NASA STUDENT LAUNCH 2019

PROPOSAL

9/19/2018

SOCIETY OF AERONAUTICS AND ROCKETRY

4202 East Fowler Avenue, MSC Box #197

Tampa, Florida 33620

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1 TEAM SUMMARY

1.1 TEAM NAME & MAILING ADDRESS

Society of Aeronautics and Rocketry (SOAR) at University of South Florida (USF)

4202 East Fowler Avenue MSC Box 197
Tampa, Florida 33620
www.usfsoar.com
contact@usfsoar.com

1.2 TEAM PERSONNEL

1.2.1 PRIMARY LEADERSHIP

1.2.1.1 TEAM MENTOR

Jim West

Member, Tripoli Advisory Panel
Tripoli Member #0706 (Certification Level III)
(863) 712-9379, jkwest@tampabay.rr.com

1.2.1.2 FACULTY ADVISOR

Dr. Manoug Manougian

Director, USF STEM Education Center; Professor, USF College of Arts & Sciences
(813) 974-2349, manoug@usf.edu

1.2.1.3 TEAM ADVISOR

The Team Advisor is a SOAR Executive Board member and acts as a liaison between the NASA Student Launch competition team, the SOAR Executive Board, and external organizations.

Ashleigh Stevenson

Chief of Operations, SOAR Executive Board
Undergraduate Senior, Mathematics
(727) 470-8081, astevenson1@mail.usf.edu

1.2.1.4 PROJECT MANAGER

The Project Manager directly oversees project operations and sub-team collaboration.

Evan Williams

Undergraduate Junior, Mechanical Engineering
(570) 691-8872, evanwilliam@mail.usf.edu

1.2.1.5 SAFETY OFFICER

Ashley de Kort

Undergraduate Junior, Mechanical Engineering
(786) 521-0404, ashleydekort@mail.usf.edu

1.2.2 TEAM STRUCTURE AND MEMBERS

1.2.2.1 ORGANIZATION CHART

Figure 1 shows all active student and advisory members of SOAR's 2019 NASA Student Launch Team. This chart is expected to grow significantly as the team continues to recruit (see 8.3.3 Recruitment for details).

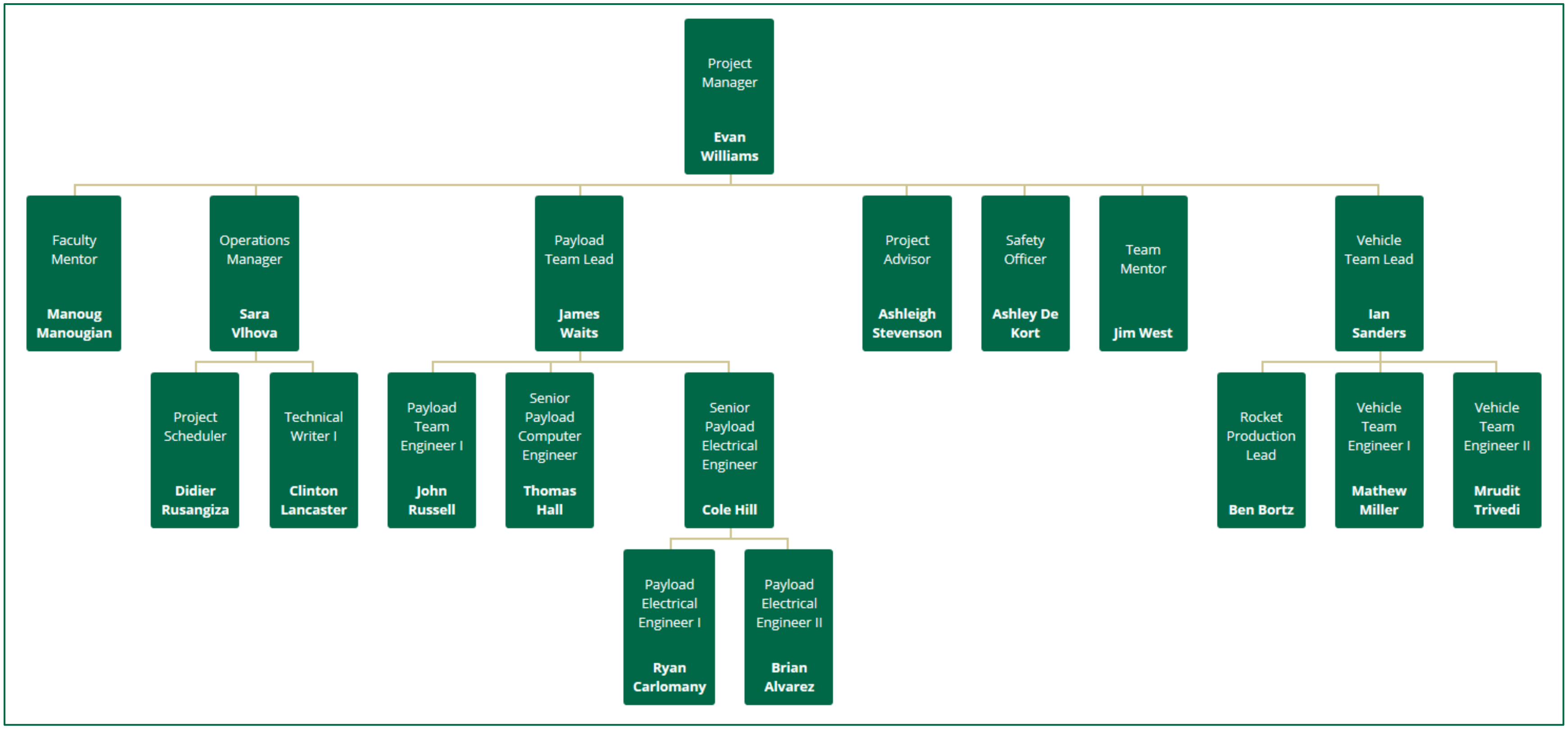

Figure 1: Team members and leadership structure.

1.2.2.2 TEAM MEMBERS

SOAR's 2019 NASA Student Launch Initiative Team consists of 15 currently active student members.

Team managers and leaders take attendance at each team meeting to ensure team members are engaged throughout the academic year. Attendance records are kept on BullSync, USF's distribution of the OrgSync student organization management software.

1.2.2.3 FOREIGN NATIONAL TEAM MEMBERS

Names and required information for foreign national team members will be submitted to the NASA Student Launch Team no later than submission of the Preliminary Design Review.

1.2.2.4 TRAVEL TEAM MEMBERS

Names and required information for team members traveling to competition week in Huntsville, AL will be submitted to NASA no later than submission of the Critical Design Review.

1.3 NAR[1]/TRA[2] AFFILIATES

The Society of Aeronautics and Rocketry at the University of South Florida will seek guidance and collaboration with the Tampa Bay prefecture (#17) of the Tripoli Rocket Association for the designing and construction of this year's NSL rocket. The local TRA chapter also provides a site in Plant City, FL for our sub-scale and full-scale launches under experienced supervision.

Tripoli Tampa Rocketry Association (TTRA)

P.O. Box 984
Kathleen, FL 33849
www.tripoli-tampa.com
ttra@earthlink.net

2 FACILITIES AND EQUIPMENT

2.1 FACILITIES WITH AVAILABLE EQUIPMENT

2.1.1 USF DESIGN FOR X (DFX) LABS

2.1.1.1 DESCRIPTION

Located within the ENB engineering building, this space is designed for engineering organizations and clubs on campus by providing a clean and effective workspace for projects. Tools

[1] NAR: National Association of Rocketry
[2] TRA: Tripoli Rocket Association

and equipment are found here, from screwdrivers and hammers to 3D printers. SOAR will utilize this space for meetings and rocket/payload construction.

2.1.1.2 EQUIPMENT

- LPKF ProtoMat S63 PCB[3] Milling Machine
- Benchman MX CNC Milling Machine
- FSLaser – Pro LF 36 Laser Cutter
- MakerBot – Replicator 3D Printer
- MakerBot – Replicator Z18 3D Printer
- MakerBot – Replicator 2X 3D Printer
- Stratasys – uPrint SE PLUS 3D Printer
- Misc. Power Tools
- Compressed Air
- Power Drops
- Wi-Fi/Wired Internet
- Function Generators
- Network Analyzers
- Solder Station
- Hot Air Rework Tool
- Mixed Domain Oscilloscope
- Multimeter
- LCR[4] Meter
- Frequency Counter
- Fume Extractor
- Electronics Vice
- Dremel Tool
- Arbitrary Waveform Generators
- Vacuums
- Work Benches
- Vinyl Cutter
- MakerBot 3D Scanner
- General Purpose Computers
- Drafting/design workstations
- Paper Cutter
- Haptic Devices
- Small Hand Tools
- Powered Hand Tools
- 3D Printers
- Laser Cutters
- Lathe

2.1.1.3 HOURS

The DFX Labs are open Monday – Friday, 7:00 am to 5:00 pm.

2.1.1.4 PERSONNEL

Michael Celestin, Ph.D.

Senior Lab Manager, USF Design for X Labs
(813) 974-5186, mcelesti@mail.usf.edu

2.1.2 ENGINEERING RESEARCH BUILDING (ENR)

2.1.2.1 DESCRIPTION

This is a workspace dedicated to engineering groups and organizations on campus. The open floor plan and adequate space will make for a comfortable and effective build environment.

[3] PCB: Printed Circuit Board
[4] LCR: Inductance (L), capacitance (C), and resistance (R)

It is located just north of the Marshall Student Center, a center point of the campus. Only basic tools are provided.

2.1.2.2 EQUIPMENT

- Small Hand Tools
- Powered Hand Tools
- Drill Presses
- Manual Milling Lathes
- Buffer
- Cold Saw
- Shear
- Arbor Press
- Band Saw

2.1.2.3 HOURS

ENR is open Monday – Friday, 9:00 am to 3:00 pm, however SOAR is permitted after-hours access when necessary.

2.1.2.4 PERSONNEL

Akari Devonish

Chief of Safety, USF Society of Aeronautics and Rocketry (SOAR)
Undergraduate Junior, Finance
(813) 418-2127, akari1@mail.usf.edu

2.1.3 COLLEGE OF ENGINEERING MACHINE SHOP (ENG)

2.1.3.1 DESCRIPTION

The USF College of Engineering Machine Shop provides custom services to student clubs and projects. A machining facility and woodshop run by professional machinists with over 70 years in experience, they can meet numerous design needs requiring precise cutting and quality materials.

2.1.3.2 EQUIPMENT

- CNC Milling Machines
- CNC Lathe Manual Milling Machines
- Manual Milling Lathes
- Surface Grinder
- Radial Arm Drill Press
- Vertical Band Saw
- Horizontal Band Saw
- Cold Saw
- Abrasive Cut-Off Saw
- Oxy-Acetylene Torch
- Plasma Cutter
- TIG Welder
- MIG Welder
- Stick Welder
- Hand-Held Spot Welder
- Shear
- Bending Brake
- Beverly Shear
- Tubing Bender
- Notcher
- Drill Press
- Arbor Press
- 17.5-Ton Hydraulic Press
- Buffer
- Drill Grinder

2.1.3.3 HOURS

The Machine Shop operates Monday – Thursday, 7:30 am to 12:00 pm and 1:00 pm to 4:30 pm. On Fridays, the shop hours are 7:30 am to 12:00 pm and 1:00 pm to 4:00 pm

2.1.3.4 PERSONNEL

Chris Taylor

Facilities and Safety manager, USF College of Engineering
(813) 974-5451, cmtaylor2@usf.edu

Tony Villicana

Senior Research Machinist, USF College of Engineering Machine Shop
(813) 974-1471, avillica@usf.edu

Chester Tamawa

Research Machinist, USF College of Engineering Machine Shop
(813) 974-1471, czeslaw@usf.edu

2.1.4 VARN RANCH (PLANT CITY, FL)

2.1.4.1 DESCRIPTION

This is the official launch site of the Tampa Tripoli Rocket Association, and where SOAR's largest rockets have flown. The area has a 10,000 ft. waiver, well over the project parameters for launching the NSL rocket. Our mentor from the Tripoli Rocket Association, and his fellow colleagues will supervise and enforce TRA launch rules and protocol. Only essential launch equipment is provided.

2.1.4.2 EQUIPMENT

- Launch Rails
- Launch System Electronics

2.1.4.3 HOURS

The Tampa chapter of the Tripoli Rocket Association holds launch days on the third Saturday of every month, 9:00 am - 3:00 pm.

2.1.4.4 PERSONNEL

Jim West

President, Tampa Tripoli Rocketry Association
(863) 712-9379, jkwest@tampabay.rr.com

Rick Waters

Prefect, Tampa Tripoli Rocketry Association
(813) 226-7570, rick@theo-group.com

2.1.5 NEFAR LAUNCH SITE (BUNNELL, FL)

2.1.5.1 DESCRIPTION

The Northeast Florida Association of Rocketry (NEFAR) is a location and launch site for Chapter 563 of the National Association of Rocketry, and Chapter 35 of the Tripoli Rocket Association. This launch site has waivers for altitudes up to 10,000 feet, and regularly collaborates with student and recreational rocket clubs. The NEFAR site has both TRA and NAR personnel to supervise and enforce the rules of safety.

2.1.5.2 EQUIPMENT

- Launch Rails
- Launch System Electronics

2.1.5.3 HOURS

NEFAR holds launch days on the second Saturday of each month, 10:00 am - 3:00 pm.

2.1.5.4 PERSONNEL

Jim West

President, Tampa Tripoli Rocketry Association
(863) 712-9379, jkwest@tampabay.rr.com

Rick Waters

Prefect, Tampa Tripoli Rocketry Association
(813) 226-7570, rick@theo-group.com

2.1.6 UNIVERSITY OF SOUTH FLORIDA LIBRARY

2.1.6.1 DESCRIPTION

The USF Library lends digital equipment[5] and has available rooms for meetings[6].

2.2 COMPUTER PROGRAMS & AIDS

2.2.1 COMMUNICATION

SOAR uses a number of software tools for communication between members. The organization's primary method of internal communication is Slack, a team collaboration service that enables organized real-time messaging within large groups. SOAR also uses openly visible Google Sheets and Google Docs files to share information such as the current status of the budget in an open and accessible manner. The use of these services has enable the creation of custom integrations with Slack (using Zapier, an integration tool; and Google Apps Script, a cloud platform scripting suite), allowing all members to view and submit important information without ever leaving the Slack app. Furthermore, SOAR uses Google Forms to collect feedback and data in order to gauge the status and performance of the organization.

[5] Details available at: https://www.lib.usf.edu/services/laptop-reserves/
[6] Details available at: https://www.lib.usf.edu/services/study-room-reservations/

2.2.2 DESIGN AND ANALYSIS

SOAR uses the 3D design software SolidWorks, which is provided free of charge by the University of South Florida to all students through the USF Application Gateway. ANSYS Simulation Software is another resource that will be employed, and it is also available to all students. These software allow the team to draft feasible mechanical models as well as engineering analysis simulations rapidly and effectively.

The USF application gateway also provides students with access to MATLAB, a resource that will prove invaluable for data processing and mathematical modelling. All MATLAB code, along with any other code written in the process of this competition, will be hosted publicly[7] using a source control management tool.

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

2.2.3 DOCUMENT DEVELOPMENT

For document development, and storage, SOAR uses organizational cloud storage provided by USF's subscription to the Google Apps suite. This database allows us to instantaneously communicate and work collaboratively on documents and presentations. This free-to-use program gives all users cloud storage and software such as Google Docs, Slides, Forms, even Drawings. Advanced reports are processed in Microsoft Office Word to obtain high-quality, consistent final documents.

2.2.4 SOCIAL MEDIA PRESENCE

SOAR regularly posts updates on its various public social media accounts (listed in Table 1) as its primary means of communicating with those outside the organization. SOAR keeps the following goals in mind when posting online:

- Keep the public and members up to date on current projects
- Inform educators and students of educational outreach programs
- Host articles, pictures, bios, and videos of SOAR team members and officers
- Host pictures, information, and videos on project related events, engagement activities and launches
- Document the progress of projects for future retrieval

[7] Published at: https://github.com/usfsoar

Table 1: SOAR social media presence URLs.

Social Media Application	SOAR Profile URL
BullSync (Accessible by USF Students)	https://orgsync.com/87456/chapter
Facebook	https://www.facebook.com/usfsoar
Instagram	https://www.instagram.com/usfsoar/
Twitter	https://twitter.com/usfsoar
LinkedIn	https://www.linkedin.com/company/usfsoar/

3 GENERAL REQUIREMENTS

Table 2 below, along with Table 3, Table 9, Table 13, and Table 20, list competition criteria from the 2019 NASA Student Launch Initiative Handbook[8] and detail how SOAR plans to meet those criteria. When a requirement is already addressed in another section of this document, a reference is provided.

Table 2: General success criteria and verification of completion.

Requirement	Method	Verification	Verification Status
1.1. Students on the team will do 100% of the project, including design, construction, written reports, presentations, and flight preparation with the exception of assembling the motors and handling black powder or any variant of ejection charges, or preparing and installing electric matches (to be done by the team's mentor).	Documentation	USF SOAR is a student-only organization. Team leads will monitor all operations and construction of the rocket and payload to ensure all work is done by the student members. Safety Officer will monitor that all handling of explosive items, electric matches or igniters, and motor assembly are conducted by the team mentor.	Verified during Project Proposal submission. Will continue to be verified throughout the course of the project until final launch day. Reference: 1.2 Team Personnel; 1.2.1.5 Safety Officer

[8] Available for download at: https://www.nasa.gov/audience/forstudents/studentlaunch/handbook/index.html

Requirement	Method	Verification	Verification Status
1.2. The team will provide and maintain a project plan to include, but not limited to the following items: project milestones, budget and community support, checklists, personnel assignments, STEM engagement events, and risks and mitigations.	Documentation	Team leader and project manager will work with sub-team leaders to construct a project timeline that includes project milestones. Project manager will designate a finance officer to monitor and create the project budget. Safety officer will build checklists, as well as risk/mitigation charts. Project manager will designate an outreach coordinator to build educational engagement opportunities. SOAR has hired a Marketing Manager to handle all community support efforts for the organization and this project. Project manager will maintain an organizational chart of all assigned personnel.	Verified with submission of Proposal. Will continue to be verified throughout the course of the project as more documents are submitted. Reference: 8 Project Plan; 1.2 Team Personnel; 7 STEM Engagement and Outreach; 4.13 Hazard Analysis
1.3. Foreign National (FN) team members must be identified by the Preliminary Design Review (PDR) and may or may not have access to certain activities during launch week due to security restrictions. In addition, FN's may be separated from their team during certain activities.	Documentation	SOAR will submit information on foreign national students no later than submission of the PDR. As of the date of this proposal, two team members are foreign nationals. Team leads will continue to monitor membership and ensure that all foreign national students are recognized.	Will be verified with submission of PDR as stated in requirement. Reference: 1.2.2.3 Foreign National Team Members

Requirement	Method	Verification	Verification Status
1.4. The team must identify all team members attending launch week activities by the Critical Design Review (CDR).	Documentation	SOAR will submit information on team member attendees no later than submission of the CDR.	Will be verified with submission of CDR. Reference: 1.2.2.4 Travel Team Members
1.4.1. Students actively engaged in the project throughout the entire year.	Documentation	SOAR's NSL Team will take attendance at each meeting to ensure team members are actively engaged throughout the academic year. Attendance records will be kept on the SOAR share drive along with a student organization website provided by the university called BullSync where we can record attendance.	Will be verified by CDR. Reference: 1.2.2.2 Team Members
1.4.2. One mentor (see requirement 1.13).	Documentation	SOAR has a designated mentor who meets the requirements of Section 1.13 of the NASA Student Launch 2019 Handbook. Mentor's involvement will be tracked through attendance records at each meeting and build day. Attendance records will be kept on the SOAR share drive along with a student organization website provided by the university called BullSync where we can record attendance.	Will be verified by CDR. Reference: 1.2.2.2 Team Members

Requirement	Method	Verification	Verification Status
1.4.3. No more than two adult educators.	Documentation	SOAR will identify no more than two adult educators who will be attending launch week.	Will be verified by CDR.
1.5. The team will engage a minimum of 200 participants in educational, hands-on science, technology, engineering, and mathematics (STEM) activities, as defined in the Educational Engagement Activity Report, by FRR. An educational engagement activity report will be completed and submitted within two weeks after completion of an event.	Documentation	SOAR has designated an Outreach Coordinator to organize and handle all outreach events. Multiple outreach events are scheduled and the Operations Manager has been designated to schedule further events.	Will be verified by submission of Educational Engagement Activity Reports during report submission period. Reference: 7 STEM Engagement and Outreach
1.6. The team will establish a social media presence to inform the public about team activities.	Documentation	SOAR has established social media accounts on Facebook, Twitter, Instagram, and LinkedIn. The NSL team will utilize these established accounts to inform the public about team activities.	Will be verified throughout the project by submission of posts to various social media accounts. Reference: 8.3.1 Social Media

Requirement	Method	Verification	Verification Status
1.7. Teams will email all deliverables to the NASA project management team by the deadline specified in the handbook for each milestone. In the event that a deliverable is too large to attach to an email, inclusion of a link to download the file will be sufficient.	Documentation	The NSL Team Advisor will be responsible to send the documentation to NASA project management for each milestone.	Will be verified upon submission of documents for each milestone. Reference: 1.2.1.3 Team Advisor, 2.2.3 Document Development
1.8. All deliverables must be in PDF format.	Documentation	The NSL Team Advisor will be in charge of reviewing all documentation before submission and will be in charge of ensuring all deliverables will be in PDF format.	Will be verified upon submission of documents for each milestone. Reference: 1.2.1.3 Team Advisor, 2.2.3 Document Development
1.9. In every report, teams will provide a table of contents including major sections and their respective sub-sections.	Documentation	The NSL Team Advisor will format and submit all documentation and is familiar with the requirement for table of contents, sections, and subsections.	Will be verified upon submission of documents for each milestone Reference: 1.2.1.3 Team Advisor, 2.2.3 Document Development

Requirement	Method	Verification	Verification Status
1.10. In every report, the team will include the page number at the bottom of the page.	Documentation	The NSL Team Advisor will format and submit all documentation and is familiar with the requirement for page numbers.	Will be verified upon submission of documents for each milestone. Reference: 1.2.1.3 Team Advisor, 2.2.3 Document Development
1.11. The team will provide any computer equipment necessary to perform a video teleconference with the review panel. This includes, but is not limited to, a computer system, video camera, speaker telephone, and a broadband Internet connection. Cellular phones can be used for speakerphone capability only as a last resort.	Demonstration	The SOAR team has access to computers, speaker phones, Wi-Fi connection, and a video camera for teleconference purposes.	Will be verified during milestone presentations. Reference: 2.1.6 University of South Florida Library
1.12. All teams will be required to use the launch pads provided by Student Launch's launch service provider. No custom pads will be permitted on the launch field. Launch services will have 8 ft. 1010 rails, and 8 and 12 ft. 1515 rails available for use.	Documentation Demonstration	Launch vehicle will be designed to utilize the standard rails made available on the NSL launch site.	Verified with submission of documents which include launch vehicle design. Reference: 5.3 Vehicle Specifications

Requirement	Method	Verification	Verification Status
1.13. Each team must identify a "mentor."	Documentation Demonstration	SOAR's NSL Team has identified a mentor who meets the qualifications specified in the NASA Student Launch 2019 Handbook. Mentor's involvement will be tracked through attendance records at each meeting and build day. Attendance records will be kept on the SOAR share drive.	Will be verified throughout the course of the project. Reference: 1.2.1.1 Team Mentor; 1.2.2.2 Team Members

4 SAFETY

Safety is a critical and necessary component in any STEM[9] activity, especially the handling and construction of rockets and its hazardous counterparts. The Society of Aeronautics and Rocketry is dedicated to promoting the concept of space exploration through amateur rocketry, while ensuring our members are informed and safe during every process and step.

[9] STEM: Science, Technology, Engineering, & Mathematics

4.1 SAFETY REQUIREMENTS

Table 3: NASA Student Launch required safety criteria and verification of completion.

Requirement	Method	Verification	Verification Status
5.1. Each team will use a launch and safety checklist. The final checklists will be included in the FRR report and used during the Launch Readiness Review (LRR) and any launch day operations.	SOP[10] Documentation	SOAR NSL Team will draft a launch safety checklist for launch procedures through each stage of the competition and will finalize a checklist for FRR.	The most updated checklist will be completed during each and every launch. Safety Officer will supervise all operations using the checklist. Reference: 4.4 Checklists and Procedures
5.2. Each team must identify a student safety officer who will be responsible for all items in section 5.3.	SOP	The Safety Officer has been identified and will ensure safety of participants, spectators and other safety procedures as mentioned in the "Launch Safety" section of NSL Student Handbook. All team activities mentioned in section 5.3 will be supervised to meet specific safety requirements.	Reference: 4.2 Safety Officer Duties & Responsibilities; 1.2.1.5 Safety Officer

[10] SOP: Standard Operating Procedures

Requirement	Method	Verification	Verification Status
5.3. The role and responsibilities of each safety officer will include, but are not limited to:	-	-	-
-5.3.1. Monitor team activities with an emphasis on Safety during: *5.3.1.1. Design of vehicle and payload* *5.3.1.2. Construction of vehicle and payload* *5.3.1.3. Assembly of vehicle and payload* *5.3.1.4. Ground testing of vehicle and payload* *5.3.1.5. Subscale launch test(s)* *5.3.1.6. Full-scale launch test(s)* *5.3.1.7. Launch day* *5.3.1.8. Recovery activities* *5.3.1.9. STEM Engagement Activities*	Inspection Testing	Construction and design of all aspects of the vehicle and payload will meet specific requirements as mentioned in the NSL Student Handbook in Section 2, 3 and 4 and on page 40. Launches will abide through launch site requirements, Federal Aviation Administration (FAA) laws, NAR/TRA requirements and other specifications mentioned in the NSL Student Handbook. STEM Engagement activities will occur throughout the year to gather more spectators to spread knowledge and awareness of STEM to encourage more students to engage in it.	The Safety Officer will keep in contact with all team leads to ensure all activities are running appropriately. Training will be implemented throughout the entire construction of the project to ensure safety of all participants Reference: 4.2 Safety Officer Duties & Responsibilities; 4.3 NAR/TRA Safety

Requirement	Method	Verification	Verification Status
5.3.2. Implement procedures developed by the team for construction, assembly, launch, and recovery activities.	SOP	SOAR NSL Team will draft a launch safety checklist for launch procedures through each stage of the competition and will finalize a checklist for FRR. SOAR has developed a Safety SOP that encompasses all shop operations.	The most updated checklist will be completed during each and every launch. Safety Officer will supervise all operations using the checklist. All SOAR members will abide by the Safety SOP. Reference: 4.4 Checklists and Procedures
5.3.3. Manage and maintain current revisions of the team's hazard analyses, failure modes analyses, procedures, and MSDS/chemical inventory data.	Documentation Inspection	Initial Hazard Analysis is included here and will be updated and reported at future milestones. MSDS/chemical inventory data from will be maintained and update in accordance with Section 4.5 of this proposal and will be updated when new materials will be used. Copies of MSDS will be maintained in all work locations	The Safety Officer will make sure the MSDS/chemical inventory data is up to date and participants are aware of the safety hazards that could occur. Reference: 4.13 Hazard Analysis
5.3.4. Assist in the writing and development of the team's hazard analyses, failure modes analyses, and procedures.	SOP	All hazard analyses, failure modes analyses will be up to date and available to all team members to be able to reference to when working on the project. Participants will be able to reference to the Current and Probable Risk Table.	Safety Officer will be present throughout the construction of the vehicle and payload which will help guide to write and develop all safety documents and procedures. Reference: 4.13 Hazard Analysis

Requirement	Method	Verification	Verification Status
5.4. During test flights, teams will abide by the rules and guidance of the local rocketry club's RSO. The allowance of certain vehicle configurations and/or payloads at the NASA Student Launch does not give explicit or implicit authority for teams to fly those vehicle configurations and/or payloads at other club launches. Teams should communicate their intentions to the local club's President or Prefect and RSO before attending any NAR or TRA launch.	Testing Inspection SOP	Teams will abide by all regulations and requirements of all launch sites, NSL requirements, federal laws and local rocketry club's RSO.	Before proceeding to test flights, all requirements will be inspected to make sure teams are working accordingly. Effective communication will be taken so the project can run smoothly. Reference: 4.3 NAR/TRA Safety
5.5. Teams will abide by all rules set forth by the FAA.	Inspection	Teams will ensure all rules are being me at all times. Participants will be able to reference to the NSL Safety Handbook and the FAA website. The Safety Officer will conduct safety training to include briefings concerning rules and regulations.	Teams will be knowledgeable of all FAA rules. The Safety Officer will ensure these rules are being met throughout the whole timeline of the project. Training records for safety training sessions will be maintained on the SOAR shared drive.

4.2 SAFETY OFFICER DUTIES & RESPONSIBILITIES

The Safety Officer (see 1.2.1.5 Safety Officer for personnel information) will be in charge of ensuring the team and launch vehicle is complying with all NAR safety regulations. The following is the list of the Safety Officer's responsibilities:

1. Monitor team activities with an emphasis on Safety during:
   a. Design of vehicle and payload
   b. Construction of vehicle and payload
   c. Assembly of vehicle and payload
   d. Ground testing of vehicle and payload
   e. Subscale launch test(s)
   f. Full-scale launch test(s)
   g. Launch day
   h. Recovery activities
   i. STEM Engagement Activities
2. Ensure all team members have read and understand the NAR and TRA safety regulations.
3. Provide a list of all hazards that may be included in the process of building the rocket and how they are mitigated, including MSDS[11], personal protective equipment requirements, and any other documents applicable.
4. Compile a binder that will have all safety related documents and other manuals about the launch vehicle.
5. Ensure compliance with all local, state, and federal laws.
6. Oversee the testing of all related subsystems.
7. Ensure proper purchase, transportation, and handling of launch vehicle components.
8. Identify and mitigate any possible safety violations.
9. Identify safety violations and take appropriate action to mitigate the hazard.
10. Establish and brief the team on a safety plan for various environments, materials used, and testing.
11. Establish a risk matrix that determines the risk level of each hazard based off of the probability of the occurrence and the severity of the event. Ensure that this type of analysis is done for each possible hazard.
12. Enforce proper use of PPE[12] during construction, ground tests, and test flights of the rocket.

[11] MSDS: Materials Safety Data Sheet
[12] PPE: Proper Protective Equipment

4.3 NAR/TRA SAFETY

4.3.1 PROCEDURES

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

1. A Level II certified member and an NAR/TRA Personnel will oversee any test launch of the vehicle and flight tests of the vehicle.
2. The launch site RSO[13] will be responsible for ensuring proper safety measures are taken and for arming the launch system.
3. If the vehicle does not launch when the ignition button is pressed, then the RSO will remove the key and wait 90 seconds before approaching the rocket to investigate the issue. Only the Project Manager and Safety Officer will be allowed to accompany the RSO in investigating the issue.
4. The RSO will ensure that no one is within 100 ft. of the rocket and the team will be behind the RSO during launch. The RSO will use a 10 second countdown before launch.
5. A certified member will be responsible for ensuring that the rocket is directed no more than 20 degrees from vertical and ensuring that the wind speed is no more than 20 mph. This individual will also ensure proper stand and ground conditions for launch including but not limited to launch rail length and cleared ground space. This member will ensure that the rocket is not launched at targets, into clouds, near other aircraft, nor take paths above civilians. Additionally, this individual will ensure that all FAA[14] regulations are abided by.
6. Another certified member will ensure that flight tests are conducted at a certified NAR/TRA launch site.
7. The safety officer will ensure that the rocket is recovered properly according to Tripoli and NAR guidelines.

4.3.2 SAFETY CODES

SOAR conducts launches at both NAR[15] and TRA[16] launches, and will abide by the appropriate High-Power Rocketry Safety Code requirements during all operations.

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[13] RSO: Range Safety Officer
[14] FAA: Federal Aviation Administration
[15] NAR Safety Code available in full at: http://www.nar.org/safety-information/model-rocket-safety-code/
[16] TRA Safety Code available for download at: http://www.tripoli.org/Portals/1/Documents/Safety%20Code/HighPowerSafetyCode%20-%202017.pdf

4.4 CHECKLISTS AND PROCEDURES

All launches and launch preparation procedures will be supervised by the Safety Officer and conducted using the relevant checklist, developed by the team and approved by the Safety Officer. In the absence of the Safety Officer, the Project Manager will designate a responsible individual to oversee launch operations with the relevant checklist.

4.5 HAZARDOUS MATERIALS

4.5.1 LISTING OF HAZARDOUS MATERIALS

SOAR will maintain a list of all hazardous chemicals used on-site. The Safety Officer will ensure that material safety data sheets are requested and obtained from the supplier of any new product ordered by the SOAR. The Safety Officer will maintain a master listing of all hazardous materials and MSDS for all materials.

4.5.2 LABELS

Material received by SOAR must have intact, legible labels. These labels must include the following, at minimum:

- The name of the hazardous substance(s) in the container
- A hazard warning
- The name and address of the manufacturer or other responsible party

4.5.3 TRAINING

The Safety Officer will insure that all members at sites where hazardous materials are kept or used receive training on hazardous material handling. The training program will include the following, at minimum:

- The location and availability of the MSDS and files
- Methods and procedures that the employee may use to detect the presence or accidental release or spill of hazardous materials in the work area, including proper clean up
- Precautions and measures employees can take to protect themselves from the hazardous materials

Annual training will be conducted for all members who deal with hazardous materials. Each new member will be trained in the handling of hazardous materials at the possible opportunity. Training must be conducted for all members when any new chemical or hazardous material enters the work site. This training must occur before the chemical or hazardous material is used by any member. After each training session, the trainer will certify a roster of all participants. Included with the roster will be a list of all hazardous materials included in the training.

4.5.4 HEALTH, SAFETY, AND EMERGENCY PROCEDURES

The following information will be available at every work site, if requested or required:

- A list of all hazardous materials used on site
- Unusual health and environmental hazards (both air and water) that may result from the release of specific quantities of hazardous substances

4.6 SAFETY BRIEFING

4.6.1 HAZARD RECOGNITION

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

4.6.2 ACCIDENT AVOIDANCE

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

4.6.3 LAUNCH PROCEDURES

At the team meeting most closely preceding the launch, the Safety Officer will be given time to help the members review launch safety and precautionary measures. Topics discussed at this time include but are not limited to: laws and regulations mandated by the FAA, NFPA[17], NAR, TRA and Florida State Statutes; prohibited launch site activities and behaviors; maintaining safe distances; and safety procedures pertaining to any potentially hazardous chemicals which will be present during the launch. All team leaders must be in attendance at this briefing, and they are obliged to address the other members with any further safety concerns they are aware of that were not mentioned by the Safety Officer. At this time, launch procedures will be scrutinized, paying special attention to the parts involving caution.

[17] NFPA; National Fire Protection Association

4.7 CAUTION STATEMENTS

4.7.1 DEFINITIONS

Warnings, cautions, and notes are used to emphasize important and critical instructions and are used for the following conditions.

4.7.1.1 WARNING

An operating procedure, practice, etc., which, if not correctly followed, could result in personal injury or loss of life.

4.7.1.2 CAUTION

An operating procedure, practice, etc., which, if not strictly observed, could result in damage to or destruction of equipment.

4.7.1.3 NOTE

An operating procedure, condition, etc., which is essential to highlight.

4.8 CHECKLISTS

4.8.1 WARNINGS

Warnings will be typed in **red** and will appear just prior to the step in the checklist to which they apply, the warning will include possible consequences of failure to heed warning and list any appropriate personal protective equipment required.

4.8.2 CAUTIONS AND NOTES

Each checklist will include a column labeled Caution/Note. This column will display the caution or note associated with the relevant step in the checklist. The caution or note will include possible consequences of failure to heed warning and list any appropriate personal protective equipment required. Cautions will be typed in **orange**.

4.9 SAFETY MANUAL

4.9.1 WARNINGS

Warnings will be typed in **red** and will appear just prior to the step, procedure or equipment to which they apply, the warning will include possible consequences of failure to heed warning and list any appropriate personal protective equipment required.

4.9.2 CAUTIONS

Cautions will be typed in **orange** and will appear just prior to the step, procedure or equipment to which they apply, the caution will include possible consequences of failure to heed caution.

4.9.3 NOTES

Notes will be typed in bold **black** and will appear just prior to the step, procedure or equipment to which they apply.

4.10 LEGAL COMPLIANCE

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

4.10.1 FEDERAL AVIATION REGULATIONS (FARS)

- CFR[18] Title 14, Chapter 1, Subchapter F, Part 101, Subpart C: *Amateur Rockets*[19]
- CFR Title 27, Chapter 2, Subchapter C, Part 555: *Commerce in Explosives*[20]
- NFPA 1127: *Code for High Power Rocketry*[21]

4.10.2 STATE OF FLORIDA LAWS AND REGULATIONS

- Florida Statutes Title XXV, Chapter 331: *Aviation and Aerospace Facilities and Commerce*[22]
- Florida Statutes Title XXXIII, Chapter 552: *Manufacture, Distribution, and Use of Explosives*[23]

4.11 PURCHASE, TRANSPORTATION & STORAGE OF MOTOR

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

4.12 STATEMENT OF COMPLIANCE

All team members understand and will abide by the following safety regulations from the 2019 NASA Student Launch Handbook:

1.6.1. Range safety inspections will be conducted on each rocket before it is flown. Each team shall comply with the determination of the safety inspection or may be removed from the program.

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[18] CFR: Code of Federal Regulations
[19] Available in full at: https://www.law.cornell.edu/cfr/text/14/part-101/subpart-C
[20] Available in full at: https://www.law.cornell.edu/cfr/text/27/part-555
[21] Available for download at: https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=1127
[22] Available in full at: https://www.flsenate.gov/Laws/Statutes/2018/Chapter331
[23] Available in full at: https://www.flsenate.gov/Laws/Statutes/2017/Chapter552

1.6.2. The Range Safety Officer has the final say on all rocket safety issues. Therefore, the Range Safety Officer has the right to deny the launch of any rocket for safety reasons.

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

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

4.13 HAZARD ANALYSIS

4.13.1 HAZARD CATEGORIES

4.13.1.1 CONTROLS RISK ASSESSMENT

The hazards outlined in this section will discuss the risks associated with the launch vehicle mechanical and electrical controls. This is critical as failures in any system will result in a failed mission.

4.13.1.2 HAZARDS TO ENVIRONMENT RISK ASSESSMENT

The hazards outlined in are risks that construction, testing or launching of the rocket can pose to the environment.

4.13.1.3 LOGISTICS RISK ASSESSMENT

The hazards outlined are risks to the schedule associated with parts ordering, milestone accomplishment, and project completion. These hazards may also be associated with the physical movement of the launch vehicle from its current location to the launch site.

4.13.1.4 LAUNCH PAD FUNCTIONALITY RISK ASSESSMENT

The hazards outlined are risks linked to the launch pad functionalities.

4.13.1.5 PAYLOAD CAPTURE DEVICE RISK ASSESSMENT

The hazards outlined in this section will discuss the risks associated with the payload capture device. The payload capture device interfaces with multiple systems, making it prone to hazards.

4.13.1.6 RECOVERY RISK ASSESSMENT

The hazards outlined are risks associated with the recovery. Since there are three recovery systems onboard, many of the failure modes and results will apply to all of the systems but will be stated only once for conciseness.

4.13.1.7 SHOP RISK ASSESSMENT

Construction and manufacturing of parts for the rocket will be performed in both on-campus and off-campus shops. The hazards assessed are risks present from working with machinery, tools, and chemicals in the lab.

4.13.1.8 STABILITY AND PROPULSION RISK ASSESSMENT

The hazards outlined are risks associated with stability and propulsion. The team has multiple members of the team with certifications supporting that they can safely handle motors and design stable rockets of the size that the team will be working with. This area is considered a low risk for the team, but it is still important to address any potential problems that the team may face throughout the project.

4.13.2 RISK LEVEL DEFINITIONS

4.13.2.1 SEVERITY

The severity of each potential risk is determined by comparing the possible outcome to criteria based on human injury, vehicle and payload equipment damage, and damage to environment. Severity is based on a 1 to 3 scale, 1 being the most severe. The severity criteria are provided in Table 4.

Table 4: Risk severity level definitions.

Description	Personnel Safety and Health	Facility / Equipment	Range Safety	Project Plan	Environmental
– 1 – Catastrophic	Loss of life or a permanent disabling injury.	Loss of facility, systems or associated hardware that result in being unable to complete all mission objectives.	Operations not permitted by the RSO and NFPA 1127 prior to launch. Mission unable to proceed.	Delay of mission critical components or budget overruns that result in project termination.	Irreversible severe environmental damage that violates law and regulation.
– 2 – Critical	Severe injury or occupational related illness.	Major damage to facilities, systems, or equipment that result in partial mission failure.	Operations not permitted by the RSO and NFPA 1127 occur during launch. Mission suspended or laws and regulations are violated.	Delay of mission critical components or budget overruns that compromise mission scope.	Reversible environmental damage causing a violation of law or regulation.

Description	Personnel Safety and Health	Facility / Equipment	Range Safety	Project Plan	Environmental
– 3 – Marginal	Minor injury or occupational related illness.	Minor damage to facilities, systems or equipment that will not compromise mission objectives.	Operations are permitted by the RSO and NFPA 1127, but hazards unrelated to flight hardware design occur during launch.	Minor delays of non-critical components or budget increase.	Mitigatable environmental damage without violation of law or regulations where restoration activities can be accomplished.
– 4 – Negligible	First aid injury or occupational-related illness.	Minimal damage to facility, systems, or equipment.	Operations are permitted by the RSO and NFPA 1127, and hazards unrelated to flight hardware design do not during launch.	Minimal or no delays of non-critical components or budget increase.	Minimal environmental damage not violating law or regulation.

4.13.2.2 PROBABILITY

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

Table 5: Risk probability levels and definitions.

Description	Qualitative Definition	Quantitative Definition	Let-ter
– A – Frequent	High likelihood to occur immediately or expected to be continuously experienced.	Probability is > 90%	A
– B – Probable	Likely to occur or expected to occur frequently within time.	90% ≥ probability > 50%	B
– C – Occasional	Expected to occur several times or occasionally within time.	50% ≥ probability > 25%	C
– D – Remote	Unlikely to occur, but can be reasonably expected to occur at some point within time.	25% ≥ probability > 1%	D
– E – Improbable	Very unlikely to occur and an occurrence is not expected to be experienced within time.	1% ≥ probability	E

4.13.3 RISK ASSESSMENT LEVELS

Each risk is finally assigned a risk level based upon a combination of the risk severity and probability. These levels range from high (red) to minimal (white) and are assigned using Table 6 and defined in Table 7.

Table 6: Risk assessment classification criteria.

Probability	Severity			
	– 1 – Catastrophic	**– 2 – Critical**	**– 3 – Marginal**	**– 4 – Negligible**
– A – Frequent	1A	2A	3A	4A
– B – Probable	1B	2B	3B	4B
– C – Occasional	1C	2C	3C	4C

Probability	Severity			
	– 1 – Catastrophic	– 2 – Critical	– 3 – Marginal	– 4 – Negligible
– D – Remote	1D	2D	3D	4D
– E – Improbable	1E	2E	3E	4E

Table 7: Risk assessment classifications definitions.

Level of Risk	Definition
High Risk	Highly Undesirable. Documented approval from the RSO, NASA SL officials, team faculty adviser, team mentor, team leads, and team safety officer.
Moderate Risk	Undesirable. Documented approval from team faculty adviser, team mentor, team leads, team safety officer, and appropriate sub-team lead.
Low Risk	Acceptable. Documented approval by the team leads and sub-team lead responsible for operating the facility or performing the operation.
Minimal Risk	Acceptable. Documented approval not required, but an informal review by the sub-team lead directly responsible for operating the facility or performing the operation is highly recommended.

4.13.4 CURRENT AND PROBABLE RISK

A table of potential risks and mitigations has been established based on prior experience and current project plans. This table will continue to be maintained and updated by the Safety Officer throughout the duration of the project.

Table 8: Hazard / risk classifications and mitigations for all project components.

Area	Hazard	Cause	Effect	Pre RAC	Mitigation	Post RAC	Verification
Environmental	Harmful substances permeating into the ground or water.	Improper disposal of batteries or chemicals.	Impure soil and water can have negative effects on the environment that in turn, affect humans and animals, causing illness.	2E	Batteries and other chemicals will be disposed of properly in accordance with the MSDS sheets. Should a spill occur, proper measure are to be followed in accordance with the MSDS sheets and any EHS standards.	2E	MSDS sheets will be kept on hand in the shop and at the launch field.
Environmental	Spray painting.	The rocket will be painted.	Water contamination. Emissions to environment.	3D	All spray painting operations will be performed in a paint booth by trained individuals. This prevents any overspray from entering into the water system or the air.	3E	Paint booth will be marked with appropriate signage for hazardous material. Training will be documented for designated individuals.

Area	Hazard	Cause	Effect	Pre RAC	Mitigation	Post RAC	Verification
Environmental	Plastic and fiberglass waste material.	Plastic used in the production of electrical components and wiring and fiberglass used in production of launch vehicle components.	Plastic or fiberglass material produced when shaving down or sanding components could harm animals if ingested by an animal. Plastic could find its way down a drain and into the water system.	3D	All plastic material will be disposed of in proper waste receptacles. Personnel will used protective equipment when sanding or cutting plastic and fiberglass.	4E	Waste receptacles will be available and properly marked. Protective equipment is on hand.
Environmental	Wire waste material.	Wire material used in the production of electrical components.	Sharp bits of wire being ingested by an animal if improperly disposed of.	3D	All wire material will be disposed of in proper waste receptacles.	4E	Waste receptacles will be available and properly marked.

Area	Hazard	Cause	Effect	Pre RAC	Mitigation	Post RAC	Verification
Logistic	Not enough time for adequate testing.	Failure to create a precise timeline.	Imprecision in the launch vehicle design and less verification of design.	3C	Create a rigorous timeline and ensure everyone stays on schedule. Make due dates at least three days in advance for deliverables. Use shared calendar to keep all personnel apprised of deadlines. A more detailed schedule was created to make sure the team remains on track. Each task has a description and expected deliverables. Full scale completion date moved earlier in the schedule to allow more testing. Alternate launch site (Bunnell) may be used if needed.	3E	Project schedule has been set with sufficient buffer time to absorb delays.
Logistic	Parts ordered late or delayed in shipping.	Long shipping times and delays, failure to order parts in timely fashion.	Project schedule delayed. Selected functions unavailable.	2C	Shared calendar will be used to keep all personnel apprised of deadlines. Reminder notifications will be sent to technical leads well in advance of deadlines. When possible, suitable substitute parts will be maintained on hand. Finance managers will be recruited and trained to track budget and parts ordering.	2E	Project schedule has been shared to all team members.

Area	Hazard	Cause	Effect	Pre RAC	Mitigation	Post RAC	Verification
Shop	Using power tools and hand tools such as blades, saws, drills, etc.	Improper use of PPE. Improper training on the use of equipment.	Mild to severe cuts or burns to personnel. Damage to rocket or components of the rocket. Damage to equipment	3C	Individuals will be trained on the tool being used. Those not trained will not attempt to learn on their own and will find a trained individual to instruct them. Proper PPE must be worn at all times. Shavings and debris will be swept or vacuumed up to avoid cuts from debris.	4D	Training will be documented for designated individuals.
Shop	Sanding or grinding materials.	Improper use of PPE. Improper training on the use of equipment.	Mild to severe rash. Irritated eyes, nose or throat with the potential to aggravate asthma. Mild to severe cuts or burns from a Dremel tool and sanding wheel.	2C	Long sleeves will be worn at all times when sanding or grinding materials. Proper PPE will be utilized such as safety glasses and dust masks with the appropriate filtration required. Individuals will be trained on the tool being used. Those not trained will not attempt to learn on their own and will find a trained individual to instruct them.	4E	Training will be documented for designated individuals.

Area	Hazard	Cause	Effect	Pre RAC	Mitigation	Post RAC	Verification
Shop	Working with chemical components resulting in mild to severe chemical burns on skin or eyes, lung damage due to inhalation of toxic fumes, or chemical spills.	Chemical splash. Chemical fumes.	Mild to severe burns on skin or eyes. Lung damage or asthma aggravation due to inhalation.	2C	MSDS documents will be readily available at all times and will be thoroughly reviewed prior to working with any chemical. All chemical containers will be marked to identify appropriate precautions that need to be taken. Chemicals will be maintained in a designated area. Proper PPE will be worn at all times when handling chemicals. Personnel involved in motor making will complete the university's Lab and Research Safety Course. All other individuals will be properly trained on handling common chemicals used in constructing the launch vehicles.	3E	Training will be documented for designated individuals. Certificates will be kept on file for trained individuals until the individuals graduate and leave the organization.

Area	Hazard	Cause	Effect	Pre RAC	Mitigation	Post RAC	Verification
Shop	Damage to equipment while soldering.	Soldering iron is too hot. Prolonged contact with heated iron.	The equipment could become unusable. If parts of the payload circuit become damaged, they could become inoperative.	3C	The temperature on the soldering iron will be controlled and set to a level that will not damage components. For temperature sensitive components sockets will be used to solder ICs to. Only personnel trained to use the soldering iron will operate it.	4D	Training will be documented for designated individuals.
Shop	Dangerous fumes while soldering.	Use of leaded solder can produce toxic fumes.	Team members become sick due to inhalation of toxic fumes. Irritation could also occur.	3D	The team will use well ventilated areas while soldering. Fans will be used during soldering. Team members will be informed of appropriate soldering techniques.	4E	Training will be documented for designated individuals.
Shop	Overcurrent from power source while testing.	Failure to correctly regulate power to circuits during testing.	Team members could suffer electrical shocks which could cause burns or heart arrhythmia.	1D	The circuits will be analyzed before they are powered to ensure they don't pull too much power. Power supplies will also be set to the correct levels. Team members will use documentation and checklists when working with electrical equipment.	2E	When available, an electrical engineering student will supervise electrical operations.

Area	Hazard	Cause	Effect	Pre RAC	Mitigation	Post RAC	Verification
Shop	Use of white lithium grease.	Use in installing motor and on ball screws.	Irritation to skin and eyes. Respiratory irritation.	3D	Nitrile gloves and safety glasses are to be worn when applying grease. When applying grease, it should be done in a well ventilated area to avoid inhaling fumes. All individuals will be properly trained on handling common chemicals used in constructing the launch vehicles.	4E	Training will be documented for designated individuals.
Shop	Metal shards.	Using equipment to machine metal parts.	Metal splinters in skin or eyes.	1D	Team members will wear long sleeves and safety glasses whenever working with metal parts. Individuals will be trained on the tool being used. Those not trained will not attempt to learn on their own and will find a trained individual to instruct them.	4D	Training on this equipment is provided by the university through the Design for X Labs orientation and safety training program.

Area	Hazard	Cause	Effect	Pre RAC	Mitigation	Post RAC	Verification
Environmental	UV exposure.	Rocket left exposed to sun for long periods of time.	Possibly weakening materials or adhesives.	3D	Rocket should not be exposed to sun for long periods of time. If the rocket must be worked on for long periods of time, shelter should be sought.	3E	Rocket is constructed and maintained in an air conditioned workshop.
Shop	Carbon fiber	Cutting/sanding. Very sharp when broken. Possible flammability and oxidation under certain conditions. Possibility of failing hoop stress test.	Proper protection will be essential. Temperature conditions should be regulated.	2D	There will be extensive testing done with carbon fiber throughout the entirety of the project.	2D	Training will be done to ensure proper handling of carbon fiber of all participants working with the material.

5 LAUNCH VEHICLE SUMMARY

5.1 VEHICLE REQUIREMENTS

Table 9: Required vehicle success criteria and verification of completion.

Requirement	Method	Verification	Verification Status
2.1 The vehicle will deliver the payload to an apogee altitude between 4,000 and 5,500 feet above ground level (AGL). Teams flying below 3,500 feet or above 6,000 feet on Launch Day will be disqualified and receive zero altitude points towards their overall project score.	Design Demonstration	The rocket will utilize the AeroTech L1117 motor for propulsion factor and the flight path can be altered with adjustable ballast. Current simulations and calculations place apogee at approximately 4,832 feet, depending on conditions and ballast.	To be tested at full scale launch. Reference: Reference: 8.1 Project Schedule
2.2 Teams shall identify their target altitude goal at the PDR milestone. The declared target altitude will be used to determine the team's altitude score during Launch Week.	Documentation	The target goal will be determined using OpenRocket simulation following any changes to the rocket prior to PDR submission.	Will be verified with submission of PDR. Reference: 5.5 Flight Characteristics
2.3 The vehicle will carry one commercially available, barometric altimeter for recording the official altitude used in determining the altitude award winner.	Design Inspection	Rocket will feature four altimeters, capable of deploying charges and recording the flight apogee. NSL Inspection as well as inspected and approved by the safety officer.	Design submitted with PDR. Reference: Section 5.6 Projected Recovery System Safety officer and NSL inspections to be completed. Reference: 4.2 Safety Officer Duties & Responsibilities

Requirement	Method	Verification	Verification Status
2.4 Each altimeter will be armed by a dedicated arming switch that is accessible from the exterior of the rocket airframe when the rocket is in the launch configuration on the launch pad.	Inspection/ Demonstration	Each altimeter will have an arming switch via an electronic rotary switch. There will be two protruding switches in the switch-band of the main altimeter bay, and two inset switches in the payload altimeter bay. All four switches will be visible and physically accessible.	Design submitted with PDR. Reference: Section 5.6 Projected Recovery System Safety officer and NSL inspections to be completed. Reference: 4.2 Safety Officer Duties & Responsibilities
2.5 Each altimeter will have a dedicated power supply.	Inspection	One standard 9V Alkaline batteries will be configured to each altimeter and be sufficient in supplying power to enable function.	Operation of selected batteries to be verified at subscale and full-scale launch
2.6 Each arming switch will be capable of being locked in the ON position for launch (i.e. cannot be disarmed due to flight forces).	Testing/ Inspection	There are two settings to the electronic rotary switch. The switch itself has small mechanical components that allow it to remain in its set position.	Operation of selected switches to be verified at subscale and full-scale launch

Requirement	Method	Verification	Verification Status
2.7 The launch vehicle will be designed to be recoverable and reusable. Reusable is defined as being able to launch again on the same day without repairs or modifications.	Testing/ Demonstration/ Inspection	The launch vehicle will contain parachutes on every separate or tethered part of the rocket that will be released at apogee, 950 feet, and 750 feet that will allow it time to open up properly and safely.	Subscale and full-scale testing to be conducted.
2.8 The launch vehicle shall have a maximum of four (4) independent sections.	Inspection	The rocket will be broken up into four sections: the nose cone, rover compartment, main altimeter bay, and the booster section. The nose cone and rover compartment will be tethered together, as will the altimeter bay and booster. Subscale designed to these specifications	Subscale construction has not yet begun.
2.8.1. Coupler/ airframe shoulders which are located at in-flight separation points will be at least one body diameter in length.	Design Inspection	Simulation rocket in OpenRocket meets this requirement and full scale fabrication will follow simulation measurements in addition to updates to vehicle design	To be measured after fabrication

Requirement	Method	Verification	Verification Status
2.8.2. Nosecone shoulders which are located at in-flight separation points will be at least ½ body diameter in length.	Design Inspection	Simulation rocket in OpenRocket meets this requirement and full scale fabrication will follow simulation measurements in addition to updates to vehicle design	To be measured after fabrication
2.9 The launch vehicle shall be limited to a single stage.	Design Inspection	Launch vehicle will contain only one motor to light and start the flight. Subscale launch vehicle designed to meet this specification.	Subscale construction has not yet begun.
2.10 The launch vehicle shall be capable of being prepared for flight at the launch site within 2 hours, from the time the Federal Aviation Administration flight waiver opens.	Testing	There will be Final Assembly and Launch Procedure Checklist before the test flights of the subscale rocket and the full-scale rocket that will be timed to ensure we complete the list safely and within the time of 2 hours.	Subscale construction has not yet begun.
2.11. The launch vehicle 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.	Testing	The launch vehicle and the electronic components within will be properly connected and sealed to prevent anything from causing it to disconnect or be damaged. The batteries will have a life long enough to be at the launch pad for an hour without losing any power.	Subscale launch testing has not been conducted.

Requirement	Method	Verification	Verification Status
2.12 The launch vehicle shall be capable of being launched by a standard 12-volt direct current firing system.	Design Demonstration	The ignitor used in the rocket will be able to withstand a 12-volt DC firing system.	Subscale launch testing has not been conducted.
2.13 The launch vehicle shall require no external circuitry or special ground support equipment to initiate launch.	Inspection/ Demonstration	The only required external circuitry will be the 12-volt direct current firing system that is compatible with the ignitor in the launch vehicle.	Subscale launch testing has not been conducted.
2.14 The launch vehicle shall use a commercially available solid motor propulsion system using ammonium perchlorate composite propellant (APCP) which is approved and certified by the National Association of Rocketry (NAR), Tripoli Rocketry Association (TRA), and/or the Canadian Association of Rocketry (CAR).	Inspection	The motor being used in the launch vehicle will be an AeroTech L1170, which is certified by the National Association of Rocketry and it made of ammonium perchlorate.	Motor simulations have been completed. Reference: 5.5 Flight Characteristics
2.14.1. Final motor choices will be declared by the Critical Design Review (CDR) milestone.	Documentation	The motor currently being used in the launch vehicle will be an AeroTech L1170, which is certified by the National Association of Rocketry and it made of ammonium perchlorate.	Motor simulations have been completed. Reference: 5.5 Flight Characteristics

Requirement	Method	Verification	Verification Status
2.14.2. Any motor change after CDR must be approved by the NASA Range Safety Officer (RSO) and will only be approved if the change is for the sole purpose of increasing the safety margin. A penalty against the team's overall score will be incurred when a motor change is made after the CDR milestone, regardless of the reason.	Documentation	The AeroTech 1170 motor is currently the motor planned to use for launch and any changes will be documented and submitted through the proper channels.	CDR has not yet been submitted
2.15 Pressure vessels on the vehicle shall be approved by the RSO and shall meet the following criteria.	Inspection	Our design does not contain a pressure vessel.	Verified with submission of Project Proposal.
2.16. The total impulse provided by a College or University launch vehicle will not exceed 5,120 Newton-seconds (L-class).	Inspection	The motor chosen is not bigger than an L class motor and has a total impulse of 4232 N-s.	Inspection of manufacturer's specifications complete.
2.17 The launch vehicle shall have a minimum static stability margin of 2.0 at the point of rail exit.	Analysis Demonstration	The center of pressure and the center of gravity in comparison to the diameter of the body tube will have a minimum stability margin of 2.0. Current simulations for configurations under consideration place stability margin at 2.8 calipers. When launch vehicle is complete, it will be physically balanced to verify data.	Analysis complete. Reference: 5.3 Vehicle Specifications Full scale balance to be completed.

Requirement	Method	Verification	Verification Status
2.18 The launch vehicle shall accelerate to a minimum velocity of 52 fps at rail exit.	Analysis Demonstration	The motor that was chosen for the rocket will allow the rocket to achieve a minimum of 52 fps at rail exit.	Analysis complete. Reference: 5.5 Flight Characteristics
2.19 All teams shall successfully launch and recover a subscale model of their rocket prior to CDR.	Demonstration	SOAR will have a subscale model ready and launched prior to CDR.	Subscale model launch planned for November 17th, 2018. Reference: 8.1 Project Schedule
2.19.1. The subscale model should resemble and perform as similarly as possible to the full-scale model, however, the full-scale will not be used as the subscale model.	Demonstration	The subscale model will be constructed to resemble the full-scale model as accurately as possible given finances and fabrication techniques.	The subscale model has not yet been constructed
2.19.2. The subscale model will carry an altimeter capable of recording the model's apogee altitude.	Documentation	The altimeter bay on the subscale rocket will include an altimeter that will record the subscale's apogee.	The subscale model has not yet been launched

Requirement	Method	Verification	Verification Status
2.19.3. The subscale rocket must be a newly constructed rocket, designed and built specifically for this year's project.	Construction	The subscale rocket will be newly constructed from a different material from previous years, specifically for this year's project.	The subscale model has not yet been constructed
2.19.4. Proof of a successful flight shall be supplied in the CDR report. Altimeter data output may be used to meet this requirement.	Documentation	An altimeter will be attached to the subscale rocket so that altimeter data can be used to prove a successful launch.	The subscale model has not yet been launched.
2.20. All teams will complete demonstration flights as outlined below.	-	-	-
2.20.1 All teams shall successfully launch and recover their full-scale rocket prior to FRR in its final flight configuration. The rocket flown at FRR must be the same rocket to be flown on launch day.	Demonstration	The full-scale rocket will be built and launched as well as recovered prior to the FRR and it will be the same rocket flown on launch day.	Full scale testing to be completed.
2.20.1.1. The vehicle and recovery system will have functioned as designed. *2.20.1.2. The full-scale rocket must be a newly constructed rocket, designed and built specifically for this year's project.*	Inspection	The vehicle and recovery system will be observed during and after full-scale launch to ensure it functions as designed	Vehicle and recovery system have not been constructed yet.

Requirement	Method	Verification	Verification Status
2.20.1.3. The payload does not have to be flown during the full-scale Vehicle Demonstration Flight. The following requirements still apply: *2.20.1.3.1. If the payload is not flown, mass simulators will be used to simulate the payload mass.* *2.20.1.3.2. The mass simulators will be located in the same approximate location on the rocket as the missing payload mass.*	Inspection	The vehicle will be inspected prior to full-scale vehicle demonstration flight to ensure that either the payload is used, or mass simulators are placed in the proper locations.	The full-scale vehicle demonstration flight has not yet been conducted.
2.21 If the payload changes the external surfaces of the rocket (such as with camera housings or external probes) or manages the total energy of the vehicle, those systems will be active during the full-scale demonstration flight.	Inspection	There are no external or protruding components from the payload.	Will be verified through submission of CDR.
2.20.1.5. Teams shall fly the launch day motor for the Vehicle Demonstration Flight. The RSO may approve use of an alternative motor if the home launch field cannot support the full impulse of the launch day motor or in other extenuating circumstances.	Demonstration	The AeroTech 1170 will be ordered and verified with the RSO prior to full-scale launch.	Motors have not yet been purchased.

Requirement	Method	Verification	Verification Status
2.20.1.6. The vehicle must be flown in its fully ballasted configuration during the full-scale test flight.	Inspection	The completed payload or equivalent simulated weight will be used in the full-scale test flight.	Full scale test has not been conducted
2.20.1.7. After successfully completing the full-scale demonstration flight, the launch vehicle or any of its components will not be modified without the concurrence of the NASA Range Safety Officer (RSO).	Documentation/ demonstration	After completing the full-scale demonstration flight, no components will be changed	Full scale test has not been conducted
2.20.1.8. Proof of a successful flight shall be supplied in the FRR report. Altimeter data output is required to meet this requirement.	Documentation	Altimeter data will be included in the FRR report to prove successful flight apogee have been achieved.	FRR has not been submitted
2.20.1.9. Vehicle Demonstration flights must be completed by the FRR submission deadline. If the Student Launch office determines that a Vehicle Demonstration Re-flight is necessary, then an extension may be granted. This extension is only valid for re-flights, not first-time flights. Teams completing a required re-flight must submit an FRR Addendum by the FRR Addendum deadline.	Documentation/ demonstration	Full-scale vehicle demonstration flight is currently planned for February 16th, 2019, prior to the FRR submission deadline	Full-scale vehicle demonstration flight has been scheduled. Reference: 8.1.2 Timeline

Requirement	Method	Verification	Verification Status
2.20.2. All teams will successfully launch and recover their full-scale rocket containing the completed payload prior to the Payload Demonstration Flight deadline.	Inspection	After the full-scale launch, the SOAR team will recover the full-scale rocket and completed payload	The full-scale launch has not yet taken place.
2.20.2.1. The payload must be fully retained throughout the entirety of the flight, all retention mechanisms must function as designed, and the retention mechanism must not sustain damage requiring repair. *2.20.2.2. The payload flown must be the final, active version.*	Inspection	The full-scale launch vehicle will be inspected following the launch to ensure all mechanisms functioned as designed and the retention mechanism did not sustain damage requiring repair. The payload flown will be the final, active version.	The full-scale launch has not yet taken place.
2.21. An FRR Addendum will be required for any team completing a Payload Demonstration Flight or NASA-required Vehicle Demonstration Re-flight after the submission of the FRR Report.	Documentation	SOAR will submit an FRR addendum if needed.	The FRR has not yet been submitted
2.22. Any structural protuberance on the rocket will be located aft of the burnout center of gravity.	Inspection	The launch team will inspect the rocket for all structural protuberances prior to launch.	Subscale and full scale rockets have not yet been constructed to confirm this requirement.

Requirement	Method	Verification	Verification Status
2.23. The team's name and launch day contact information shall be in or on the rocket airframe as well as in or on any section of the vehicle that separates during flight and is not tethered to the main airframe.	Inspection	The launch team will inspect the rocket airframe and any section that separates to ensure this information will be present.	Subscale and full scale rockets have not yet been constructed to include this information
2.24. Vehicle Prohibitions	Inspection	The vehicle will not contain any of the prohibited items.	Vehicle simulation does not contain any prohibited items.

5.2 DESIGN OVERVIEW

The proposed launch vehicle design borrows significantly from the design for SOAR's 2018 NASA Student Launch rocket, *Apis II* (detailed in SOAR's 2018 NSL FRR[24]). However, significant improvements have been made to accommodate lessons learned through that competition, as well as new design requirements. The rocket keeps almost the same three-parachute recovery system method, as this was extremely reliable and safe. In order to increase payload capacity and design flexibility, the body diameter has been increased and the body material has been changed to carbon fiber. As a result of these changes, a 5.5:1 Von Karman nose cone has been selected, the fins have been redesigned, and the length of every component has increased. Exact specifications for the rocket can be found in Table 10, and the proposed design is shown in Figure 2. Figure 3 features a 3D render in which the payload is highlighted green, structural components are red and black, and recovery components are shown in blue.

[24] Available for download at: http://www.usfsoar.com/wp-content/uploads/2018/03/Univ-of-S-Florida-2018-FRR.pdf

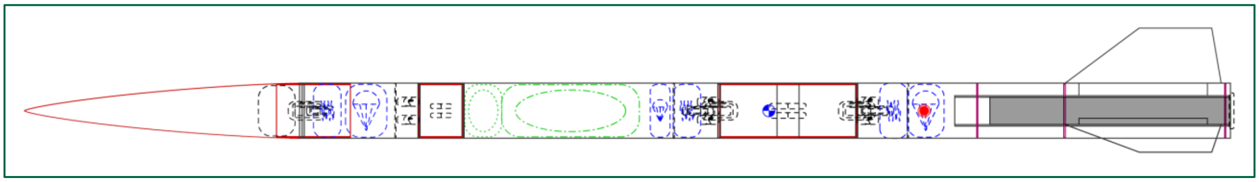

Figure 2: Overview drawing of launch vehicle assembly with motor installed. Cg and Cp are noted in red and blue, respectively.

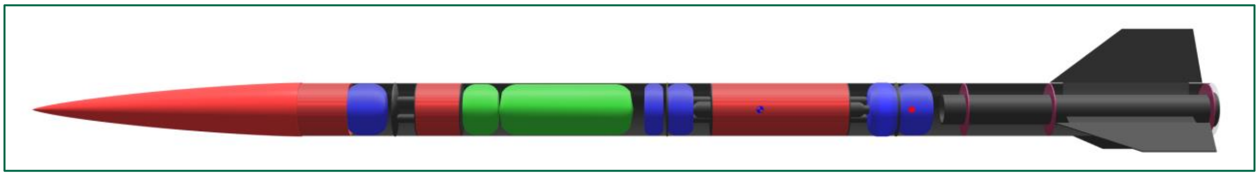

Figure 3: Overview 3D render of launch vehicle assembly.

5.3 VEHICLE SPECIFICATIONS

The rocket has been designed to accommodate the maximum possible payload size and weight while still comfortable reaching the desired altitude. Furthermore, the selected design can be easily modified in the future to account for unforeseen factors. Primary specifications for the proposed rocket are listed in Table 10.

Table 10: Primary specifications of the proposed launch vehicle, as selected and/or calculated by OpenRocket.

Property	Value
Diameter (in)	6
Overall Length (in)	132
Projected Unloaded Weight (lb)	35.6
Projected Loaded Weight (lb)	46.6
Projected Motor	AeroTech L1170
Airframe Material	Carbon Fiber + Fiberglass

Property	Value
Center of Pressure (in, from tip)	81.01
Center of Gravity (in, from tip)	98.007
Static Stability Margin (cal)	2.82
Rail Lugs Size (standard T-slot rail)	1515

5.4 CONSTRUCTION METHODS

The rocket will be primarily constructed of carbon fiber, with compatible fiberglass components used when necessary. This body tube, booster section, and altimeter bay will be custom-wound in two layers, one with a 55° winding angle and the other with an 80° winding angle, using 3K carbon tow and Aeropoxy embedded epoxy, on an X-Winder desktop carbon fiber filament winder. Through the use of a commercial coupler designed for 6-inch rockets as a mandrel, the inner diameter of the rocket will exactly match the inner diameter of a typical 6-inch fiberglass body tube. This will enable the implementation of a commercial off-the-shelf fiberglass nose cone (which is difficult to wind due to its shape and the limitations of the filament winding software) and altimeter / payload bays (which are difficult to wind due to the challenge in winding for an exact outer diameter).

Once the booster section is wound, three ⅛-inch slots will be cut for the fins, at a 120° angle to each other. The fins will be laser cut from commercial off-the-shelf sheets of ⅛-inch carbon fiber before being epoxied to the filament-wound carbon fiber motor mount with carbon fiber-reinforced Aeropoxy. Three centering rings, also laser cut from carbon fiber sheets, will also be installed to the motor mount. The fully-fabricated fin can will then be slid into the booster section, at which point 1.25” Aeropoxy fillets will be added for increased strength. Launch rail lugs intended for use with standard 1515 rail will be installed on the exterior of the rocket.

All altimeter bays and the nose cone shoulder will be cut from a commercial 6-inch diameter fiberglass coupler tube. All bulkheads will be laser cut from ⅛-inch carbon fiber sheets.

In the nose cone, an 8-inch section with an epoxied bulkhead will be bolted into the nose cone with steel hardware, and a removable ballast system will be installed in the resulting section.

For the two altimeter bays, removable bulkheads, held on by ¼-inch steel threaded rods and wing nuts, will be installed on each end. These bulkheads (except the 5-inch long payload-facing bulkhead on the forward altimeter bay) will also each hold two PVC deployment charge containers and single U-bolts for parachute attachment. The 15-inch main altimeter bay and coupler will have a 2.5-inch long switch band for easy access to the altimeter switches.

Holes for shear pins will be drilled for each separation point of the launch vehicle. Shear pins will be used during each launch to retain coupled sections until scheduled separation.

5.5 FLIGHT CHARACTERISTICS

This rocket and motor combination has been simulated using the OpenRocket software, yielding the primary flight characteristics shown in Table 12 and Figure 4. The configured parameters for this simulation are listed in Table 11.

Table 11: Proposed flight configuration simulation parameters.

Parameter	Value
Software	OpenRocket, v15.03
Average Wind Speed (mph)	5
Turbulence (%)	10
Launch Site Altitude (ft)	600
Launch Site Latitude (°N)	34.7
Launch Site Longitude (°W)	-86.0
Atmospheric Conditions	Standard
Launch Rod Length (in)	144
Launch Rod Cant (°)	0

Table 12: Primary flight characteristics of the proposed vehicle and motor, as simulated.

Characteristic	**Value**
Velocity Off Rod (ft/s)	66.6
Apogee (ft)	4,832
Maximum Velocity (ft/s)	562
Maximum Acceleration (ft/s^2)	201
Time to Apogee (s)	18.2
Total Flight Time (s)	101
Descent Time (s)	82.8

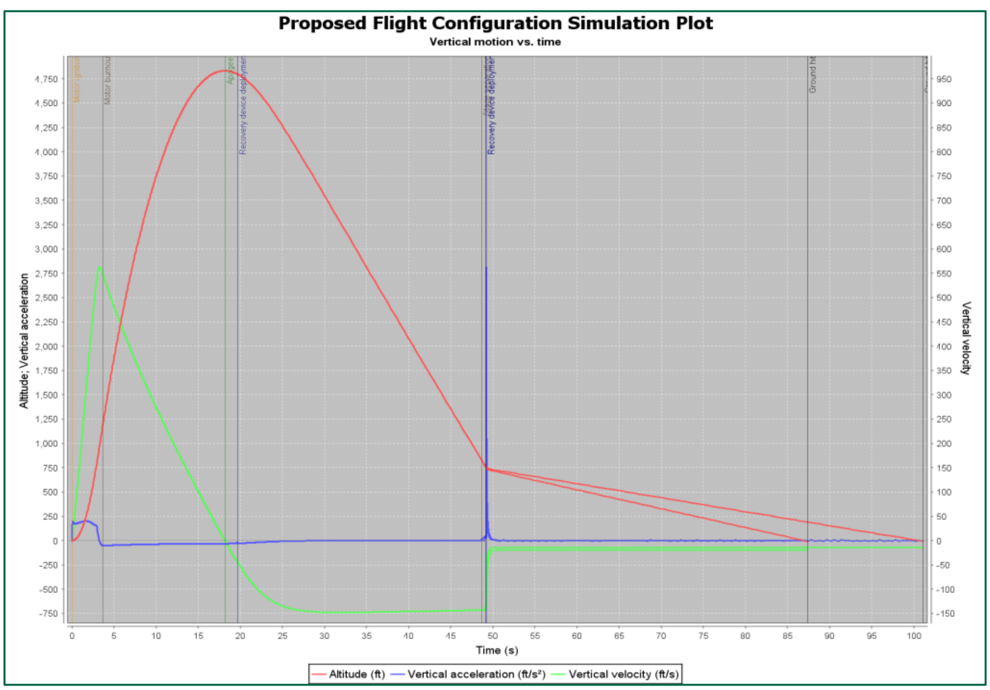

Figure 4: Plot of simulated flight profile, showing each section as separate lines after separation. Generated with OpenRocket.

5.6 PROJECTED RECOVERY SYSTEM

5.6.1 RECOVERY REQUIREMENTS (INCOMPLETE)

Table 13: Required vehicle recovery success criteria and verification of completion.

Requirement	Method	Verification	Verification Status
3.1. The launch vehicle shall stage the deployment of its recovery devices, where a drogue parachute is deployed at apogee and a main parachute is deployed at a much lower altitude.	Documentation Demonstration	Design Parameters: The launch vehicle is designed to deploy the drogue parachute at apogee using no delay. The Nose cone and payload separate from the booster at an altitude of 750ft with the main Booster section parachute deploying thereafter and the Main Payload section parachute at an altitude of 740ft. Testing: Separation Ground Test, Subscale Launch Test, Full Scale Launch Test	Design submitted with PDR. Reference: 5.6 Projected Recovery System Subscale and Full Scale Launch Tests Scheduled. Reference: 8.1 Project Schedule
3.1.1. The main parachute shall be deployed no lower than 500 feet.	Documentation Demonstration	Design Parameters: The launch vehicle is designed to deploy the drogue parachute at apogee using no delay. The Nose cone and payload separate from the booster at an altitude of 750ft with the main Booster section parachute deploying thereafter and the Main Payload section parachute at an altitude of 740ft. Testing: Separation Ground Test, Subscale Launch Test, Full Scale Launch Test	Design submitted with PDR. Reference: 5.6 Projected Recovery System Subscale and Full Scale Launch Tests Scheduled. Reference: 8.1 Project Schedule

Requirement	Method	Verification	Verification Status
3.1.2. The apogee event may contain a delay of no more than 2 seconds.	Documentation Demonstration	Design Parameters: The launch vehicle is designed to deploy the drogue parachute at apogee using no delay. The Nose cone and payload separate from the booster at an altitude of 750ft with the main Booster section parachute deploying thereafter and the Main Payload section parachute at an altitude of 740ft. Testing: Subscale Launch Test, Full Scale Launch Test	Design submitted with PDR. Reference: 5.6 Projected Recovery System Subscale and Full Scale Launch Tests Scheduled. Reference: 8.1 Project Schedule
3.2. Each team must perform a successful ground ejection test for both the drogue and main parachutes. This must be done prior to the initial subscale and full-scale launches.	Testing	A ground ejection test for the drogue and main parachute will be completed prior to initial subscale and full-scale launches. Testing: Ground Ejection Tests	Subscale and Full Scale Launch Tests Scheduled. Reference: 8.1 Project Schedule
3.3. At landing, each independent sections of the launch vehicle shall have a maximum kinetic energy of 75 ft·lbf	Simulation Demonstration	The correct and appropriate parachute size will be chosen in order to slow the launch vehicle down enough to ensure a kinetic energy of less than 75 ft·lbf. Multiple tests will be simulated. Calculations in this report detail the descent rate and kinetic energy at impact. Simulation: OpenRocket Simulations and Kinetic Energy Calculations Testing: Subscale and Full Scale Launch Tests	Analysis included with PDR and will be adjusted if vehicle mass alters. Reference: 5.6.5 Recovery Calculations and Simulations Subscale and Full Scale Launch Tests Scheduled. Reference: 8.1 Project Schedule

Requirement	Method	Verification	Verification Status
3.4. The recovery system electrical circuits shall be completely independent of any payload electrical circuits.	Design Inspection	NSL Inspection as well as inspected and approved by safety officer. Recovery electrical system is connected only to the recovery system altimeters. Payload design incorporates a separate power supply.	Verified with design submission. Reference: 6.2 Rover Design Safety officer and NSL inspections to be completed. Reference: 4.2 Safety Officer Duties & Responsibilities
3.5. All recovery electronics will be powered by commercially available batteries.	Design Inspection	Current design incorporates commercially available 9V batteries. NSL Inspection as well as inspected and approved by safety officer.	Verified with design submission. Reference: 5.6 Projected Recovery System Safety officer and NSL inspections to be completed. Reference: 4.2 Safety Officer Duties & Responsibilities
3.6. The recovery system shall contain redundant, commercially available altimeters.	Design Inspection	The current design includes redundant, commercially available altimeters. The rocket will use a total of four altimeters, each powered by a separate 9-volt battery that will not power any other equipment. Two for the main altimeter bay will be Missile Works RRC3 altimeters and the other two at the payload altimeter bay will be Missile Works RRC2+. NSL Inspection as well as inspected and approved by safety officer.	Verified with design submission. Reference: 5.6 Projected Recovery System Safety officer and NSL inspections to be completed. Reference: 4.2 Safety Officer Duties & Responsibilities

Requirement	Method	Verification	Verification Status
3.7. Motor ejection is not a permissible form of primary or secondary deployment.	Design Inspection	Launch vehicle design does not include motor ejection as means of deployment. NSL Inspection as well as inspected and approved by safety officer.	Verified with design submission. Reference: 5.6 Projected Recovery System Safety officer and NSL inspections to be completed. Reference: 4.2 Safety Officer Duties & Responsibilities
3.8. Removable shear pins will be used for both the main parachute compartment and the drogue parachute compartment.	Design Inspection	NSL Inspection as well as inspected and approved by safety officer. Launch vehicle has been designed with shear pins at each separation point: between altimeter bay and booster, between altimeter bay and payload section, and between nose cone and payload section.	Verified with design submission. Reference: 5.4 Construction Methods Safety officer and NSL inspections to be completed. Reference: 4.2 Safety Officer Duties & Responsibilities
3.9. Recovery area will be limited to a 2500 ft. radius from the launch pads.	Simulation Demonstration	Data from simulations. Drift calculated manually. Subscale and full scale launch data.	Simulation complete. Reference: 5.6.5 Recovery Calculations and Simulations Subscale testing and full scale testing to be completed. Reference: Section 8.1 Project Schedule

Requirement	Method	Verification	Verification Status
3.10. Descent time will be limited to 90 seconds (apogee to touch down).	Simulation Demonstration	Data from simulations. Subscale and full scale launch data. The rocket will use a total of four altimeters, each powered by a separate 9-volt battery that will not power any other equipment. Two for the main altimeter bay will be Missile Works RRC3 altimeters and the other two at the payload altimeter bay will be Missile Works RRC2+.	Simulation complete. Reference: 5.6.5 Recovery Calculations and Simulations Subscale testing and full scale testing to be completed. Reference: Section 8.1 Project Schedule
3.11. An electronic tracking device will be installed in the launch vehicle and will transmit the position of the tethered vehicle or any independent section to a ground receiver.	Design Inspection	A loud audible beacon transmitter has been included in both altimeters bays separate from the recovery electronics. The beacon will produce a high enough decibel that will allow us to locate the separate sections.	Verified with design submission. Reference: 5.6.2 Recovery System Safety officer and NSL inspections to be completed. Reference: 4.2 Safety Officer Duties & Responsibilities
3.11.1. Any rocket section, or payload component, which lands untethered to the launch vehicle, will also carry an active electronic tracking device.	Design Inspection	A loud audible beacon transmitter has been included in both altimeters bays separate from the recovery electronics. The beacon will produce a high enough decibel that will allow us to locate the separate sections.	Verified with design submission. Reference: 5.6.2 Recovery System Safety officer and NSL inspections to be completed. Reference: 4.2 Safety Officer Duties & Responsibilities

Requirement	Method	Verification	Verification Status
3.11.2. The electronic tracking device will be fully functional during the official flight on launch day.	Design Inspection	The sounding beacons are planned to be installed within the altimeter bays and will be functional on launch day.	Verified with design submission. Reference: 5.6.2 Recovery System Safety officer and NSL inspections to be completed. Reference: 4.2 Safety Officer Duties & Responsibilities
3.12. The recovery system electronics will not be adversely affected by any other on-board electronic devices during flight (from launch until landing).	-	-	-
3.12.1. The recovery system altimeters will be physically located in a separate compartment within the vehicle from any other radio frequency transmitting device and/or magnetic wave producing device.	Design Inspection	The rocket will use a total of four altimeters, each powered by a separate 9-volt battery that will not power any other equipment. Two for the main altimeter bay will be Missile Works RRC3 altimeters and the other two at the payload altimeter bay will be Missile Works RRC2+. Safety Officer will use a checklist to inspect launch vehicle prior to each launch.	Verified with design submission. Reference: 5.6.2 Recovery System Safety officer and NSL inspections to be completed. Reference: 4.2 Safety Officer Duties & Responsibilities

Requirement	Method	Verification	Verification Status
3.12.2. The recovery system electronics will be shielded from all onboard transmitting devices to avoid inadvertent excitation of the recovery system electronics.	Design Inspection	The current design includes no other transmitting devices. Safety Officer will monitor updates to design and all payload and launch operations.	Verified with design submission. Reference: 6.2 Rover Design Safety officer and NSL inspections to be completed. Reference: 4.2 Safety Officer Duties & Responsibilities
3.12.3. The recovery system electronics will be shielded from all onboard devices which may generate magnetic waves (such as generators, solenoid valves, and Tesla coils) to avoid inadvertent excitation of the recovery system.	Design Testing	The current design includes magnetic induction solenoid valves for the payload retention system. This mechanism is separated from the altimeters by parachutes, shock cord, and fiberglass bulkheads. Payload retention system tests will incorporate testing for interference with all altimeters.	Verified with design submission. Reference: 6.2.1 Retention Method Payload Electrical Testing Reference: 6 Projected Payload
3.12.4. The recovery system electronics will be shielded from any other onboard devices which may adversely affect the proper operation of the recovery system electronics.	Design Testing	The current design includes magnetic induction solenoid valves for the payload retention system. This mechanism is separated from the altimeters by parachutes, shock cord, and fiberglass bulkheads. Payload retention system tests will incorporate testing for interference with all altimeters.	Verified with design submission. Reference: 6.2.1 Retention Method Payload Electrical Testing Reference: 6 Projected Payload

5.6.2 RECOVERY SYSTEM

A dual deployment system consisting of three parachutes and two separate sections (each with its own altimeter bay) will be used to ensure safety and follow the competition requirements. This deployment process is described in detail in 5.6.3 Deployment Procedure, using the parachutes described in 5.6.4 Selected Parachute Properties.

The four altimeters (two MissileWorks RRC2+s and two RRC3s), each powered by a separate 9V battery, have been selected due to their proved reliability, small size, and capability to record high-quality data with minimal setup. The parachutes have been selected based on a combination of their ability to fold tightly (as shown in Figure 2), their low mass, and relatively high coefficients of drag. Each altimeter will have an arming switch via an electronic rotary switch. There will be two protruding switches in the switch band of the main altimeter bay, and two inset switches in the payload altimeter bay. All four switches will be visible and physically accessible.

In addition to the altimeters, loud, high-pitched audible beacon transmitters will be installed in each altimeter bay to ease location of primary rocket components on the ground.

5.6.3 DEPLOYMENT PROCEDURE

Four deployment events will occur and are listed below:

1. The first parachute deployment will consist of a drogue at apogee, deployed by a black powder charge and controlled by a Missile Works RRC3 altimeter. This charge will separate the booster (motor) section from the main body tube. The SkyAngle Classic 20” drogue parachute will be protected by a Nomex sheet to prevent burns or other damage from the powder charge. The rocket will fall under this drogue parachute until it reaches an altitude of 750 ft.
2. At 750 ft, the black powder charges on the opposite side of the main altimeter bay will fire, separating the nose cone and payload section from the booster and deploying the booster’s Fruity Chutes Iris Ultra 60” Standard main parachute.
3. After a short delay (long enough to prevent tangling parachutes, but short enough to prevent free fall for any significant amount of time), at 740 ft, the RRC2+ altimeters in the payload altimeter bay will fire the final set of black powder charges to separate the nose cone from the body tube and deploy the payload’s Fruity Chutes Iris Ultra 84” Standard parachute. After this final event, the rocket will drift to the ground at a safe velocity.
4. Upon impact with the ground, as determined by an on-board altimeter, the parachute attached to the rover compartment will be separated from the rover compartment via a black powder charge in the Tender Descender, which will be attached to the shock cord near the exit area of the rover compartment.

5.6.4 SELECTED PARACHUTE PROPERTIES

5.6.4.1 DROGUE PARACHUTE

Table 14: SkyAngle Classic 20" parachute properties. (b2 Rocketry Company)

Property	**Value**
Manufacturer	SkyAngle
Model	Classic 20"
Diameter (in)	20
Drag Coefficient	0.80
Mass (lb)	0.312
Packed Length (in)	4.0

5.6.4.2 MAIN BOOSTER PARACHUTE

Table 15: Fruity Chutes Iris Ultra 60" parachute properties. (Fruity Chutes)

Property	**Value**
Manufacturer	Fruity Chutes
Model	Iris Ultra 60" Standard
Diameter (in)	60
Drag Coefficient	2.20
Mass (lb)	0.681

Property	Value
Packed Length (in)	2.2

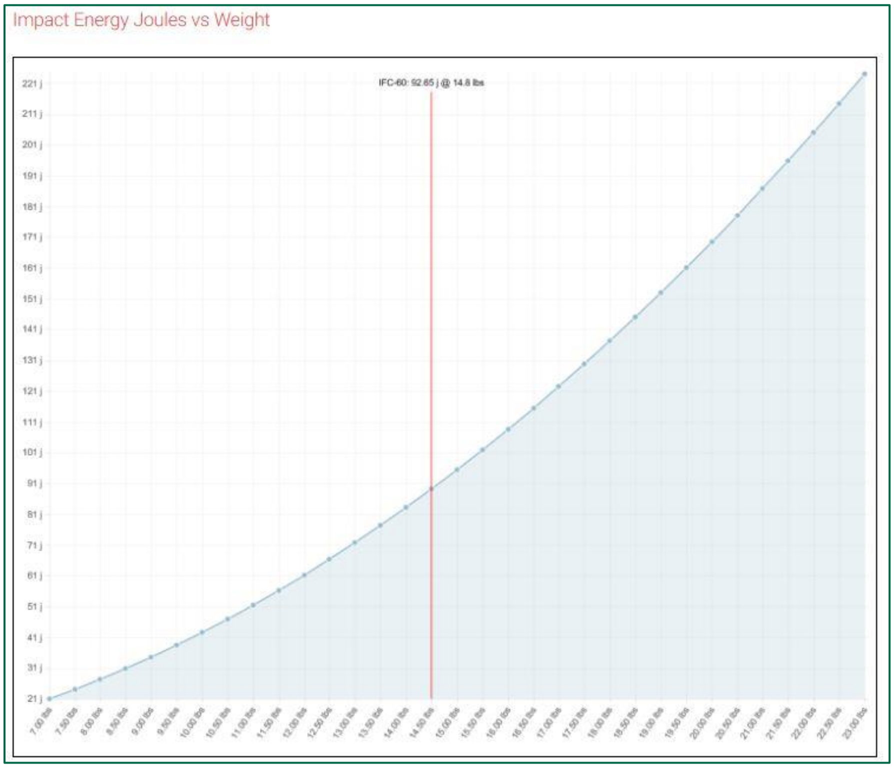

Figure 5: Fruity Chutes Iris Ultra 60" parachute impact energy vs. weight plot. (Fruity Chutes, 2019)

5.6.4.3 MAIN PAYLOAD PARACHUTE

Table 16: Fruity Chutes Iris Ultra 84" parachute properties. (Fruity Chutes)

Property	Value
Manufacturer	Fruity Chutes
Model	Iris Ultra 84" Standard
Diameter (in)	84

Property	Value
Drag Coefficient	2.20
Mass (lb)	1.19
Packed Length (in)	4.5

Figure 6: Fruity Chutes Iris Ultra 84" parachute impact energy vs. weight plot. (Fruity Chutes, 2019)

5.6.5 RECOVERY CALCULATIONS AND SIMULATIONS

To ensure that the kinetic energy at landing is less than 75 ft-lbf, appropriate parachute sizes have to be selected that maintain a safe descent rate for the two sections. Equation 1 was used to calculate the maximum descent rate velocities. In that equation, v_{max} represents the maximum velocity, E_{max} represents the maximum allowable kinetic energy on impact with the ground (defined in the NASA Student Launch Handbook as 75 ft-lbf), and m represents the mass of the section under the parachute.

$$v_{max} = \sqrt{\frac{2E_{max}}{m}}$$

Equation 1: Relationship between energy and velocity.

The maximum velocity was used to determine the minimum parachute drag coefficient and canopy area using Equation 2, where A is the parachute area, C_d is the coefficient of drag of the parachute, g is the force due to gravity at Earth's surface, m is the mass of the section under the parachute, ρ_{air} is the typical density of air, and v_{max} is defined above:

$$(A \cdot C_d)_{min} = \frac{2gm}{\rho_{air} v_{max}^2}$$

Equation 2: Parachute descent velocity equation.

Using the above calculations, the minimum $A \cdot C_d$ value was determined for each section. These values are listed in Table 17.

Table 17: Minimum $A \cdot C_d$ values for recovery sections.

Section	**Minimum $A \cdot C_d$** (ft^2)
Nose Cone and Payload	75.62
Booster (with Main Altimeter Bay)	38.18

5.7 PROJECTED MOTOR

Based on the vehicle success criteria and properties of the selected design, the AeroTech L1170 motor has been selected. The properties of this motor are listed in Table 18.

Table 18: AeroTech 1170 motor properties. (ThrustCurve, 2014)

Property	**Value**
Manufacturer	AeroTech
Manufacturer Designation	L1170

Property	Value
Average Thrust (N)	1141.0
Maximum Thrust (N)	1489.0
Total Impulse (N·s)	4232.0
Burn Time (s)	3.7
Case	RMS-75/5120

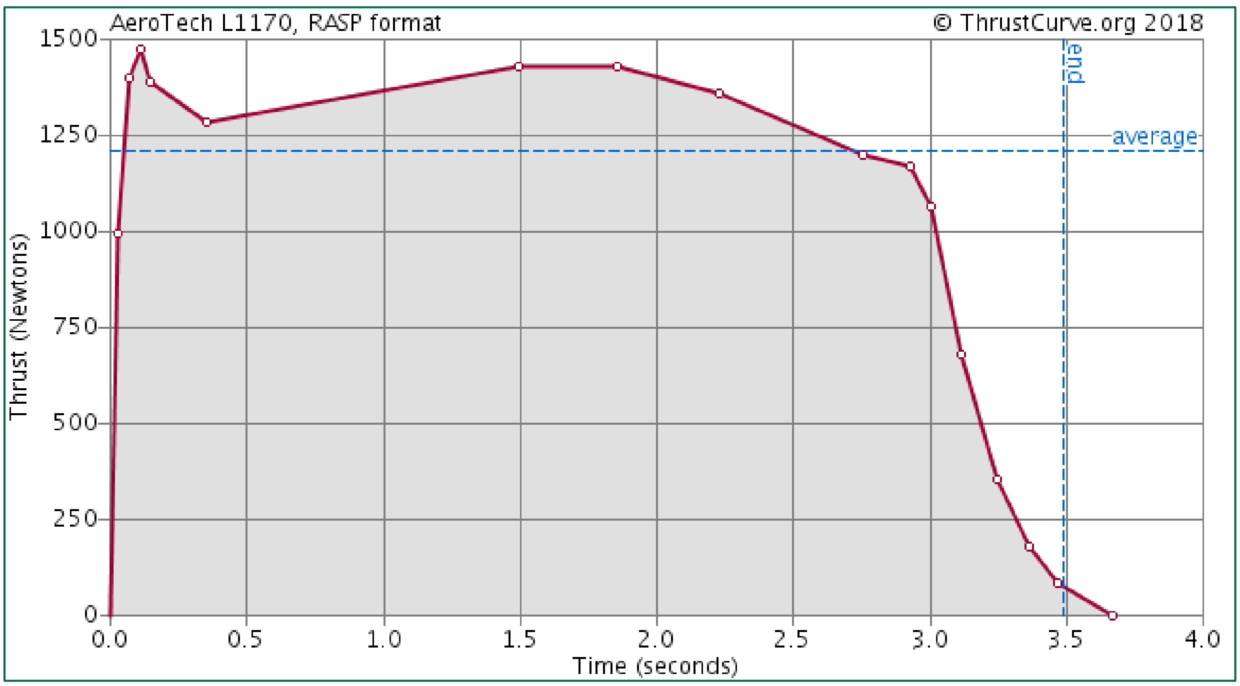

Figure 7: AeroTech 1170 thrust curve plot. (ThrustCurve & Koelsch, 2009)

5.8 TECHNICAL CHALLENGES

Foreseen major technical challenges involved in designing, fabricating, and launching the vehicle have been detailed in Table 19.

Table 19: Launch vehicle design and fabrication technical challenges.

Challenge	Solution	Solution Status
Due to the lack of prior data available on custom-wound carbon fiber rocket bodies, the ideal winding properties (ie winding angle, tow selection, and epoxy selection) are unknown.	The competition vehicle team will perform multiple tests by winding numerous subscale airframes with varying properties, testing to determine optimal solutions.	In progress; one tube has already been wound and several more have been planned.
SOAR does not currently possess or have access to the laboratory-quality static testing equipment required to determine the material properties of carbon fiber tubes.	Professors and faculty members across campus will be contacted and access to testing machines will be requested. Barring this, SOAR will rent access to equipment.	In progress; faculty members have been contacted but replies have not been received yet.
The carbon fiber body tube must be able to survive flight stresses, including both compression stresses from the motor and hoop/pressure stresses from multiple black powder charges.	The vehicle team will perform tests to determine the exact material properties of the wound tube, falling back to off-the-shelf fiberglass components if necessary.	In progress; tests and testing equipment are being developed and procured.
After the 2018 NASA Student Launch Competition, SOAR re-launched the competition rocket and the resulting parachute deployment broke the nose cone bulkhead. This must be prevented.	The nose cone bulkhead will be reinforced in a stronger manner and under stricter material conditions.	Planned, not yet implemented.

Challenge	Solution	Solution Status
The payload section of the rocket, due to the relatively high mass, has a large kinetic energy even at low velocities. This requires a longer descent time, increasing drift.	The vehicle team will work closely with the payload team to ensure efficient payload-vehicle integration and that the payload engineers are aware of the need to minimize payload mass.	In progress; weekly general Student Launch body meetings are held to ensure collaboration and communication.

6 PROJECTED PAYLOAD

6.1 PAYLOAD REQUIREMENTS (INCOMPLETE)

Table 20: Payload success criteria and verification of completion.

Requirement	Method	Verification	Verification Status
4.3.1. Teams will design a custom rover that will deploy from the internal structure of the launch vehicle.	Documentation	The current design is a sled pulled by a large wheel. We have designed the rover to be deployed from the internal structure of the launch vehicle using a sled and winch system.	Verified with proposal submission. Reference: 6.2 Rover Design

Requirement	Method	Verification	Verification Status
4.3.2. The rover will be retained within the vehicle utilizing a fail-safe active retention system. The retention system will be robust enough to retain the rover if atypical flight forces are experienced.	Documentation Testing	The current design uses a solenoid that will secure the rover in place using magnetic induction. This retaining method was used for our rover last year and was tested during competition week so we know that it is a valuable design. More testing will be done to test the security of this year's rover design. All testing will be recorded and addressed for success and failure which will be inspected and approved by the safety officer.	Documentation: Verified with submission of proposal submission. Reference: 6.2 Rover Design Testing: To be completed during sub scale and full scale launch.
4.3.3. At landing, and under the supervision of the Remote Deployment Officer, the team will remotely activate a trigger to deploy the rover from the rocket.	Testing	Multiple wireless communications tests will be conducted. All results will be recorded in order to effectively choose the best materials to use.	Testing is dependent on construction of the deployment system.

Requirement	Method	Verification	Verification Status
4.3.4. After deployment, the rover will autonomously move at least 10 ft. (in any direction) from the launch vehicle. Once the rover has reached its final destination, it will recover a soil sample.	Testing	Test will be conducted in order to measure the capabilities of the rover. We will perform electrical, obstacle detection, and power consumption tests. Each of these test will contribute to the rover's capability of moving a successful 10 feet.	Testing is dependent on construction of the first rover prototype.
4.3.5. The soil sample will be a minimum of 10 milliliters (mL).	Testing	Tests will be conducted in order to measure the amount of soil that the rover can collect.	Testing dependent on construction of rover.
4.3.6. The soil sample will be contained in an onboard container or compartment. The container or compartment will be closed or sealed to protect the sample after collection.	Documentation Testing	The rover design will include an onboard container in order to protect the soil sample. Testing will be done to test the capabilities of the onboard compartment.	Testing dependent on construction of rover.

Requirement	Method	Verification	Verification Status
4.3.7. Teams will ensure the rover's batteries are sufficiently protected from impact with the ground.	Documentation Testing	The rover is design to protect all electrical components. Stress tests will be conducted to ensure the batteries can withstand impact with the ground. In addition to stress test we will use subscale and full scale flight results to ensure the rover batteries are sufficiently protected and able to survive impact.	To be tested during subscale and full scale launches.
4.3.8. The batteries powering the rover will be brightly colored, clearly marked as a fire hazard, and easily distinguishable from other rover parts.	Inspection	Proper supplies will be used to ensure that the batteries for the rover are secure, safe for transport, and are distinguishable from other rover components. Shipping guidelines and recommendations from IATA and PHMSA will be considered when marking, labeling, and protecting batteries from impact.	Will be verified during construction of the rover.

6.2 ROVER DESIGN

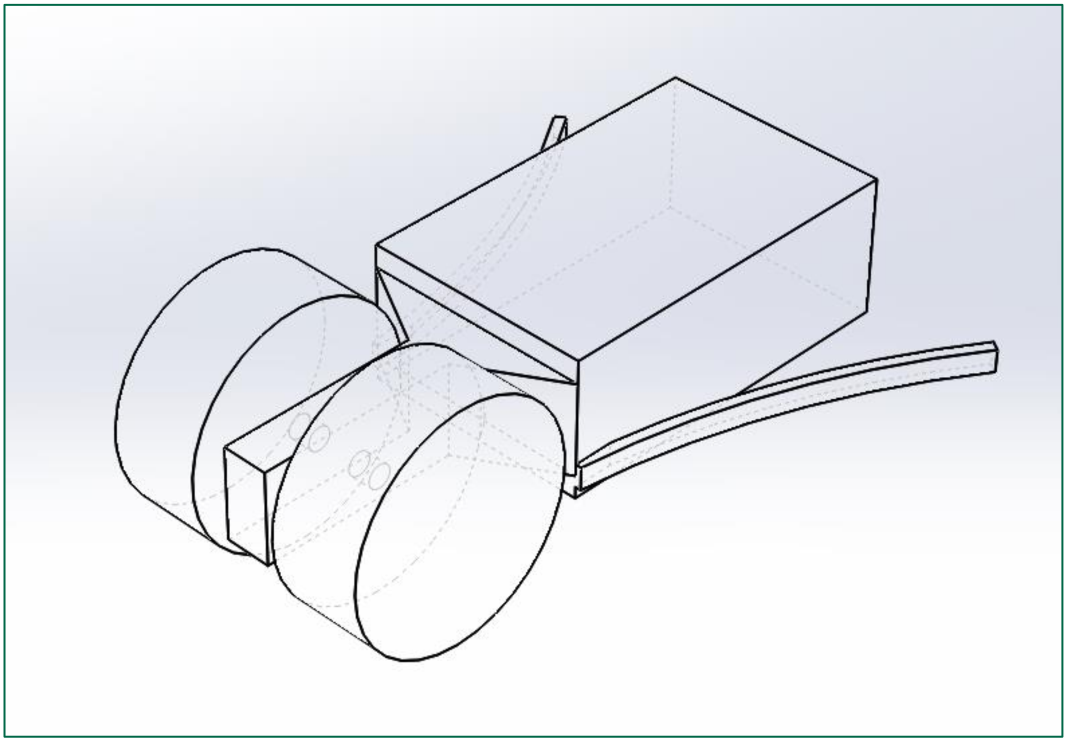

Figure 8: Concept sketch of proposed rover locomotion design. Sample collection system not shown.

6.2.1 RETENTION METHOD

The rover will be retained via magnetic induction by using a set of solenoids. The solenoids will be powered through batteries external of the rover's, so that proper power can be supplied to account for any unexpected forces while in flight.

6.2.2 MEANS OF LOCOMOTION

The rover will move through the use of a large wheel in the front of the rover design that is driven by a DC brush motor. A driver board connected to a Raspberry Pi will be used to drive the motor. Obstacle detection will be used to ensure that the rover can successfully move 10 feet. Using Pulse Width Modulation through the microcontroller, the rover can have a variable speed to handle various types of terrain. Stability arms will mounted to the side of the rover to insure that the rover remains in the driving orientation. These are will be flexible and will be pushed tight to the rover body by the inner walls of the rocket cargo area. When the rover is pushed clear of the rocket the arms will spring out. The rover will have position detection sensors to enable it to know which way to turn the wheel for locomotion.

6.2.2.1 DEPLOYMENT METHOD

A sled and winch system, to pull the rover out of the vehicle body. An Xbee receiver compatible with the Raspberry Pi will receive a signal remotely from a trigger. Once the desired signal is received, a relay will power on the Raspberry Pi and its auxiliary components. A step down transformer/converter will be used to safely step a higher voltage down to a safe level for the circuit components.

6.2.2.2 MEANS OF NAVIGATION

Using an ultrasonic sensor, a sensor to determine orientation, and various programming methods to autonomously move rover away from the vehicle and initiate soil collection procedures. Redundant accelerometers will be used to ensure that a distance is measured and the rover will stop within a reasonable distance past 10 feet.

6.2.2.3 SOIL COLLECTION

The rover will collect the necessary soil sample while moving 10 feet. Two identical milling heads will be attached to the dorsal and ventral sides of the rover's body, so that soil will be collected regardless of the orientation of the vehicle's landing. As the rover moves, the milling heads will feed soil into a single secure storage container. The milling heads will be made of a material that can handle variable soil conditions, so that the collection of soil will be possible.

6.2.3 TECHNICAL CHALLENGES

Table 21: Payload design and fabrication technical challenges.

Challenge	Solution	Solution Status
The open end of the airframe may fill with dirt/mud upon impact.	By placing an airbag inside the airframe, we will be able to prevent dirt from coming inside upon impact.	Our team is currently researching and developing specific parts and techniques.
The rover must not tip during operation.	The current design includes elastic wings that will fold beside the rover when loaded inside of the airframe, once the rover is deployed the wings will release and help prevent the rover from flipping over.	A rover prototype is being constructed in order to test this solution. Data will be provided when testing is complete.
All types of soil must be collected, regardless of consistency.	Test the milling heads to make sure they are strong enough.	Testing to be completed. Researching the strongest parts to be used.

Challenge	Solution	Solution Status
The rover must be able to collect a soil sample regardless of its orientation.	Two identical and opposite spinning Milling heads will be attached to the dorsal and ventral sides of the rover, which will feed into a single storage container.	Our team is currently researching and designing sensing materials, soil collection parts, and material.
The batteries must last for a significant period of time without dying.	The Raspberry Pi and auxiliary components will be powered on remotely once a signal is received after landing instead of turning them on when loading the rover into the rocket.	In early research and development of power management and effective power transfer principles.
The rover must be able to maneuver and steel on difficult and unexpected terrain.	The flexible control wings will allow for the rover to move with greater stability and enable the rover to turn. Pulse Width Modulation will be utilized to allow for variable speeds of the rover's motor depending on ground conditions.	In early research and development for parts and techniques.
All devices must have strong signals in order to maintain communication.	We will use an external antenna along with amplifiers to make a strong radio signal so that the Xbees connected to the Raspberry Pi have a larger signal range.	In early research and development for phase for signal strength and supporting electrical components.

Challenge	Solution	Solution Status
All components of the rocket must be properly integrated and communication is kept between sub-teams.	General meetings will be held to allow for sub teams to collaborate and ensure the system are integrated properly.	General body meetings for the NASA Student Launch project are being conducted weekly. Updates are given after each sub-team meeting to ensure the teams are aware of each other's designs.
The rover must not run into obstacles.	We plan to use an ultrasonic range-finder/sensor to detect obstacles that may impede the movement of the rover.	In early research stages to find the best programming and hardware implementation methods.
The rover needs to be aware of how far is has travelled.	We plan to use redundant accelerometers that will be linked to the rover's wheel in order to measure the total distance travelled. The redundancies are useful to average values in case there are differences in calibrations.	Currently researching and developing specific parts and techniques.

7 STEM ENGAGEMENT AND OUTREACH

The Society of Aeronautics and Rocketry plans on organizing events with the community and local schools to inform students on our projects and teach them the importance of STEM Education. We will be having members visit and engage with students through hands-on activities and demonstrations. We will also be engaging in university events that bring in local students to learn about STEM Education, specifically in the engineering field. In addition to these events we will be organizing other events to showcase our current and previous projects to teach fellow students about what we do. We have also developed a questionnaire to give to students after the presentation so that we can gain some insight on whether or not the children learned from our presentation. Criteria for the evaluations will be based on the relevance, effectiveness, student engagement, student enjoyment, and impact of the presentations and activities.

Table 22: Outreach events that SOAR plans to participate in.

Event	Date	Projected Participants	Description
Transfer Day	Oct 09, 2018	50	For this event, there will be a College Facility Tour with visits to student organization/research tables on the tour. Members of our team will set up a booth to talk to local high school students about our organization and the various projects we work on. We will bring some of our rockets. We will explain to students how different disciplines and majors are incorporated into our projects in order to fill the engineering, business, and administrative aspects of our teams.
Stampede	Oct 13, 2018	150	For this event, there will be a College Facility Tour with visits to student organization/research tables on the tour. Members of our team will set up a booth to talk to local high school students about our organization and the various projects we work on. We will bring some of our rockets. We will explain to students how different disciplines and majors are incorporated into our projects in order to fill the engineering, business, and administrative aspects of our teams.
Manatee County Engineering Day	Nov 09, 2018	120	For this event, there will be college lab tours and demonstrations with visits to student organization/research tables. Members of our team will set up a booth to talk to local high school students about our organization and the various projects we work on. We will bring some of our larger rockets that were built for specific competitions and one of our Tripoli Level 1 certification rockets. We will show students the parts of the rockets including their parachutes, fins, and nosecones. We will discuss the specific design of each rocket and what its function was. We want to share with students what possibilities our university and organization can provided for them especially when it comes to valuable hands-on STEM experience. We will explain to students how different disciplines and majors are incorporated into our projects in order to fill the engineering, business, and administrative aspects of our teams.

Great American Teach in Pinellas County	Nov 14, 2018	TBD	For this event, USF SOAR will be going to a school in Pinellas County to demonstrate and engage students in a hands on STEAM activity. SOAR will be partner with a local school to introduce students to career options, hobbies and activity that they may never otherwise experience. This will be demonstrated through a PowerPoint presentation and hands on activities with the students. We will talk about the engineering cycle and how it applies to our rocket building. We will discuss how an idea is developed from the design stages to the building stages. We will stress the process of what it takes to build something along with the safety measures that must be met. We will also stress that because the engineering cycle is in fact a cycle that it takes repetitive testing until you get the final product. We will also talk about STEM education and how all of the disciplines come together to complete a project.
Great American Teach in Hillsborough County	Nov 15, 2018	TBD	For this event, USF SOAR will be going to a school in Hillsborough County to demonstrate and engage students in a hands on STEAM activity. SOAR will be partner with a local school to introduce students to career options, hobbies and activity that they may never otherwise experience. This will be demonstrated through a PowerPoint presentation and hands on activities with the students. We will talk about the engineering cycle and how it applies to our rocket building. We will discuss how an idea is developed from the design stages to the building stages. We will stress the process of what it takes to build something along with the safety measures that must be met. We will also stress that because the engineering cycle is in fact a cycle that it takes repetitive testing until you get the final product. We will also talk about STEM education and how all of the disciplines come together to complete a project.

Bulls Unite Day	Nov 17, 2018	150	For this event, there will be a College Facility Tour with visits to student organization/research tables on the tour. Members of our team will set up a booth to talk to local high school students about our organization and the various projects we work on. We will bring some of our rockets. We want to share with students what possibilities our university and organization can provided for them especially when it comes to valuable hands-on STEM experience. We will explain to students how different disciplines and majors are incorporated into our projects in order to fill the engineering, business, and administrative aspects of our teams.
Pinellas County Engineering Day	Jan 17, 2019	120	For this event, there will be college lab tours and demonstrations with visits to student organization/research tables. Members of our team will set up a booth to talk to local high school students about our organization and the various projects we work on. We will bring some of our rockets. We want to share with students what possibilities our university and organization can provided for them especially when it comes to valuable hands-on STEM experience. We will explain to students how different disciplines and majors are incorporated into our projects in order to fill the engineering, business, and administrative aspects of our teams.
Bulls Unite Day	Feb 02, 2019	150	For this event, there will be a College Facility Tour with visits to student organization/research tables on the tour. Members of our team will set up a booth to talk to local high school students about our organization and the various projects we work on. We will bring some of our rockets. We will explain to students how different disciplines and majors are incorporated into our projects in order to fill the engineering, business, and administrative aspects of our teams.

Engineering Expo	Feb 14-15, 2019	TBD	The Engineering Expo is a two-day event that features hands-on exhibits and shows that help encourage more students to pursue careers in the STEM fields. This event provided us with an opportunity to teach local students about our organization and how the value of a STEM education and experience. We plan to engage these students with an interactive activities that will inspire them to seek a future in STEM and hopefully rocketry.
Rocket Exhibition	TBD	TBD	This is an event in the Marshall Student Center Ballroom at the University of South Florida to showcase our rockets and other various equipment. We set up multiple stations including: A showcase of our organization's past rockets with information describing what they were created for and some details about the design. A virtual reality launch experience that allowed participants to use a virtual reality headset to view one of our rocket launches as if they were actually there. A rocket building/launch station that provided participants with a chance to build their own rocket on the computer and use a simulator to launch it. This station gave participants an idea of how we visualize our designs for the projects we are working on. A presentation about our organization's projects and rocket.
Joshua House	TBD	TBD	Our organization will partner with an organization on campus who embraces education in STEM and art, ESTEAM. Members will go to Joshua House, a safe haven for abused, neglected, and abandoned children in the Tampa Bay Area. We will invite any child at the home who wanted to participate to learn how to build water rockets and measure the altitude after launching.

High School Presentation	TBD	TBD	As part of our educational engagement, we will engage a local high school in the Tampa Bay area. Members will organize an event at a high school. SOAR will conduct a presentation and some activities with some of the students in the school. We will stay with one teacher the entire day and talk to each one of their classrooms. At this school we plan to discuss STEM career options and rocketry. Furthermore, we plan to educate the students on our NASA Student Launch rocket and rover design as well as overall basic rocket dynamics. Finally, we're planning to conduct a hands-on activity that involves the students building and testing bottle rockets.

8 PROJECT PLAN

8.1 PROJECT SCHEDULE

The project schedule will be used to track, schedule, and organize progress throughout the duration of the competition.

8.1.1 GANTT CHARTS

The charts in the following figures allow easy and accessible visualization of the project timeline.

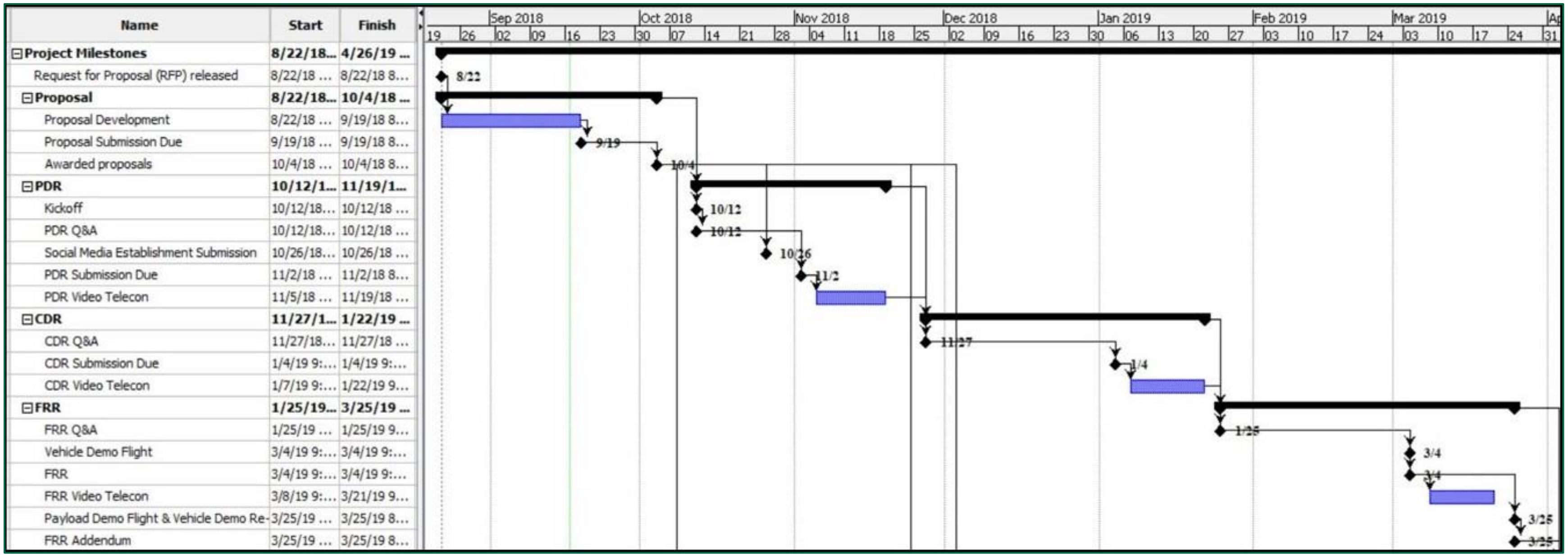

Figure 9: Project milestones Gantt chart.

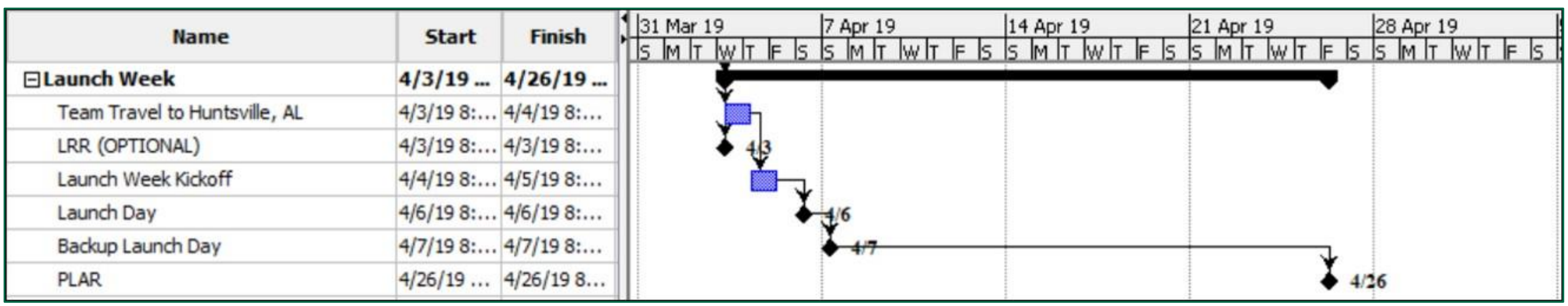

Figure 10: Launch week Gantt chart.

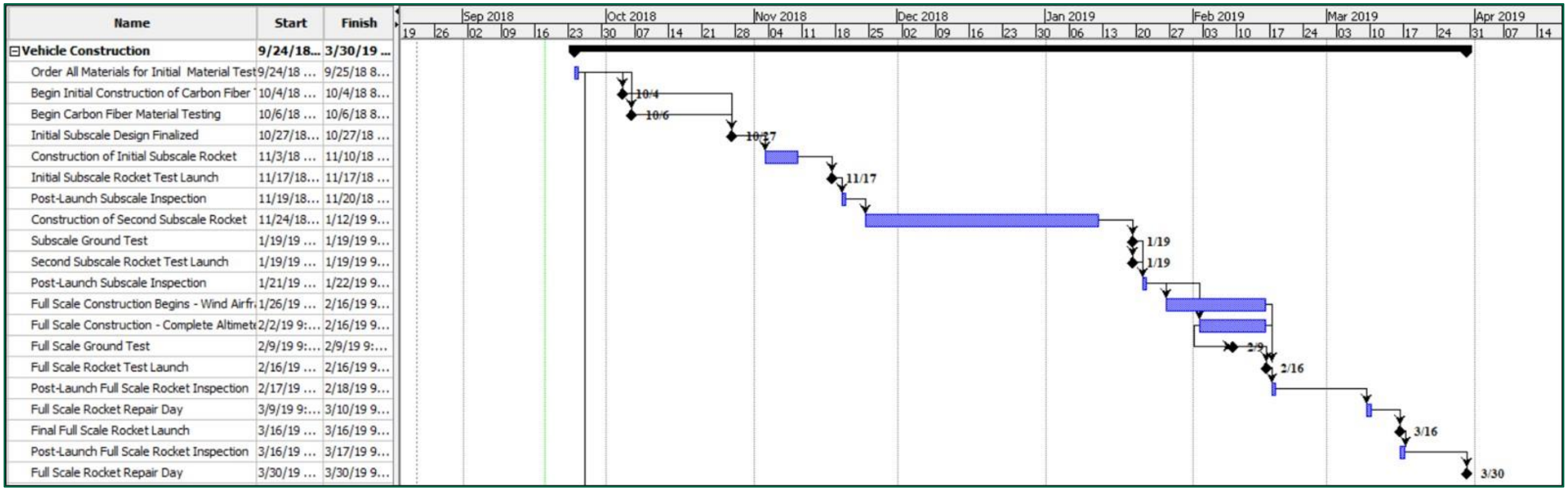

Figure 11: Vehicle construction Gantt chart.

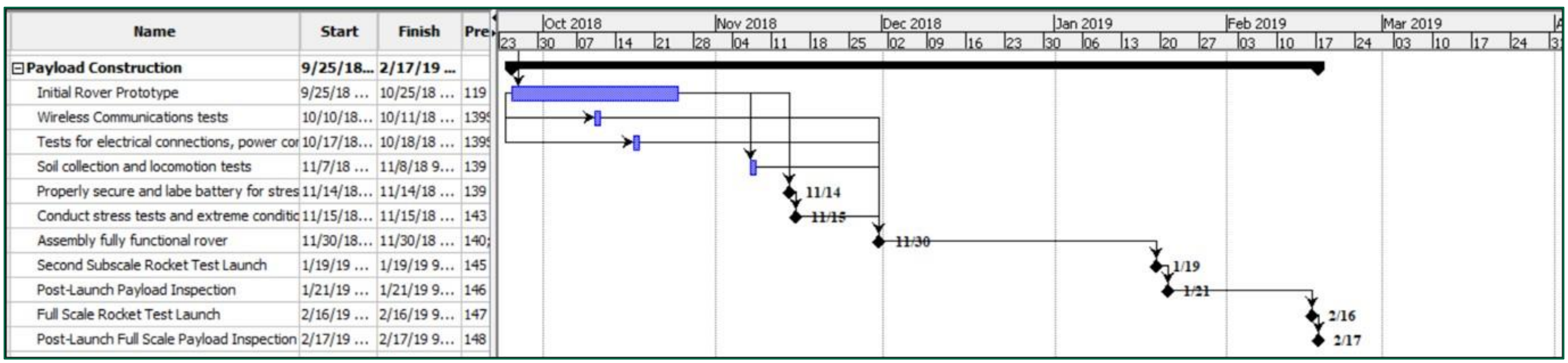

Figure 12: Payload construction Gantt chart.

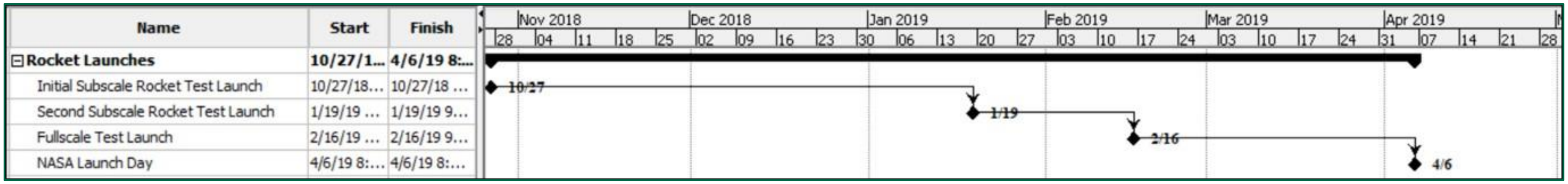

Figure 13: Planned launches Gantt chart.

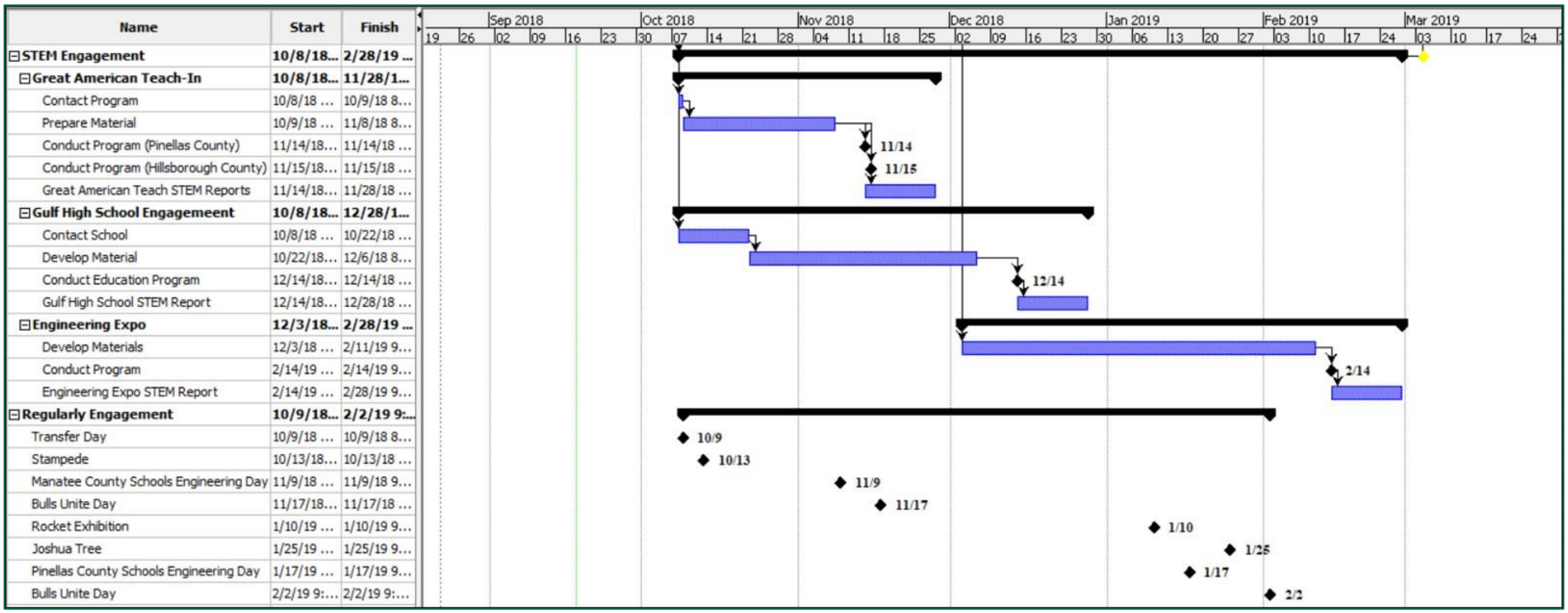

Figure 14: Outreach Gantt chart.

8.1.2 TIMELINE

The project timeline is detailed in the following tables, with dates provided for every significant event or deadline.

Table 23: General project timeline.

Date	Item Due	Team Responsible	Status
August 29th, 2018	NSL General Team Meeting	Payload Team, Vehicle Team	Complete
September 5th, 2018	NSL General Team Meeting	Entire NSL Team	Complete
September 6th, 2018	NSL Handover Meeting	Entire NSL Team	Complete
September 12th, 2018	NSL General Team Meeting	Entire NSL Team	Complete
September 14th, 2018	NSL Proposal Group Writing Session	Entire NSL Team	Complete
September 19th, 2018	NSL General Team Meeting	Entire NSL Team	Complete
September 19th, 2018	NSL Project Proposal Due	Entire NSL Team	Complete
September 26th, 2018	NSL General Team Meeting	Entire NSL Team	
October 3rd, 2018	NSL General Team Meeting	Entire NSL Team	
October 9th, 2018	Outreach Event: Transfer Day	Entire NSL Team	

Date	Item Due	Team Responsible	Status
October 10th, 2018	NSL General Team Meeting	Entire NSL Team	
October 13th, 2018	Outreach Event: Stampede	Entire NSL Team	
October 1 7th, 2018	NSL General Team Meeting	Entire NSL Team	
October 24th, 2018	NSL General Team Meeting	Entire NSL Team	
October 31st, 2018	NSL General Team Meeting	Entire NSL Team	
November 2nd, 2018	NSL PDR Due Date	Entire NSL Team	
November 7th, 2018	NSL General Team Meeting	Entire NSL Team	
November 9th, 2018	Outreach Event: Manatee County Engineering Day	Entire NSL Team	
November 14th, 2018	Outreach Event: Great American Teach In Pinellas County	Entire NSL Tem	
November 14th, 2018	NSL General Team Meeting	Entire NSL Team	
November 15th, 2018	Outreach Event: Great American Teach In Hillsborough County	Entire NSL Team	

Date	Item Due	Team Responsible	Status
November 17th, 2018	Outreach Event: Bulls Unite Day	Entire NSL Team	
November 21st, 2018	NSL General Team Meeting	Entire NSL Team	
November 28th, 2018	NSL General Team Meeting	Entire NSL Team	
December 5th, 2018	NSL General Team Meeting	Entire NSL Team	
December 12th, 2018	NSL General Team Meeting	Entire NSL Team	
December 19th, 2018	NSL General Team Meeting	Entire NSL Team	
January 2nd, 2019	NSL General Team Meeting	Entire NSL Team	
January 4th, 2019	NSL CDR Due Date	Entire NSL Team	
January 9th, 2018	NSL General Team Meeting	Entire NSL Team	
January 16th, 2019	NSL General Team Meeting	Entire NSL Team	
January 17th, 2019	Outreach Event: Pinellas County Engineering Day	Entire NSL Team	

Date	Item Due	Team Responsible	Status
January 23rd, 2019	NSL General Team Meeting	Entire NSL Team	
January 30th, 2019	NSL General Team Meeting	Entire NSL Team	
February 2nd, 2019	Outreach Event: Bulls Unite Day	Entire NSL Team	
February 6th, 2019	NSL General Team Meeting	Entire NSL Team	
February 13th, 2019	NSL General Team Meeting	Entire NSL Team	
February 14th, 2019	Outreach Event: Engineering Expo	Entire NSL Team	
February 15th, 2019	Outreach Event: Engineering Expo	Entire NSL Team	
February 20th, 2019	NSL General Team Meeting	Entire NSL Team	
February 27th, 2019	NSL General Team Meeting	Entire NSL Team	
March 4th, 2019	NSL FRR Due Date	Entire NSL Team	
March 6th, 2019	NSL General Team Meeting	Entire NSL Team	

Date	Item Due	Team Responsible	Status
March 13th, 2019	NSL General Team Meeting	Entire NSL Team	
March 20th, 2019	NSL General Team Meeting	Entire NSL Team	
March 27th, 2019	NSL General Team Meeting	Entire NSL Team	
April 3rd, 2019	Team Leaves for Huntsville	Entire NSL Team	
April 6th, 2019	Competition Day	Entire NSL Team	
April 26th, 2019	NSL Post-Launch Assessment Review Due Date	Entire NSL Team	

Table 24: Vehicle sub-team timeline.

Date	Item Due	Team Responsible	Status
August 31th, 2018	NSL Vehicle Team Meeting	Vehicle Team	Complete
September 10th, 2018	X-Winder Training Session	Vehicle Team	Complete
September 24th, 2018	Order All Materials for Initial Material Testing	Vehicle Team	

Date	Item Due	Team Responsible	Status
October 4th, 2018	Begin Initial Construction of Carbon Fiber Tubes for Testing	Vehicle Team	
October 6th, 2018	Begin Carbon Fiber Material Testing	Vehicle Team	
October 27th, 2018	Initial Subscale Design Finalized	Vehicle Team	
November 3rd, 2018	Begin Construction of Initial Subscale Rocket	Vehicle Team	
November 10th, 2018	Complete Construction of Initial Subscale Rocket	Vehicle Team	
November 17th, 2018	Initial Subscale Rocket Test Launch	Vehicle Team	
November 19th, 2018	Post-Launch Subscale Inspection	Vehicle Team	
November 24th, 2018	Begin Construction of Second Subscale Rocket	Vehicle Team	
January 12th, 2019	Complete Construction of Second Subscale Rocket	Vehicle Team	
January 19th, 2019	Subscale Ground Test	Vehicle Team	
January 19th, 2019	Second Subscale Rocket Test Launch	Vehicle Team, Payload Team	

Date	Item Due	Team Responsible	Status
January 21st, 2019	Post-Launch Subscale Inspection	Vehicle Team	
January 26th, 2019	Full Scale Construction Begins - Wind Airframe, Cut Fins	Vehicle Team	
February 2nd, 2019	Full Scale Construction - Complete Altimeter Bays, Cut Bulkheads, Centering Rings	Vehicle Team	
February 9th, 2019	Full Scale Ground Test	Vehicle Team	
February 16th, 2019	Full Scale Rocket Test Launch	Vehicle Team, Payload Team	
February 17th, 2019	Post-Launch Full Scale Rocket Inspection	Vehicle Team	
March 9th, 2019	Full Scale Rocket Repair Day	Vehicle Team	
March 16th, 2019	Final Full Scale Rocket Launch	Vehicle Team, Payload Team	
March 17th, 2019	Post-Launch Full Scale Rocket Inspection	Vehicle Team	
March 30th, 2019	Full Scale Rocket Repair Day	Vehicle Team	

Table 25: Payload sub-team timeline.

Date	Item Due	Team Responsible	Status
August 23rd, 2018	NSL Payload Team Meeting	Payload Team	Complete
August 30th, 2018	NSL Payload Team Meeting	Payload Team	Complete
September 6th, 2018	NSL Payload Team Meeting	Payload Team	Complete
September 13th, 2018	NSL Payload Team Meeting	Payload Team	Complete
September 20th, 2018	NSL Payload Team Meeting	Payload Team	
September 20th, 2018	NSL Payload Team Meeting	Payload Team	
October 4th, 2018	NSL Payload Team Meeting	Payload Team	
October 10th, 2018	Wireless Communications tests will be conducted for RF components	Payload Team	
October 11th, 2018	Wireless Communications tests will be conducted for RF components	Payload Team	
October 17th, 2018	Tests for proper electrical connections, power consumption and program debugging will be conducted	Payload Team	

Date	Item Due	Team Responsible	Status
October 18th, 2018	Tests for proper electrical connections, power consumption and program debugging will be conducted	Payload Team	
October 25th, 2018	NSL Payload Team Meeting / complete initial prototype of the rover	Payload Team	
November 1st, 2018	NSL Payload Team Meeting	Payload Team	
November 7th, 2018	Conduct soil collection and locomotion tests.	Payload Team	
November 8th, 2018	Conduct soil collection and locomotion tests.	Payload Team	
November 14th, 2018	Begin properly securing and labeling battery for stress and impact tests.	Vehicle Team, Payload Team	
November 15th, 2018	Conduct stress tests and extreme conditions tests for the battery and electrical components.	Payload Team	
November 29th, 2018	NSL Payload Team Meeting	Payload Team	
November 30th, 2018	Assembly of the fully functional rover completed	Payload team	
December 6th, 2018	NSL Payload Team Meeting	Payload Team	
December 13th, 2018	NSL Payload Team Meeting	Payload Team	

Date	Item Due	Team Responsible	Status
December 20th, 2018	NSL Payload Team Meeting	Payload Team	
January 3rd, 2018	NSL Payload Team Meeting	Payload Team	
January 10th, 2018	NSL Payload Team Meeting	Payload Team	
January 17th, 2018	NSL Payload Team Meeting	Payload Team	
January 19th, 2019	Second Subscale Rocket Test Launch/Payload Test	Vehicle Team, Payload Team	
January 21st, 2019	Post-Launch Payload Inspection	Payload Team	
January 24th, 2018	NSL Payload Team Meeting	Payload Team	
January 31st, 2018	NSL Payload Team Meeting	Payload Team	
February 7th, 2018	NSL Payload Team Meeting	Payload Team	
February 14th, 2018	NSL Payload Team Meeting	Payload Team	
February 16th, 2019	Full Scale Rocket Test Launch/Test Payload	Vehicle Team, Payload Team	

Date	Item Due	Team Responsible	Status
February 17th, 2019	Post-Launch Full Scale Payload Inspection	Payload Team	
February 21st, 2018	NSL Payload Team Meeting	Payload Team	
February 28th, 2018	NSL Payload Team Meeting	Payload Team	
March 7th, 2018	NSL Payload Team Meeting	Payload Team	
March 14th, 2018	NSL Payload Team Meeting	Payload Team	
March 21st, 2018	NSL Payload Team Meeting	Payload Team	
March 28th, 2018	NSL Payload Team Meeting	Payload Team	

8.2 PROJECT BUDGET

The budget estimate in Table 26 has been developed based on material costs, planned test launches, subscale launches, prior years' expenses, and estimated travel and housing costs. These are projected costs and are subject to change as the need arises.

Table 26: Project budget overview.

Category	Amount Budgeted ($)
Rocket Materials	5,500

Category	Amount Budgeted ($)
Launch Motors	250
Test Launch Motors	750
Subscale Materials	750
Subscale Motor	350
Payload	1,200
Miscellaneous Hardware	100
Travel	1,500
Total	10,400

8.3 SUSTAINABILITY

8.3.1 SOCIAL MEDIA

The Executive Board members of SOAR maintain all social media accounts (listed in 2.2.4 Social Media Presence) for the organization. These board members will coordinate members on the team to have access based on activity and involvement. The process as to how members post to social media is a working progress. We have proposed that a single member of the project who is the most active may have the ability to post directly to the social media accounts while others may submit photos along with a suggested post for a board member to approve and post. The logistics of this process are in the process of being determined, as this is a newer requirement for the NSL Initiative.

8.3.2 PARTNERSHIPS

SOAR is currently working on building new partnerships with members of the USF and Tampa Bay communities and industries. We have recently received confirmation that Carbon Marine, a local carbon fiber shop, is willing and able to provide us guidance and mentorship on the use of Carbon Fiber to build out rocket frame. We are also working on gaining access to autoclave to cure our rockets through the Society of Automotive Engineers at USF. This only represents our initial efforts toward partnership, we plan to engage additional sponsors in the growing space industry in Florida.

8.3.3 RECRUITMENT

SOAR has an active recruitment plan that involved attending recruitment events as well as reaching out to multiple departments and student organizations. Since the summer semester SOAR has participated in five recruiting events four of which were set up by USF's College of Engineering and one that was set up by our Recruitment Team. SOAR keeps statistical data on its recruitment process through surveys, member tracking, and involvement. Through our communications tool, Slack, we send out a recruitment survey using Google Forms which then tracks data on the responses and notifies us when a new member responds. Recruitment updates are given weekly through our communication tool, Slack, this update usually includes any new member data pulled from our Student Organization website called BullSync as well as any new survey responses. In August of 2018 we had a total of 43 new members, this is nearly double the number of new members during August of the previous two years. SOAR will continue to monitor its recruitment efforts in order to maximize project involvement.

Through social media, SOAR is also able to recruit members who are not able to attend social events. SOAR recently launched a campaign on all of USF's Facebook class pages to increase student awareness of our organization and the events that we have. The events listed above not only provide educational engagement opportunities, but it also helps us recruit new members to our organization. In addition to recruiting new students we are also able to use these events to recruit new resources such as faculty and staff who may be interested in the work we are doing. By having an active social media presence, we are able to reach out to other social media account from the University in order to help bring more awareness to our organization.

SOAR is actively working on a plan to retain its members by providing opportunities and experience that cannot be found in any other student organization. SOAR provides multiple projects for its members to join in order to help them gain professional experience in multiple different disciplines. We encourage all students no matter their field of study or involvement to attend our build days, launches, and social events. We also host guest speakers and tours in order to provide unique experiences to our members. Since we are a student organization we cannot compensate members for their time, but we are actively working on finding ways to show our members appreciation.

8.3.4 RECURRING ENGAGEMENT

SOAR participates in several recurring engagement activities each year, these include USF's Engineering Expo along with several other events put on by the College of Engineering at USF. We have also participated in events like the Great American Teach-In for the past two years and plan on continuing this engagement opportunity this year. Last year we coordinated with several other organizations both on and off campus for outreach events which we plan on holding again this year. In addition to the events that SOAR has already established we will continue to organize new events and partner with new organizations who we do not currently have events planned with.

Finally, education is primary among our many goals at SOAR. The Tripoli Rocket Association, recognizes three levels of certification, each authorizing the rocketeer to launch ever more powerful rockets. To this end, we conduct Level I and Level II Certification courses to help members learn the basics of rocketry and build a strong base of knowledgeable members. We believe this endeavor is paramount to the success of our organization and to transmitting knowledge from graduating members to new and upcoming students of rocketry.

8.3.5 CONTINUING FUNDING

USF's Student Government is our primary source of funding; however we are actively seeking other sources of income. We are currently applying to two different grants, the Florida Space Grant and the USF Student Organizations Travel Grant. The Florida Space Grant is run by the Florida Space Grant Consortium in support of the expansion and diversification of Florida's space industry by providing grants, scholarships, and fellowships to students and educators from Florida's public and private institutes of higher education; receiving this grant could provide up to $2,000 of additional funding for the project. The USF Student Organizations Travel Grant is run by USF Student Government and would be used to subsidize the trip to Huntsville. Finally, we continue to work on building partnerships with industry leaders in the growing Florida space industry in order to obtain sponsorships.

In addition to student government funding, SOAR conducts fundraising at the local launches by selling food during lunch time. We have also established an account through the University's non-profit USF Foundation fund, a tax-deductible donation account. CAE[25], a Tampa Bay engineering company that designs simulation equipment and software, donated $2,500 in 2017, and we have several other prospective sponsorship partners we are in contact with. NSL will also initiate a crowdfunding campaign through HerdFunder[26], a crowdfunding service that also deposits funds to the USF Foundations account, for specific milestones of the project. In addition to these sources of funding, SOAR is also working on setting up spirit night-like fundraisers with local restaurants which are an adequate way of receiving funding while dedicating minimal resources. Once this plan is in put into action, SOAR will be able to hold monthly fundraisers in order to have a steady source of income.

[25] Information available at: https://www.cae.com/
[26] Information available at: https://usffdn.usf.edu/herdfunder/

APPENDIX A: CONTRIBUTORS

This document was made possible through the hard work and dedication of the following SOAR members (in alphabetical order):

- Ashleigh Stevenson
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