale model of the rocket prior to CDR. The team currently has a planned launch date of November 23rd. This date allows time for a back-up launch.
2.17.1. The team will design and manufacture a sub-scale model to reflect the full-scale model that is separate from the full-scale model.
2.17.2. The team will place a Stratologger SL100 in the subscale rocket to record the model's apogee altitude.
2.17.3. The team will construct the subscale rocket for the current year's project.
2.17.4. The team will provide flight data and photo evidence to prove that a successful flight was achieved in the CDR report.
2.18.1. Vehicle Demonstration Flight – the team will successfully launch and recover the full-scale rocket prior to FRR in its final flight configuration. The current launch date is planned for February 15th; the same rocket will be flown on launch day.
2.18.1.1. The vehicle and recovery system will be tested to solve any malfunctions or errors before launch.
2.18.1.2. The team will manufacture the currently designed launch vehicle.
2.18.1.3. The team plans to fly the payload during the full-scale Vehicle Demonstration Flight.
2.18.1.3.1. The team will use mass simulators to simulate the payload mass if it is not flown.
2.18.1.3.2. The team will place mass simulators in the same approximate location on the rocket as the missing payload mass.
2.18.1.4. The team will activate any systems which changes the external surface of the rocket or manages the total energy of the vehicle during the full-scale Vehicle Demonstration Flight.
2.18.1.5. The team will fly the launch day motor for the Vehicle Demonstration Flight.

2.18.1.6. The team will fly the rocket in its fully ballasted configuration during the full-scale test flight.
2.18.1.7. The team will preserve the design of the rocket following full-scale demonstration flight unless the NASA Range Safety Office (RSO) is consulted.
2.18.1.8. The team will provide flight data and photo evidence to prove a successful flight in the FRR report.
2.18.1.9. The team will complete Vehicle Demonstration flights February 15th, well before the FRR submission deadline.
2.18.2. Payload Demonstration Flight – The team will successfully launch and recover the full-scale rocket containing the completed payload February 15th.
The team will ensure the rocket flown will be the same rocket to be flown on launch day.

The following criteria will be met during the Payload Demonstration Flight:
2.18.2.1. The current payload design includes a retention system to ensure the payload will remain inside the vehicle until its intended deployment.
2.18.2.2. The payload will not be flow until it is in its final version.
2.18.2.4. The payload demonstration flight will be completed February 15th during the full-scale launch.
2.19. If the team requires a Payload or Vehicle Demonstration Re-flight, and addendum will be submitted to NASA. A launch date of March 21st has been scheduled to accommodate this.
2.19.1. The team will not fly the vehicle at launch week if unable to submit the FRR Addendum by the deadline.
2.19.2. The team will not fly the payload at launch week despite successfully completing a Vehicle Demonstration Flight if there is a failure to qualify the payload by satisfactorily completing the Payload Demonstration Flight requirement.
2.19.3. The team may petition the NASA RSO for permission the fly the payload at launch week if the Payload Demonstration Flight is not successful.
2.20. The team's name and launch day contact information will be clearly printed in and on the rocket airframe as well as in and on any section of the vehicle that separates during flight and is not tethered to the main airframe in a manner that allows the information to be retrieved without the need to open or separate the vehicle
2.21. The team will not be using Lithium Polymer batteries.
2.22.1. The team will not design or manufacture forward canards on the rocket unless used for camera housing which causes minimal aerodynamic effect on the rocket's stability.
2.22.2 The launch vehicle does not utilize forward firing motors.
2.22.3 The motor uses White Lighting propellant, which does not contain any titanium sponges.
2.22.4 The launch vehicle will use a solid rocket motor.
2.22.5 The launch vehicle utilizes only one motor.
2.22.6. The team will utilize centering rings, a motor retainer and a thrust plate for motors.
2.22.7 The launch vehicle will reach a Mach number of 0.48.
2.22.8 The unballasted launch vehicle weighs 37.0 lbs., while the ballasted launch vehicle weighs 39.8 lbs. The weight of the ballast is 9.4% of the unballasted launch vehicles weight.
2.22.9. The transmitters the team will use do not exceed 250 mW of power.
2.22.10. The team will utilize unique frequencies for transmitters used. Testing will be done to ensure no excessive interference is created.
2.22.11. The team will not use excessive and/or dense metal in the design and construction of the vehicle; the team will minimally use lightweight metal to ensure structural integrity of the airframe under the expected operating stresses.

4.6.3 Recovery System Requirements

3.1. The team will use a Stratologger SL100s which utilizes black-powder ejection charges to deploy the drogue parachute at apogee and the main parachute at 550 feet.

3.1.1. The main parachute will be deployed at 550 feet, with a backup ejection charge firing at 500 feet to ensure deployment.
3.1.2. The drogue parachute will be deployed at apogee, with the backup ejection charge occurring one second after apogee.
3.1.3. Parachute deployment will utilize black-powder ejection charges.
3.2. The team will perform successful ground ejection tests for both the drogue and main parachutes prior to initial subscale and full-scale launches.
3.3. The team will run simulations to ensure that each independent section of the launch vehicle will have a maximum kinetic energy of 75 ft-lbf at landing.
3.4. The recovery system will be controlled by two Stratologger SL100s, each independently powered and operating, and each connected to its own set of ejection charges.
3.5. Each altimeter will be powered by its own 9V battery.
3.6. Each altimeter will be armed by a keylock electrical switch that will be accessible from the exterior of the airframe.
3.7. The key lock electrical switch will be locked in an on-position during flight.
3.8. The recovery altimeters will not be connected in any way to the payload electronics.
3.9. The main and drogue compartments will each be secured by three nylon shear pins.
3.10. The simulated lateral distance is 750ft.
3.11. Descent time is 83.5 seconds
3.12. A GPS tracking unit will be on board the rocket and located in the nosecone.
3.12.1. The rocket will be tethered together as one piece upon landing and will contain a GPS tracking unit.
3.12.2. The GPS tracking unit will be powered on and tested prior to flight for functionality.
3.13. The recovery electronics will be in their own compartment during flight and will be shielded from all other onboard electronic equipment.
3.13.1. The GPS tracking unit will be stored away from the altimeters in the nosecone. The payload electronics will be stored in the upper airframe.
3.13.2. The upper avionics bulkhead will be wrapped in a layer aluminum foil to block any interferences from the GPS unit or payload electronics.
3.13.3. See 3.13.2.
3.13.4. See 3.13.2.

4.6.4 Payload Experiment Requirements

4.2. The team will design a remote-controlled quadcopter UAV with a device capable of scooping and retaining simulated lunar ice. A robust retention system will be designed such that the payload cannot exit the airframe and the UAV will be secure inside the payload bay. The UAV will be registered with the FAA because it will be over 0.55 lbs. in weight.
4.3.1. All components for the UAV and retention system will begin and remain inside the airframe until landing.
4.3.2. The UAV will be equipped with a semi- cylindrical ice container with a servo motor to scoop up and retain the simulated ice. A camera will be used for an RC pilot to locate a nearby ice patch.
4.3.3. The ice container will be at least 20 ml in volume to ensure at least 10 mL of ice will be recovered.
4.3.4. The container will close as it finishes scooping the sample, ensuring retention of the sample.
4.3.5. The team will register the UAV with the FAA and will ensure the payload adheres to all FAA and NAR rules.
4.3.6. A mechanical deployment system will be used on the ground.
4.3.7. A robust rail and brake system will be designed and tested to ensure retention of the payload.
4.3.7.1. A mechanical system using significant positive mechanical engagement will be used to retain payload

4.3.7.2. The retention system will be designed with flight forces in mind, and a suitable factor of safety will be implemented.
4.3.7.3. The system will be tested repeatedly to ensure there will be no failures during competition.
4.3.7.4. Shear pins will not be responsible for retaining the payload
4.4.1. The team will use a ground deployment.
4.4.2. The team will use ground deployment.
4.4.3. The team will abide by all FAA regulations.
4.4.4. The team will register the UAV with the FAA because it will weight over 0.55 lbs.

4.6.5 Safety Requirements

5.1. The safety officer will create a launch and safety checklist.
5.2. The team's safety officer will be Chas Wilson.
5.3.1.1. All designs of the vehicle and payload will be reviewed by the team's safety officer.
5.3.1.2. The safety officer or a safety steward will be present during any construction activities.
5.3.1.3. The safety officer will be present during the assembly of the vehicle and payload.
5.3.1.4. The safety officer will be present during the testing of the vehicle and payload.
5.3.1.5. The safety officer will accompany the team to any subscale launches.
5.3.1.6. The safety officer will accompany the team to any full-scale launches.
5.3.1.7. The safety officer will accompany the team to launch day.
5.3.1.8. The safety officer will be present during any recovery activities.
5.3.1.9. The safety officer will be present during any STEM engagement activities.
5.3.2. The safety officer will create and disseminate to the team, safety procedures to be followed whenever construction, assembly, launch, and recovery activities occur.
5.3.3. The team will create hazard analyses, failure mode analyses, procedures, and MSDS/chemical inventory data at the beginning of the design phase and will continuously update the documents as the designs develops.
5.3.4. The safety officer will oversee the safety documentation.
5.4. The team will do research and contact the local rocketry club for their rules during test flights. The team will design the vehicle around the rules set for the rocketry club. The team will also be in contact with the local rocketry club to make them aware of the launch dates the team will be attending.
5.5. The team's safety officer will do research and educate the team on the FAA rules that will affect the design.

4.7 Major Technical Challenges and Solutions

4.7.1 Predicted Payload Challenges and Solutions

The team predicts that overcoming the task of deploying the payload will be the most difficult part of the project. To ensure the team can overcome this challenge, many designs will be considered and compared to determine the most efficient. Once the best design is chosen, the team will perform many tests to prove that the payload can deploy out of the body tube as it is intended to do. The team will also test the retention system repeatedly to ensure it will not prevent the payloads deployment.

4.7.2 Predicted Manufacturing Challenges and Solutions

The student shop and rapid prototyping lab is shared with several student organizations and can be used by individuals for other projects or classes. As a result, availability of equipment is limited. To ensure the team will manufacture the required parts in time, a manufacturing schedule will be created to optimize time spent in the student shop. Requests for 3D printed parts will be sent to the queue ahead of schedule and relations with lab technicians will be maintained to ensure the parts are received on time.

New members may not have the required experience to safely operate equipment. The team will hold workshops for inexperienced members to teach proper operation and procedure of equipment in the lab. These workshops will cover safety, machining basics, drawing analysis and machining practice.

4.7.3 Predicted Modeling and Simulation Challenges and Solutions

Due to the limitation of OpenRocket and of the competition, its naturally impossible to get a 100% accurate simulation of the flight of the rocket. Factors include wind conditions, variability in the simulation, and a lack of accurate drag coefficients for the entire rocket. The main objective forward will be to minimize these factors by using MATLAB and SolidWorks simulations to determine which configurations and designs of the rocket and fins will produce the most stable and precise flight.

5. STEM Engagement

Science, technology, engineering, and math (STEM) are fundamental to the advancement of human knowledge and understanding of the world around us. Progress in these fields occurs from the joint efforts of a multitude of people from various cultures, backgrounds, and ages. The Swamp Launch Rocket Team at the University of Florida believes the future of human advancement lies in instilling future generations of students with a passion towards STEM. Our Educational Engagement division seeks to use rocketry as a medium to educate and encourage further study of STEM topics within the Alachua county community and with students.

5.1 Engagement at Local Schools and Youth Groups

The Swamp Launch Rocket Team's history of working with Alachua County Public Schools and local community youth groups allows us to engage with young students and promote STEM learning opportunities in both traditional and nontraditional learning environments. We strive to provide age-appropriate lessons on physics, aerodynamics, and engineering design while also allowing students to engage in hands-on activities that promote creativity and critical thinking. Schools and youth groups are presented an overview of rocketry, our team's rocket building process, and videos of our team's earlier launches and past competition rockets. Students will be able to interact with the rockets from the videos depending on location.

Younger students' (K-2) hands-on activities focus on designing a space vehicle capable of adapting to specific environmental challenges. Students are broken up into teams with a member of the Rocket Team and each team receives a list of "facts" about a fictional planet. These age-appropriate "facts" describe many challenges that a space vehicle may have to overcome such as increased gravity, extreme cold, etc. Each team draws their design and receives some input from their respective Rocket Team member. At the end of the hands-on activity, the teams will present their drawing while elaborating on their design choices. This project will promote teamwork and the understanding of the basics behind the engineering design process.

Our largest engagement group, grades 3-12, will design and build a bottle rocket. Once again, students will be split into small teams and are assigned a Rocket Team member. Each team will then be given simple components: construction paper, tape, Popsicle sticks, and a water bottle. Using these materials and the rocketry information presented during the lecture segment of the event, each team will construct their own bottle rocket. Rocket Team members will provide guidance to the students based on age, with younger students receiving more input. Once all rockets have be created, the students will be led outside to a preconstructed launch pad that will launch the rockets using water and pressurized air from a manual pump. The water fills a small portion of the bottle to help visualize thrust during the launch. Depending on the age of the student, the manual pump may be operated by a Rocket Team member or one of the students. Each rocket will be judged based on criterion such as stability and maximum height. Time depending, each team may observe their rocket's performance and redesign some elements for a second launch. The team whose rocket scores the highest cumulative score will receive a small, age-appropriate prize. This activity highlights the aerodynamic and rocketry sections of the lecture while also heavily encouraging the engineering design process, as students are required to make design decisions to accomplish a specific objective, evaluate their initial results, and make design changes to reach their objectives in the future.

5.3 Engagement at the University of Florida

The Swamp Launch Rocket Team plans to promote on-campus engagement in two main forms; collaborations and General Education Meetings (GEMs).

Because of the diverse backgrounds of our members, our team has ties to many different societies at the University of Florida. We plan to use these ties to host joint events and give presentations at functions hosted by at least one of the following organizations: the American Institute of Aeronautics and Astronautics (AIAA), the American Society of Mechanical Engineers (ASME), the National Society of Black Engineers (NSBE), the Society of Women Engineers (SWE), the Society of Hispanic Professional Engineers (SHPE), Solar Gators, and/or Gator Motor Sports. These societies host shadowing events with local high schoolers. We plan to assist in these events by having Rocket Team members bring these high school students to their various classes to learn about college level engineering courses and college in general. After attending some college classes, these students will be able to interact with past competition rockets, observe high-power rocket models created by our team members, and learn about the various systems of the rocket from experienced members of the Rocket Team. A live demonstration or bottle rocket competition may occur depending on location.

In addition to collaborating with the many societies and clubs on campus, the Rocket Team plans to collaborate with the neighboring children's hospital. UF Health Shands Children's Hospital offers pediatric care to ill and injured children from across the nation. We want to provide a positive learning environment and offer fun hands-on activities to the children receiving treatment at the hospital. The same lesson plan from our local school engagements will be used to educate the patients on aerodynamics, physics, and engineering design. We would also allow patients to interact with a past competitions rocket if permitted within the hospital. Because most patients will not be able to leave the hospital and limitations in the surrounding areas, a bottle rocket competition will not be held. Instead, patients will create rocket-themed arts and crafts projects such as drawings or paper models of a rocket designed by the student based on the knowledge gained from the lecture. The goal of these arts and crafts projects is to promote creativity and design skills while also giving patients items that can be used to decorate their hospital room.

General Education Meetings (GEMs) are a lecture series presented by the Rocket Team leadership to educate our members about every aspect of rocketry in a casual setting that allows for discussion and more personalized learning. There is not a class offered at the university that adequately explains all the systems involved in rocketry, so we give our members the opportunity to learn and further their own education without the pressure of grades and exams. The GEM is highly encouraged for all our new members but is not exclusive to just them. Any UF student interested in rocketry or STEM in general is welcome to attend. Upon the completion of the GEM series, participants will have all the knowledge to complete their Level 1 High Powered Rocketry Certification from the National Association of Rocketry.

5.4 Online Engagement

All the team's GEM lectures will be posted online, creating a database for rocketry basics that will be accessible by anyone. In addition to this, all educational presentations done at local schools will be available on the website as well as other educational tools and information, like NASA's own education database.

6. Project Plan

6.1 Development Timeline

The team will follow a strict schedule that will be implemented using Microsoft Teams. Each design lead has been assigned tasks that need to be completed by a specific date for the team to stay on schedule. Below is a tentative task list created for the team to stay on schedule for the project (Table IX.). The team has also created a Gantt chart using Microsoft Excel. The chart will be followed by everyone to ensure everyone stays on schedule (Fig. 27). Most of the tasks are due on every Tuesday, the reason for this is the design leads have weekly meetings with the project manager to ensure they are staying on track with the schedule. The design leads will complete these assignments with help from the general body members by having sub-team meetings once a week. The team has planned meeting times with the sub-teams as follows:

- Structures: Thursdays at 6pm
- Payloads: Thursdays at 7pm
- Propulsion and Modeling & Simulations: Thursdays at 5pm
- Avionics and Recovery: Tuesdays at 5pm
- Testing: Tuesdays at 6pm

Table IX Swamp Launch Rocket Team Design Leads Task Due Dates and Assignments

Date	Assignment
August 22nd	RFP Released – begin brainstorming
August 29th	• General OpenRocket design due • General idea for the payload design established
September 5	• Starting baseline vehicle dimensions due • Preliminary material selection for the vehicle due
September 10th	• Final draft of OpenRocket vehicle design due • CAD model of projected payload due • Motor selection with simulations due • Materials list due • Recovery system design due
September 13th	Proposal due to project management, faculty advisor, and mentor for review
September 18th	Proposal due to NASA
September 24th	Begin design matrices to decide which design is appropriate for each sub-system
October 1st	• Descriptions of each different subsystem designs due • Justifications for each design choice due (design matrix)
October 8th	• Have vehicle dimensions finalized • Begin flight simulations • Have materials for vehicle finalized • Begin FMEA's for each subsystem

October 15th	• FMEA's due • Recovery system finalized • Avionics CAD model due • Wiring schematics for avionics due • Final selected payload CAD model due
October 22nd	• Final altitude target choice due • Flight simulations due • Descriptions of changes made since proposal due
October 23rd	PDR due to project manager for review
October 25th	PDR due to team advisor and mentor for review
October 28th	PDR presentation slides due to project manager
November 1st	PDR due to NASA
November 4th	• Be prepared for PDR presentation • Begin final vehicle CAD model • Have final materials list • Begin submitting purchase orders
November 9th	Begin construction of sub-scale vehicle
November 12th	• Start flight simulations on final vehicle design • Run flight simulations on sub-scale vehicle • Begin recovery system final sketches and electrical schematics • Begin final wiring schematic for payload • Begin writing justifications for all material and electrical components chosen
November 19th	• Recovery system tasks due • Flight simulations for sub-scale vehicle due • Be close to done with manufacturing the sub-scale vehicle
November 22nd	• Sub-scale vehicle construction completed • Avionics and recovery systems tested and ready for launch by today
November 23rd	Potential Sub-Scale Launch Day
November 26th	• Analysis of sub-scale vehicle flight results due • Begin making necessary changes to the vehicle based on sub-scale launch • Begin making predictions for full-scale vehicle based on sub-scale launch • Final payload electronics schematic and justifications due
December 3rd	• Begin constructing the payload • Make edits to FMEA based on sub-scale launch

December 10th	Entire vehicle design should be completed by today Have most of the CDR report finished by now, anything not completed needs to be completed over winter break
January 1st	CDR due to project manager for review
January 3rd	• CDR due to faculty advisor and mentor for review • Finalize presentation
January 10th	Turn in CDR to NASA
January 13th	Be prepared for presentation to NASA
January 14th	• Begin working on FRR • Begin constructing full-scale vehicle • Finalize full-scale flight simulations • Have payload constructed • Begin testing the payload
January 21st	• Have the full-scale vehicle construction halfway done • Update CAD model for rocket changes made during construction • Payload testing completed and begin making necessary edits
January 28th	• Test payload again after edits made • Have recovery system finalized, begin testing
February 4th	• Recovery subsystem edited to accommodate errors in test • Payload in final configuration (ready for launch)
February 11th	• Have full scale vehicle finished completely and ready for launch • Flight simulations need to be completed
February 15th	Potential full-scale vehicle launch date
February 18th	• Review full-scale vehicle launch flight data and begin analysis for predictions • Update payload if complications during launch • Begin making any necessary design changes based on full-scale vehicle test launch • Create flysheet
February 21st	FRR due to project manager for review
February 24th	• FRR due to faculty advisor and mentor for review • Flysheet completed • Presentation completed

March 2nd	• FRR due to NASA • Flysheet due to NASA • Vehicle demonstration flight due to NASA • FRR presentation due to NASA
March 6th	Be ready for presentation
March 10th	Begin reconstruction rocket or payload if first full scale vehicle launch was a failure
March 21st	Full scale launch for addendum if first launch is a failure
March 23rd	Addendum due to NASA
March 24th	• Have flight simulations completed based on full-scale launch • Vehicle should be completely assembled and ready for launch for competition • Have list of design changes completed • Create pre-flight checklist and flysheet
March 27th	Have all preparations for LRR completed
April 1st	Competition begins
April 7th	Begin PLAR
April 17th	PLAR due to project manager for review
April 20th	PLAR due to faculty advisor and mentor for review
April 27th	PLAR due to NASA

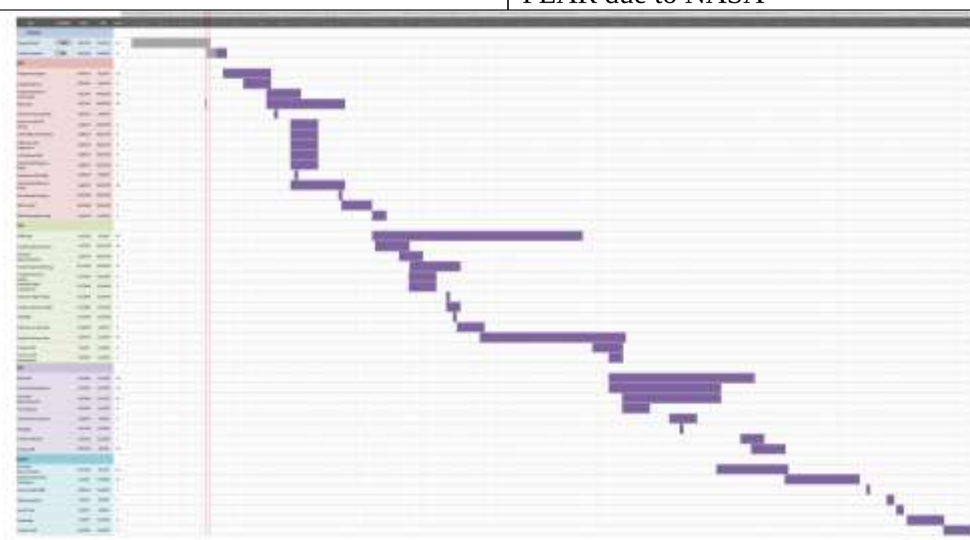

Figure 27 The Gantt chart the team will be using to stay on schedule

6.2 Detailed Budget

Our budget for 2019-2020 is estimated to be just over $7,500, as shown below (Fig. 28), (Table X-XVIII). This budget is based off previous years' budgets, accounting for inflation, and the components we will need for each full-scale rocket subgroup. These components are listed below. Travel and our sub-scale rocket cost us a significant part of our budget. The costs for these two categories are detailed after each full-scale subgroup component breakdown.

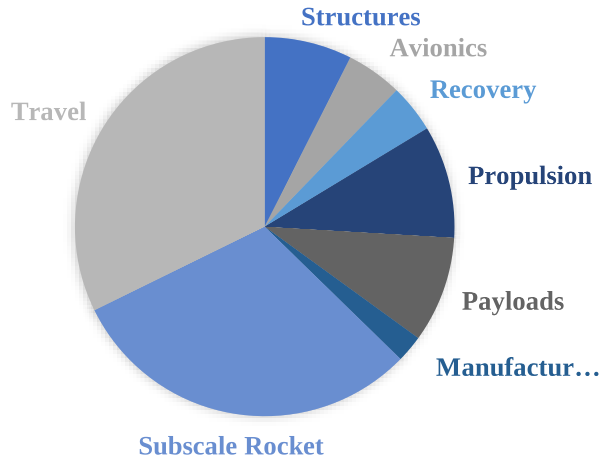

Figure 28 Budget Breakdown Visual

Table X Total Project Cost

Category	**Total Cost ($)**
Full-Scale Rocket	2,685
Travel	3,800
Sub-Scale Rocket	650
Testing	400
Total:	**7,535**

Table XI Full-Scale Budget Breakdown and Total

Subgroup	**Total Cost ($)**
Structures	770
Avionics	50
Recovery	175
Propulsion	690
Payloads	700
Manufacturing	300
Total:	**2,685**

Table XII Structures Component List Estimates

Component	**Quantity**	**Total Cost ($)**
Nose Cone 5.5" G12	1	85
5.5" G12 Airframe	2	365
5.5" G12 Coupler	1	70
G10 Sheet 1ft^2 * 1/8"	5	140
Bulkhead	4	40
Shear Pins	1	4
Rivets	2	8
5.5" Thrust Plate	1	57
Structures Total Cost:	**$769**	

Table XIII Propulsion Component List Estimates

Component	Quantity	Total Cost ($)
L1150 Motor	2	435.48
75 mm Forward Enclosure	1	99.69
3 in. G12 Fiber glass 60"	1	100
Aerotech 75mm Retainer	1	51
Propulsion Total Cost:	**$686.17**	

Table XIV Payloads Component List Estimates

Component	Quantity	Total Cost ($)
DC Motors for Propellers	4	80
Servo Motor	1	20
PixHawk Mini 4	1	215
Receiver/Controller	1	60
LiPo Battery	1	40
AV Transmitter/Receiver	1	30
Camera	1	30
BEC	1	15
Electronic Speed Controllers	5	50
6" Propellers	1	15
Heat Shrink	1	10
Stepper Motor	1	60
Servo Motor	1	20
Micro Controller	1	20
Altitude Sensor	1	15
Deployment LiPo Battery	1	20
Payloads Total Cost:	**$700**	

Table XV Avionics Component List Estimates

Component	Quantity	Total Cost ($)
StratoLogger SL100 Altimeter	2	0 (in inventory)
9V Battery Terminal	2	12.86
1/2" PVC Cap (Black powder charge well)	4	4.00
Lock Switch	2	15
GPS Tracker	1	12.99
Avionics Total Cost:	**$44.85**	

Table XVI Recovery Component List Estimates

Component	Quantity	Total Cost ($)
18x18 Nomex	1	10.95
9x9 Nomex	1	7.21
LOC 78" Parachute	1	69.95
30" Drogue Parachute	1	28.5
3/4" Recovery Harness	(50 ft worth)	50
U Bolt	3	2.64
Eye Bolt	1	0.93
Recovery Total Cost:	**$170.18**	

Table XVII Travel Costs

	Total Cost ($)
Gas for 5 Cars	700
4 Large Hotel Rooms (sleeps 5 people each)	3,100
Total Travel Cost:	**3,800**

Table XVIII Sub-scale Rocket Cost

Components	**Total Cost ($)**
3" Fiberglass Nosecone	32.19
2 3" G12 Airframes	189.6
3" G12 Coupler	27.3
2 G10 Sheets 1ft^2 * 1/8"	56
Shear Pins	4
2 Rivets	8
3 U Bolts	2.64
Eye Bolt	0.93
24-inch drogue	10
36 inch main	17.67
3/4" Recovery Harness	50
J420R Motor	76.49
38mm Forward Enclosure	34.2
30 in 38 mm G12	32
38mm Retainer	27.78
3 in Thrust Plate	31.38
Total Sub-Scale Cost:	**$600.36**

6.3 Detailed Funding Plan

The team is being funded primarily by University of Florida's Department of Mechanical and Aerospace Engineering. The team aims to limit complete reliance on funds from UF's MAE Department by attempting to receive corporate sponsorships. These sponsorships will range from $250 to $1,000 and perhaps more. Funds will first be received by our educators Dr. Niemi and Dr. Lind and will then be allocated to our team as needed by our Treasurer and our other Student Team Leaders.

6.4 Sustainability

The team will host weekly General Body Meetings that will include a lecture series for the education of new members. The topics covered will include modeling and simulation, avionics and recovery, propulsion, and other aspects of rocket design and construction. By providing a source of learning for our members, the team is training their future leadership and ensuring that all members, regardless of sub-team, have a well-rounded basis in rocketry and engineering practices. The meetings will also engage members and inform them of the activities of the sub-teams. New members will be recruited through a variety of advertising methods such as social media, event tabling, flyers, announcements at the beginning of class lectures, and joint events with other design teams. Most funding will be provided by UF's MAE

Department, Swamp Launches' number one partner, which has proved to be stable. However, the team will still seek corporate sponsorships as a secondary form of funding. The team will provide many STEM engagement activities by visiting local elementary and middle schools and teaching the students about rocketry.

7. Conclusion

This document declares the Swamp Launch Rocket Team from the University of Florida's intent to participate in the NASA Student Launch Competition. The team intends to meet the overall mission by creating a payload that will be a UAV that can scoop up the simulated lunar ice. The team will continue to develop the designs until announcements have been made of accepted proposals.

8. References

[1] http://www.mae.ufl.edu/sites/default/files/MAE_SP16_Final.pdf
[2] http://www2.mae.ufl.edu/designlab/Photos/Facility/Current/IMG_3877.JPG
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