NASA STUDENT LAUNCH

2022-2023

University of South Florida

Society of Aeronautics and Rocketry

4202 East Fowler Avenue, MSC Box #197

September 19th, 2022

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1. GENERAL INFORMATION

a. **Team Name & Mailing Address**

Society of Aeronautics and Rocketry (SOAR) at the University of South Florida. Mailing address: 4202 East Fowler Avenue MSC Box 197 Tampa, Florida 33620

b. **Team Personnel**

i. **Primary Leadership**

1. **Team Mentor**
   - Jonathan Fitzer. Member, Previous SOAR President (Certification Level III) (813) 389-3876, fitzer@mail.usf.edu
2. **Faculty Advisor**
   - Professor Nikolas Baksh. Director, USF STEM Education Center; Professor, USF College of Arts & Sciences (813) 974-2349, nbaksh@usf.edu
3. **Team Advisor**
   - Frank Alvarez. President, SOAR Executive Board Undergraduate Senior, Mechanical Engineering (941) 404-9919, falvarez1@usf.edu
4. **Project Managers**
   - Frank Alvarez. President, SOAR Executive Board Undergraduate Senior, Mechanical Engineering (941) 404-9919, falvarez1@usf.edu
   - Enrique Hernandez. Chief of Finance, SOAR Executive Board Undergraduate Junior, Mechanical Engineering (352) 457-2291, enrique17@usf.edu

5. **Safety Officer**
    - Matthew Montes. Chief of Safety, SOAR Executive Board Undergraduate Sophomore, Mechanical Engineering (813) 340-0027, matthewmontes@usf.edu

ii. Team Structure and Members

1. **Organization Chart**

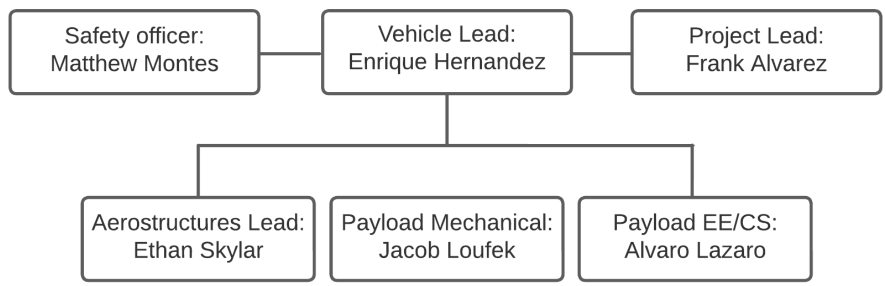

***Figure 1**: Organizational chart of the key managers and technical personnel.*

2. **Team 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 BullConnect, USF's distribution of the OrgSync student organization management software.

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.

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.

5. **NAR/TRA 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

6. **Proposal/Brainstorming/Meeting Hours Spent**

   Many hours were spent in preparation of the NASA Student Launch Proposal. This includes time spent brainstorming preliminary payload and vehicle design, meeting between leadership members of SOAR, and drafting of the proposal. The total hours spent on the NSL Proposal between all contributing team members is 23 hours.

2. FACILITIES/EQUIPMENT

a. USF Design For X (DFX) Labs

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

ii. EQUIPMENT:

- LPKF ProtoMat S63 PCB3 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
- LCR4 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

iii. **HOURS:** The DFX lab is open Monday-Friday, 7:00am to 5:00pm

iv. **PERSONNEL:** Michael Celestin, Ph.D.

b. Engineering Research Building (ENR)

i. **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.

ii. **EQUIPMENT:**

- Small Hand Tools

• Powered Hand Tools

• Drill Presses

• Manual Milling Lathes

• Buffer

• Cold Saw

• Shear

• Arbor Press

• Band Saw

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

iv. **PERSONNEL: Matthew Montes**

Chief of Safety, USF Society of Aeronautics and Rocketry (SOAR) undergraduate sophomore, (813)340-0027, matthewmontes@usf.edu

c. **College of Engineering Machine Shop (ENG)**

i. **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 of experience, they can meet numerous design needs requiring precise cutting and quality materials.

ii. **EQUIPMENT:**

• CNC Milling Machines

• CNC Lathe Manual Milling Ma- chines

• 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

iii. **HOURS:** The Machine Shop operates Monday – Thursday, 7:30 am to 12:00 pm and 1:00 pm to 4:30 pm. Friday: 7:30 am to 12:00 pm and 1:00 pm to 4:00 pm

iv. **PERSONNEL:**

1. **Chris Taylor:**

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

2. **Tony Villicana:**

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

3. **Chester Tamawa:**

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

d. **Varn Ranch (Plant City, FL)**

i. **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.

ii. **EQUIPMENT:** • Launch Rails • Launch System Electronics

iii. **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.

iv. **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

e. **COMPUTER PROGRAMS & AIDS**

i. SOAR uses a number of software tools for communication between members. The organization's primary method of internal communication is Discord, a team collaboration service that enables organized real-time messaging within large groups. SOAR has previously used Slack as the primary method of communication but the incorporation of Discord has led to a more user friendly experience during use. SOAR also uses openly vis- ible 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 cr ation 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.

ii. **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 modeling. All MATLAB code, along with any other code written in the process of this competition, will be hosted publicly7 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 be- tween these programs will provide a model of best fit.

iii. **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

3. SAFETY

a. Written safety plan addressing the safety of the materials used, facilities involved, and student responsible, i.e. Safety Officer, for ensuring that the plan is followed

i. MATERIALS:

The manufacturing of SOAR's rocket inherently leads to the exposure of fiberglass dust in the air and mixing of chemicals to create adhesives to join rocket bodies together.

SOAR takes the safety of their members to the utmost importance. When cutting fiberglass materials or mixing a batch of epoxy, SOAR requires all members to wear PPE that consists of particulate masks that contain a filter strong enough to keep out fiberglass dust and other harmful chemicals.Sanding and cutting of fiberglass materials must be done in an outdoor setting or in a well ventilated area. SOAR also requires that members wear proper gloves and, when necessary, long sleeve jumpsuits when working with harmful chemicals that cannot come in contact with the skin.

ii. FACILITIES:

The majority of the manufacturing for the 2022-2023 subscale and full scale rocket will take place in "The Shop" where SOAR is located. This building was previously a bus repair depot where at both ends of the building contain a garage style door that can be opened for ventilation The Shop contains multiple manufacturing tool sets used for production of engineering projects. To use these machines, a training class is required through USF. The Chief of Safety of SOAR is required to inform members on how to safely operate tools before they are able to utilize them.

b. Description of the procedures for NAR/TRA personnel to perform

i. COMPLIANCE WITH NAR HIGH POWER SAFETY CODE REQUIREMENTS:

[http://www.nar.org/safety-information/high-power-rocket-safety-code/].

a. SAFETY OFFICER DUTIES & RESPONSIBILITIES:

The Safety Officer (see 1.B.i.5 Safety Officer for personnel information) will be in charge of ensuring the team and launch vehicle is complying with all NAR and TRA 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 activities

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 MSDS11, personal protective equipment re- quirements, 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 on 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 PPE12 during construction, ground tests, and test flights of the
Rocket.

b. 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 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 re- move 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.

c. **SAFETY CODE:**

SOAR conducts launches at both NAR15 and TRA16 launches, and will abide by the appropriate High-Power Rocketry Safety Code requirements during all operations.

ii. PERFORMANCE OF ALL HAZARDOUS MATERIALS HANDLING AND HAZARDOUS OPERATIONS:

a. **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.

b. **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

c. **TRAINING:**

The Safety Officer will ensure 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 oppor- tunity. 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.

c. Plan for briefing students on hazard recognition and accident avoidance as well as for conducting pre-launch briefings

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 earliest 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.

The designated safety officer within SOAR will also provide training on accident avoidance with respect to fiberglass and carbon fiber machining, general shop etiquette and safety measures, and the locations of first-aid kits, emergency eyewash stations, and fire extinguishers.

Before a launch is conducted, the designated safety officer within SOAR will prepare a pre-launch checklist to ensure all safety measurements are followed. This includes parachute and recovery redundancies, securing electronics components, and motor assembly precautions. The safety officer within SOAR is responsible for preparing this checklist in accordance with the precautions required by each team.

d. Describe methods to include necessary caution statements in plans, procedures, and other working documents, including the use of proper Personal Protective Equipment (PPE)

The safety officer within SOAR will draft necessary caution statements in all working documents. The use of proper PPE will be highlighted where applicable to ensure hazardous activities such as machining or cutting fiberglass and carbon fiber, and performing black powder tests, are completed in a safe manner with minimal opportunity for accidents to occur.

e. Plan for complying with federal, state, and local laws regarding unmanned rocket launches and motor handling

SOAR launches will occur on a TRA sanctioned launch day. Tampa Tripoli Rocketry Association is permitted to launch rockets up to 14,900 feet above ground level. Due to close proximity to several airports, the TTRA staff require prior approval to any launches projected to 10,000 feet apogee. These altitudes are much higher than expected for any NASA Student Launch activities. TRA range safety officers, along with the designated safety officer within SOAR, will ensure motor handling is done safely with due regard for federal, state, and local laws.

f. Provide a plan for NAR/TRA mentor purchase, storage, transportation, and use of rocket motors and energetic device

The designated mentor for SOAR will purchase the necessary rocket motors and energetic devices required for NASA Student Launch. The rocket motor purchases will be coordinated with Student Business Services at USF to ensure the necessary components are bought with SOAR's budget. The purchased rocket motors will be stored in a fireproof storage unit within the ENR workshop to ensure safety. All transported rocket motors will be designated with an appropriate warning sticker adhering to federal law.

g. Written statements to abide by safety regulations:

i. 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.

All team members will allow range safety officers to complete safety inspections on each rocket before it is flown. The team will accept the final work of the range safety officer at the risk of being removed from the program otherwise.

ii. 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.

All team members will respect the range safety officer's final say on any rocket safety issues. The team will respect the range safety officer's decision to deny the launch of any rocket for safety reasons.

iii. 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.

The team will not fly any rocket until the mentor has reviewed the design, examined the build, and is satisfied the rocket meets established amateur rocketry design and safety guidelines.

iv. ANY TEAM THAT DOES NOT COMPLY WITH THE SAFETY REQUIREMENTS WILL NOT BE ALLOWED TO LAUNCH THEIR ROCKET.

The team acknowledges that not complying with safety requirements will result in the denial of privilege to launch the rocket.

4. TECHNICAL DESIGN

a. Proposed and detailed approach to rocket and payload design

i. GENERAL VEHICLE DIMENSIONS, PRELIMINARY MATERIAL SELECTION AND JUSTIFICATION, AND CONSTRUCTION METHODS

Our projected vehicle dimensions aim to achieve an airframe diameter of four inches, with a vertical length of roughly 80 inches. The majority will consist of the body tube, where the avionics bay, motor tube, shock cords, parachutes, etc. will be housed. The upper section of the rocket, consisting of the transition and the nose cone, will be designated as the payload. Airframe and fin composition are projected to be Carbon Fiber, the nose cone being wound-fiberglass, and internal components consisting of a range of materials; from PLA (Polylactic Acid) for 3D printed items, to Stainless Steel for hardware. Carbon Fiber proves to be a very efficient option for body tube construction as its stiffness and strength provide additional stability on ascent, and added protection for the rocket and its components on descent, thus increasing the ability of the rocket as a whole to be reusable. This is as the use of Fiber Glass yielded “zippering” damages to the airframe upon the sudden exerted tension force created by shock cord extension. Fiberglass remains an ideal choice for the nose cone as it is very structurally rigid, as well as malleable so the nose cone shape can be created easily during construction. Given the fact that Stainless Steel in contact with Carbon Fiber leads to Galvanic corrosion of that Stainless Steel, plastic washers will be used as an intermediary between the two materials to ensure not only the functionality of the vehicle, but its reusability as well. Optimal nose cone design will be a Haack Series or Von Karman structure. This was determined to be the most aerodynamically efficient option as the minimization of drag is ideal for a uniform diameter and length. Given the subsonic speeds achieved by the vehicle during flight, trapezoidal fins with a height of roughly five inches and a length of roughly 10 inches are suitable to ensure the overall stability of the rocket. Construction of the rocket will occur in-house through the utilization of practices such as CNC Milling, as used to form the trapezoidal fin set, and the use of a vertical band saw to ensure exact dimensions on body-tubes. Material to manufacture the vehicle components, including internal avionics and recovery elements, will consist of acquired Commercial off-the-Shelf products that will be modified and assembled in-house.

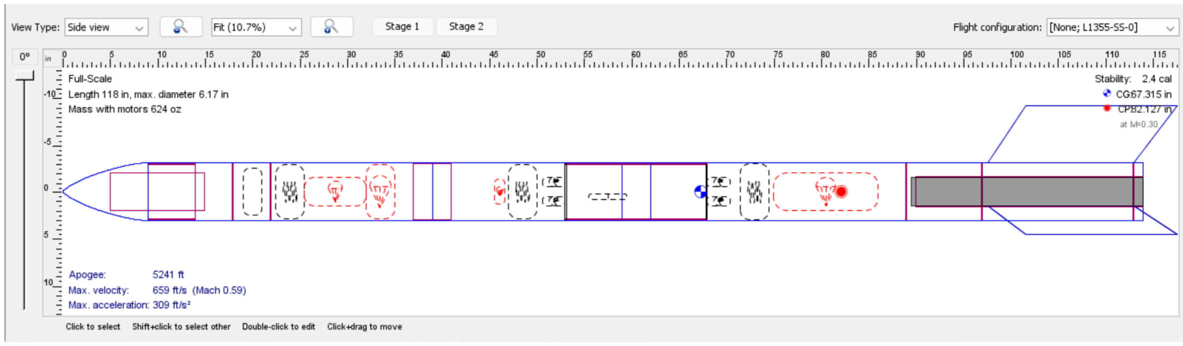

Figure 2:Proposed Full Scale Launch Vehicle Design. OpenRocket Software

ii. PROJECTED ALTITUDE AND CALCULATION METHODS:

Projected flight altitude is 4,500 feet, as calculated through simulation in Open Rocket software. Redundant calculations will also be made by hand, and both calculation methods will be updated within one hour prior to launch, factoring in elements such as current wind speed and direction, to ensure the altitude goal is met as closely as possible.

iii. PLANNED RECOVERY SYSTEM DESIGN:

Upon apogee, the launch vehicle will utilize four black powder charges, two primary charges and two for redundancy, to separate the payload, midsection containing the avionics bay, and booster section. The midsection and booster section will be connected via shock cord, while the payload will be jettisoned. Upon ignition of the charges, a drogue parachute will deploy to support the midsection and booster section, while a streamer will be utilized to control payload descent. The booster section drogue parachute will be a Standard Low-Porosity one-foot 1.1 Ripstop Parachute, and the payload streamer will be an Apogee Components 2” x 56” Aluminized Mylar streamer. On descent, at roughly 750 feet the main parachute for both the payload and lower sections will deploy. The main parachute for both sections will be a Standard Low-Porosity 1.1 Ripstop

Parachute, with the payload parachute maintaining a diameter of seven feet, and the lower section parachute maintaining a diameter of 12 feet. For ease of finding all launch vehicle components after touchdown, the team intends to utilize an in-house built RC quadcopter equipped with a camera and GPS sensor.

iv. Projected Motor Brand and Designation:

The launch vehicle is projected to be equipped with a Cessaroni 4025-L1355-SS-0 ‘Smokey Sam’ Solid Reloadable rocket motor. Specifications include L-class, and area of 2.95 x 24.45 inches, a total impulse of 4025.50 Ns, a maximum thrust of 1792.20 N, an average thrust of 1355.70 N, a specific impulse of 136.26s, a burntime of 2.97s, a loaded weight of 4962g, and a burnout weight of 1886g.

v. Detailed Description of the Team’s Projected Payload:

Upon apogee, the launch vehicle will separate into two independent sections each utilizing their own parachute. The top independent portion of the launch vehicle will consist of the nose cone and payload. This section will feature deployable landing legs that will extend at a certain altitude, landing it vertically. It will position this section with the nose cone tip facing the planetary surface while the open section that connects the tethered parachute, will be oriented up towards the sky. This will align the camera system along the z-axis and allow for 360° rotation. There will be four deployable landing legs that will be spaced 90° apart. A certain altitude will be calculated and used allowing ample time for the legs to deploy with a motor. For a redundancy measure, the legs will also be deployed after a certain time based on the apogee reached and constant acceleration equations to correlate with our desired deployment altitude. The legs will utilize dampers to minimize bounce upon landing and help protect the sensitive camera equipment. During launch, the legs will be either flush or streamlined with the main airframe and have minimal drag impact

The camera will be positioned on the inside of the top airframe. An approximate 10 inch length piece of clear acrylic tube, the diameter of the main rocket, will be positioned within a section of the body just below the nose cone. This will allow the camera system to look outside and swivel 360° with minimal interaction of the paracord above. The clear tube will be mounted like any other body tube using couplers and epoxy. Tensile and other stress tests will be performed to determine what loads the clear acrylic tube can withstand and see if additional reinforcement is necessary.

Inside the payload will have an onboard small computer that will process commands, and perform the required actions. The current dimensions of the main computer are projected to be those of a raspberry-pi zero (66.0mm x 30.5mm x 5.0mm). The system as a whole will also include a small microcontroller, which along with the main computer will operate as master/slave, with the microcontroller being mainly used to control the camera motors. To receive the radio-signals the payload will also be equipped with a Lo-Ra module. The main computer will interface with the Lo-Ra module to interpret the Radio Frequency Commands. The main computer will also interface directly with the camera module, allowing the image data to quickly undergo any processing necessary and be safely stored in memory.

Other ideas considered to tackle the payload challenge are as follows:

Idea 1: After the payload section has landed vertically, a telescoping rod will be extended upwards with the camera on the end. The camera will then be exposed out of the body and have the ability to rotate and see 360°.

Idea 2: The payload section will fall gently to the ground and lay on its side. Using legs on the side and a sensor to determine its orientation, it will proceed to prop the whole section up, placing the camera high enough to take quality pictures.

Idea 3: While the payload section is still laying on its side, a sensor will determine the orientation of the camera inside. An arm will extend out and swing upwards placing the camera above the rocket body allowing it to swivel 360° and take pictures.

Idea 4: When altitude is reached to deploy the landing legs, they will be unlocked and fall with gravity. Then they will connect to a latch locking them and securing them in place.

vi. GENERAL, VEHICLE, RECOVERY, PAYLOAD, AND SAFETY REQUIREMENTS

GENERAL REQUIREMENTS	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). Teams will submit new work. Excessive use of past work will merit penalties.	Verified during Project Proposal submission. Will continue to be verified throughout the course of the project until final launch day.

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.	Verified with submission of Proposal. Will continue to be verified throughout the course of the project as more documents are submitted.
1.3 The team shall identify all team members who plan to attend Launch Week activities by the Critical Design Review (CDR). Team members will include: 1.3.1. Students actively engaged in the project throughout the entire year. 1.3.2. One mentor (see requirement 1.13). 1.3.3. No more than two adult educators.	SOAR will have a detailed roster of the team members that plan on attending Launch Week to meet university travel grant requirements as well.
1.4 Teams shall engage a minimum of 250 participants in Educational Direct Engagement STEM activities in order to be eligible for STEM Engagement scoring and awards. These activities can be conducted in person or virtually. To satisfy this requirement, all events shall occur between project acceptance and the FRR due date. A template of the STEM Engagement Activity Report can be found on pages 39–42.	SOAR engages in multiple Educational Direct Engagement STEM activities events throughout the Fall and spring semesters that actively inspire and motivate youths to explore the field of aerospace and rocketry.
1.5 The team will establish and maintain a social media presence to inform the public about team activities.	SOAR has designated an Outreach Coordinator to organize and handle all outreach events.
1.6 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. Late submissions of PDR, CDR, FRR milestone documents	Will be verified upon submission of documents for each milestone.

shall be accepted up to 72 hours after the submission deadline. Late submissions shall incur an overall penalty. No PDR, CDR, FRR milestone documents shall be accepted beyond the 72-hour window. Teams that fail to submit the PDR, CDR, FRR milestone documents shall be eliminated from the project.	
1.7 Teams who do not satisfactorily complete each milestone review (PDR, CDR, FRR) shall be provided action items needed to be completed following their review and shall be required to address action items in a delta review session. After the delta session the NASA management panel shall meet to determine the teams' status in the program and the team shall be notified shortly thereafter.	SOAR understands this requirement, and will strive to complete the milestone review to the best of our ability.
1.8. All deliverables shall be in PDF format.	Will be verified upon submission of documents for each milestone.
1.9. In every report, teams will provide a table of contents including major sections and their respective sub-sections.	Will be verified upon submission of documents for each milestone.
1.10. In every report, the team will include the page number at the bottom of the page.	Will be verified upon submission of documents for each milestone.
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 sufficient Internet connection. Cellular phones should be used for speakerphone capability only	Will be verified during milestone presentations.

as a last resort.	
1.12. All teams attending Launch Week will be required to use the launch pads provided by Student Launch's launch services provider. No custom pads will be permitted at the NASA Launch Complex. At launch, 8-foot 1010 rails and 12-foot 1515 rails will be provided. The launch rails will be canted 5 to 10 degrees away from the crowd on Launch Day. The exact cant will depend on Launch Day wind conditions.	Current rocket design will utilize 1515 rail buttons for rocket mounting on pad. Launch conditions will be verified on launch day.
1.13. Each team shall identify a "mentor." A mentor is defined as an adult who is included as a team member, who will be supporting the team (or multiple teams) throughout the project year, and may or may not be affiliated with the school, institution, or organization. The mentor shall maintain a current certification, and be in good standing, through the National Association of Rocketry (NAR) or Tripoli Rocketry 8 General and Proposal Requirements Association (TRA) for the motor impulse of the launch vehicle and must have flown and successfully recovered (using electronic, staged recovery) a minimum of 2 flights in this or a higher impulse class, prior to PDR. The mentor is designated as the individual owner of the rocket for liability purposes and must travel with the team to Launch Week. One travel stipend will be provided per mentor regardless	SOAR's NSL Team has identified a mentor who meets the qualifications specified in the NASA Student Launch 2023 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.

of the number of teams he or she supports. The stipend will only be provided if the team passes FRR and the team and mentor attend Launch Week in April.	
1.14. Teams will track and report the number of hours spent working on each milestone.	Will be verified throughout the course of the Documentation
VEHICLE REQUIREMENTS	**VERIFICATIONS STATUS**
2.*1 The vehicle will deliver the payload to an apogee altitude between 4,000 and 6,000 feet above groundlevel (AGL). Teams flying below 3,500 feet or above 6,500 feet on their competition launch will receive zero altitude points towards their overall project score and will not be eligible for the Altitude Award.*	The rocket will utilize a sufficient Cesaroni motor for propulsion factor and the flight path can be altered with adjustable ballast. Current simulations and calculations place apogee at approximately 4,500 feet, depending on conditions and ballast.
2.2 Teams shall declare their target altitude goal at the PDR milestone. The declared target altitude will be used to determine the team's altitude score.	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.
2.3 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.	SOAR is committed to creating a recoverable and reusable that can last multiple launches.
2.4. The launch vehicle will have a maximum of four (4) independent sections. An independent section is defined as a section that is either tethered to the main vehicle or is recovered separately from the main vehicle using its own parachute.	2.4 The rocket will be broken up into four sections: the nose cone, payload section, main altimeter bay, and the booster section. The nose cone and payload will be tethered together, as will the altimeter bay and booster. Subscale designed to

2.4.1. Coupler/airframe shoulders which are located at in-flight separation points will be at least 2 airframe diameters in length. (One body diameter of surface contact with each airframe section). *2.4.2. Nosecone shoulders which are located at in-flight separation points will be at least ½ body diameter in length.*	these specifications. 2.4.1 The proposed full-scale rocket design meets the coupler/airframe requirement. 2.4.2 The proposed full-scale rocket design meets the coupler/airframe requirement.
2.5. The launch vehicle will be capable of being prepared for flight at the launch site within 2 hours of the time the Federal Aviation Administration flight waiver opens.	There will be a 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.
2.6. The launch vehicle and payload will be capable of remaining in launch-ready configuration on the pad for a minimum of 2 hours without losing the functionality of any critical on-board components, although the capability to withstand longer delays is highly encouraged.	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.
2.7. The launch vehicle will be capable of being launched by a standard 12-volt direct current firing system. The firing system will be provided by the NASA-designated launch services provider.	The ignitor used in the rocket will be able to withstand a 12-volt DC firing system.
2.8. The launch vehicle will require no external circuitry or special ground support equipment to initiate launch (other than what is provided by the launch services provider).	The only required external circuitry will be the 12-volt direct current firing system that is compatible with the ignitor in the launch vehicle.

2.9. Each team shall use commercially available ematches or igniters. Hand-dipped igniters shall not be permitted.	SOAR will utilize the ematches provided by the motor manufacturer from said purchased motor.
2.10. The launch vehicle will use a commercially available solid motor propulsion system using ammonium perchlorate composite propellant (APCP) which is approved and certified by the National Association of Rocketry (NAR), Tripoli Rocketry Association (TRA), and/or the Canadian Association of Rocketry (CAR). 2.10.1. Final motor choices will be declared by the Critical Design Review (CDR) milestone. 2.10.2. Any motor change after CDR shall be approved by the NASA Range Safety Officer (RSO). Changes for the sole purpose of altitude adjustment will not be approved. 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.	The motor that will be selected will be from Cesaroni Technologies which is certified by the Tripoli Rocketry Association. Final motor choices will be chosen by the time of the CDR. SOAR understands this penalty for changes to the motor selection.
2.11. The launch vehicle will be limited to a single motor propulsion system.	The proposed rocket will solely have one reloadable single motor propulsion system.
2.12. The total impulse provided by a College or University launch vehicle will not exceed 5,120 Newtonseconds (L-class).	The selection for the full-scale motor will not exceed the 5,120 Ns maxim.
2.13. Pressure vessels on the vehicle will be approved by the RSO and will meet the	SOAR's subscale/full scale design does not contain a pressure vessel.

following criteria: 2.13.1. The minimum factor of safety (Burst or Ultimate pressure versus Max Expected Operating Pressure) will be 4:1 with supporting design documentation included in all milestone reviews. 2.13.2. Each pressure vessel will include a pressure relief valve that sees the full pressure of the tank and is capable of withstanding the maximum pressure and flow rate of the tank. 2.13.3. The full pedigree of the tank will be described, including the application for which the tank was designed and the history of the tank. This will include the number of pressure cycles put on the tank, the dates of pressurization/depressurization, and the name of the person or entity administering each pressure event.	
2.14. The launch vehicle will have a minimum static stability margin of 2.0 at the point of rail exit. Rail exit is defined at the point where the forward rail button loses contact with the rail.	The 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 2.5 calipers. When the launch vehicle is complete, it will be physically balanced to verify data.
2.15. The launch vehicle will have a minimum thrust to weight ratio of 5.0 : 1.0.	Upon finalizing the motor selection, SOAR will verify that this requirement is met through Open Rocket software calculations.
2.16. Any structural protuberance on the	The launch team will inspect the rocket

rocket will be located aft of the burnout center of gravity. Camera housings will be exempted, provided the team can show that the housing(s) causes minimal aerodynamic effect on the rocket's stability.	for all structural protuberances prior to launch.
2.17. The launch vehicle will accelerate to a minimum velocity of 52 fps at rail exit.	Using Open Rocket simulations and proper motor selections, SOAR will verify that the designed rocket will meet this requirement.
2.18. All teams will successfully launch and recover a subscale model of their rocket prior to CDR. Success of the subscale is at the sole discretion of the NASA review panel. The subscale flight may be conducted at any time between proposal award and the CDR submission deadline. Subscale flight data shall be reported in the CDR report and presentation at the CDR milestone. Subscales are required to use a minimum motor impulse class of E (Mid Power motor). *2.18.1. 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.* *2.18.2. The subscale model will carry an altimeter capable of recording the model's apogee altitude.* *2.18.3. The subscale rocket shall be a newly constructed rocket, designed and built specifically for this year's project.* *2.18.4. Proof of a successful flight shall be supplied in the CDR report.* *2.18.4.1. Altimeter flight profile graph(s)*	SOAR plans on launching the first subscale model on November 19th, well before the CDR. Subscale model will resemble the full scale rocket and carry multiple altimeters for redundancy. Manufacturing of the subscale and full scale rocket will occur in house at SOAR's workshop. CDR shall have detailed proof of a successful flight done by SOAR.

OR a quality video showing successful launch, recovery events, and landing as deemed by the NASA management panel are acceptable methods of proof. Altimeter flight profile graph(s) that are not complete (liftoff through landing) shall not be accepted. 2.18.4.2. Quality pictures of the as landed configuration of all sections of the launch vehicle shall be included in the CDR report. This includes but not limited to nosecone, recovery system, airframe, and booster. 2.18.5. The subscale rocket shall not exceed 75% of the dimensions (length and diameter) of your designed full-scale rocket. For example, if your full-scale rocket is a 4"	
2.19. All teams will complete demonstration flights as outlined below. 2.19.1. Vehicle Demonstration Flight—All teams will successfully launch and recover their full-scale rocket prior to FRR in its final flight configuration. The rocket flown shall be the same rocket to be flown for their competition launch. The purpose of the Vehicle Demonstration Flight is to validate the launch vehicle's stability, structural integrity, recovery systems, and the team's ability to prepare the launch vehicle for flight. A successful flight is defined as a launch in which all hardware is functioning properly (i.e. drogue chute at apogee, main chute at the	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.

intended lower altitude, functioning tracking devices, etc.). The following criteria shall be met during the full-scale demonstration flight: 10 General and Proposal Requirements 2.19.1.1. The vehicle and recovery system will have functioned as designed. 2.19.1.2. The full-scale rocket shall be a newly constructed rocket, designed and built specifically for this year's project. 2.19.1.3. The payload does not have to be flown during the full-scale Vehicle Demonstration Flight. The following requirements still apply: 2.19.1.3.1. If the payload is not flown, mass simulators will be used to simulate the payload mass. 2.19.1.3.2. The mass simulators will be located in the same approximate location on the rocket as the missing payload mass. 2.19.1.4. If the payload changes the external surfaces of the rocket (such as camera housings or external probes) or manages the total energy of the vehicle, those systems will be active during the full-scale Vehicle Demonstration Flight. 2.19.1.5. Teams shall fly the competition launch motor for the Vehicle Demonstration Flight. The team may request a waiver for the use of an alternative motor in advance if the home launch field cannot support the full impulse of the competition launch motor or	

in other extenuating circumstances. *2.19.1.6. The vehicle shall be flown in its fully ballasted configuration during the full-scale* *test flight. Fully ballasted refers to the maximum amount of ballast that will be flown* *during the competition launch flight. Additional ballast may not be added without a* *re-flight of the full-scale launch vehicle.* *2.19.1.7. 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).* *2.19.1.8. Proof of a successful flight shall be supplied in the FRR report.* *2.19.1.8.1. Altimeter flight profile data output with accompanying altitude and velocity* *versus time plots is required to meet this requirement. Altimeter flight* *profile graph(s) that are not complete (liftoff through landing) shall not* *be accepted.* *2.19.1.8.2. Quality pictures of the as landed configuration of all sections of the launch* *vehicle shall be included in the FRR report. This includes but not limited to nosecone, recovery system, airframe, and booster.* *2.19.1.9. Vehicle Demonstration flights shall be completed by the FRR submission deadline.* *No exceptions will be made. 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 shall submit an FRR Addendum by the FRR* *Addendum deadline.*	
2.20. An FRR Addendum will be required for any team completing a Payload Demonstration Flight or NASArequired Vehicle Demonstration Re-flight after the submission of the FRR Report. *2.20.1. Teams required to complete a Vehicle Demonstration Re-Flight and failing to submit the FRR* *Addendum by the deadline will not be permitted to fly a final competition launch.* *2.20.2. Teams who successfully complete a Vehicle Demonstration Flight but fail to qualify the payload* *by satisfactorily completing the Payload Demonstration Flight requirement will not be permitted* *to fly a final competition launch.* *2.20.3. Teams who complete a Payload Demonstration Flight which is not fully successful may petition* *the NASA RSO for permission to fly the payload at launch week. Permission will not be granted* *if the RSO or the Review Panel have any safety concerns.*	If SOAR requires a re-flight for payload demonstration, it will follow the necessary requirements to do so.
2.21. 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*	The launch team will inspect the rocket airframe and any section that separates to ensure this information will be present.

to the main airframe. This information shall be included in a manner that allows the information to be retrieved without the need to open or separate the vehicle.	
2.22. All Lithium Polymer batteries will be sufficiently protected from impact with the ground and will be brightly colored, clearly marked as a fire hazard, and easily distinguishable from other payload hardware.	Stress tests will be conducted to ensure the batteries can withstand impact with the ground. In addition to stress tests, we will use subscale and full scale flight results to ensure the payload's batteries are sufficiently protected and able to survive impact.
2.23. Vehicle Prohibitions 2.23.1. The launch vehicle will not utilize forward firing motors. 2.23.2. The launch vehicle will not utilize motors that expel titanium sponges (Sparky, Skidmark, MetalStorm, etc.) 2.23.3. The launch vehicle will not utilize hybrid motors. 2.23.4. The launch vehicle will not utilize a cluster of motors. 2.23.5. The launch vehicle will not utilize friction fitting for motors. 2.23.6. The launch vehicle will not exceed Mach 1 at any point during flight. 2.23.7. Vehicle ballast will not exceed 10% of the total unballasted weight of the rocket as it would sit on the pad (i.e. a rocket with an unballasted weight of 40 lbs. on the pad may contain a maximum of 4 lbs. of ballast). 2.23.8. Transmissions from onboard transmitters, which are active at any point prior to landing, will not exceed 250 mW of power (per transmitter).	Vehicle simulation does not contain any prohibited items.

2.23.9. Transmitters will not create excessive interference. Teams will utilize unique frequencies, handshake/ passcode systems, or other means to mitigate interference caused to or received from other teams. *2.23.10. Excessive and/or dense metal will not be utilized in the construction of the vehicle. Use of lightweight metal will be permitted but limited to the amount necessary to ensure structural integrity of the airframe under the expected operating stresses.*	
RECOVERY SYSTEM REQUIREMENTS	**VERIFICATION STATUS**
3.1. The full scale launch vehicle will stage the deployment of its recovery devices, where a drogue parachute is deployed at apogee, and a main parachute is deployed at a lower altitude. Tumble or streamer recovery from apogee to main parachute deployment is also permissible, provided that kinetic energy during drogue stage descent is reasonable, as deemed by the RSO. *3.1.1. The main parachute shall be deployed no lower than 500 feet.* *3.1.2. The apogee event may contain a delay of no more than 2 seconds.* *3.1.3. Motor ejection is not a permissible form of primary or secondary deployment.*	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 750ft.
3.2. Each team will perform a successful ground ejection test for all electronically initiated recovery events	A ground ejection test for the drogues and main parachutes will be completed prior to initial subscale and full-scale launches

prior to the initial flights of the subscale and full scale vehicles.	while following new safety guidelines.
3.3. Each independent section of the launch vehicle will have a maximum kinetic energy of 75 ft-lbf at landing. Teams whose heaviest section of their launch vehicle, as verified by vehicle demonstration flight data, stays under 65 ft-lbf will be awarded bonus points.	The correct and appropriate parachute size will be chosen in the PDR and will be adjusted if order to slow the launch vehicle mass down enough to ensure a kinetic energy of less than 75 ft·lbf. Multiple tests will be simulated.
3.4. The recovery system will contain redundant, commercially available barometric altimeters that are specifically designed for initiation of rocketry recovery events. The term "altimeters" includes both simple altimeters and more sophisticated flight computers.	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 a safety officer. .
3.5. Each altimeter will have a dedicated power supply, and all recovery electronics will be powered by commercially available batteries.	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. One standard 9V Alkaline batteries will be configured to each altimeter and be sufficient in supplying power to enable function.

3.6. Each altimeter will be armed by a dedicated mechanical arming switch that is accessible from the exterior of the rocket airframe when the rocket is in the launch configuration on the launch pad.	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 Testing/switches to be Inspected and verified at subscale and full-scale launch
3.7. Each arming switch will be capable of being locked in the ON position for launch (i.e. cannot be disarmed due to flight forces).	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 Testing/switches to be Inspected verified at subscale and full-scale launch
3.8. The recovery system, GPS and altimeters, electrical circuits will be completely independent of any payload electrical circuits.	The recovery system will be powered through the circuits located in the avionics bay. Design of the rocket has recovery and payload electronics completely separated.
3.9. Removable shear pins will be used for both the main parachute compartment and the drogue parachute compartment.	Launch vehicle has been designed with shear pins at each separation point: between altimeter bay and booster, between altimeter bay and payload section.
3.10. The recovery area will be limited to a 2,500 ft. radius from the launch pads.	Using Open Rocket drift calculations and manual calculations will assure that our designed rocket falls well within the 2,500 ft. radius and through subscale and full-scale flight verifications.
3.11. Descent time of the launch vehicle will be limited to 90 seconds (apogee to	Using Open Rocket descent time calculations and manual calculations will

touch down). Teams whose launch vehicle descent, as verified by vehicle demonstration flight data, stays under 80 seconds will be awarded bonus points.	assure that our designed rocket falls well within the90 second. radius and through subscale and full-scale flight verifications.
3.12. An electronic GPS 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. *3.12.1. Any rocket section or payload component, which lands untethered to the launch vehicle, will contain an active electronic GPS tracking device.* *3.12.2. The electronic GPS tracking device(s) will be fully functional during the official competition launch.*	SOAR has a GPS tracking device designed into the altimeter bay of the rocket. SOAR will assure that all sections of the designed rocket have a tracking feature for the event that the visual line of sight of the rocket is broken.
3.13. The recovery system electronics will not be adversely affected by any other on-board electronic devices during flight (from launch until landing). *3.13.1. 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.* *3.13.2. The recovery system electronics will be shielded from all onboard transmitting devices to avoid inadvertent excitation of the recovery system electronics.* *3.13.3. 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*	Extensive altimeter testing will be conducted such that radio frequencies and other electronic interference do not compromise the functionality of our recovery system during flight time.

inadvertent excitation of the recovery system. 3.13.4. The recovery system electronics will be shielded from any other onboard devices which may adversely affect the proper operation of the recovery system electronics.	
PAYLOAD EXPERIMENT REQUIREMENTS	**VERIFICATION STATUS**
4.1. College/University Division—Teams shall design a payload capable upon landing of autonomously receiving RF commands and performing a series of tasks with an on-board camera system. The method(s)/design(s) utilized to complete the payload mission shall be at the team's discretion and shall be permitted so long as the designs are deemed safe, obey FAA and legal requirements, and adhere to the intent of the challenge.	The current design involves deployable landing legs that will ensure the payload section lands upright and a midsection of the payload whose exterior will be made out of clear acrylic tube so that pictures of the outside can be taken.
4.2. Radio Frequency Command (RAFCO) Mission Requirements 4.2.1. Launch Vehicle shall contain an automated camera system capable of swiveling 360º to take images of the entire surrounding area of the launch vehicle.	The payload section with the camera will have an exterior made out of clear acrylic tube, allowing the camera to have a clear 360° view of its surroundings. The camera itself will be mounted on a servo motor that will enable us to accurately turn to the desired angle.
4.2.1.1. The camera shall have the capability of rotating about the z axis. The z axis is perpendicular to the ground plane with the sky oriented up and the planetary surface oriented down.	The landing system design, with the deployable landing legs will ensure the payload's z-axis lands upright
4.2.1.2. The camera shall have a FOV of at least 100º and a maximum FOV of 180º.	The team will make sure the camera sensor and the camera lens acquired comply with the minimum-maximum

4.2.1.3. The camera shall time stamp each photo taken. The time stamp shall be visible on all photos submitted to NASA in the PLAR.	FOV. The team will also make sure the camera sensor hardware has the capability to timestamp. Any setup needed to get the timestamp working will be performed and checked before tests and launch.
4.2.1.4. The camera system shall execute the string of transmitted commands quickly, with a maximum of 30 seconds between photos taken.	Before acquiring the servomotor and the camera sensor, the team will make sure the servomotor has the right speed to get the camera to each angle quickly and the camera sensor will be checked to be capable of taking continuous pictures in less than 30 seconds.
4.2.2 NASA Student Launch Management Team shall transmit a RF sequence that shall contain a radio call sign followed by a sequence of tasks to be completed. The list of potential commands to be given on launch day along with their radio transcriptions which shall be sent in a RF message using APRS transmission in no particular order are: *A1—Turn camera 60º to the right* *B2—Turn camera 60º to the left* *C3—Take picture* *D4—Change camera mode from color to grayscale* *E5—Change camera mode back from grayscale to color* *F6—Rotate image 180º (upside down).* *G7—Special effects filter (Apply any filter or image distortion you want and state what filter or distortion was used).* *H8—Remove all filters.* *4.2.2.1. An example transmission sequence could look something like, "XX4XXX C3 A1 D4 C3 F6 C3 F6 B2 B2 C3." Note the call sign that NASA will use shall be distributed to teams at a later time.*	The current design projects to use a LoRA module to receive the radio signals, and once the main payload computer receives the decoded signals from the LoRa, it will make sure to have a dictionary with which to compare the radio signals received and be able to identify which command they must execute. After completely decoded into commands the master computer will interface with the slave microcontroller and the microcontroller will make sure the motor and camera executes the commands. The main program will also include a modifiable input for identifying the call sign NASA will use on launch day.

4.2.3. The NASA Student Launch Management Panel shall transmit the RAFCO using APRS. 4.2.3.1. NASA will use dedicated frequencies to transmit the message. NASA will operate on the 2-Meter amateur radio band between the frequencies of 144.90 MHz and 145.10 MHz. No team shall be permitted to transmit on any frequency in this range. The specific frequency used will be shared with teams during Launch Week. NASA reserves the right to modify the transmission frequency as deemed necessary.	The current design projects the use of a LoRa module to receive the radio frequency commands. The team will set up and test the lora module to work within the frequencies specified. The payload leads will also establish a procedure to be able to switch the inspected frequencies in a timely manner in case NASA deems it necessary to change them.
4.2.3.2. The NASA Management Team shall transmit the RAFCO every 2 minutes. 4.2.3.3. The payload system shall not initiate and begin accepting RAFCO until AFTER the launch vehicle has landed on the planetary surface.	The payload team shall conduct tests on the LoRa module to ensure it can receive the RAFCO every 2 minutes. The payload software team will also make sure the main program won't start running until the RAFCO commands start to be received.
4.2.4. The payload shall not be jettisoned.	The current landing system design allows the completion of the challenge without the payload being jettisoned.
4.2.5. The sequence of time-stamped photos taken need not be transmitted back to ground station and shall be presented in the correct order in your PLAR	The current payload design and components do not account for the functionality to send any data back to base over RF. The current main computer is projected to be able to store the pictures in its memory to later be retrieved.
4.3. General Payload Requirements 4.3.1. Black Powder and/or similar energetics are only permitted for deployment of in-flight recovery systems.	The current payload design is projected to not require any black powder or energetics to perform the payload challenge.

Energetics shall not be permitted for any surface operations.	
4.3.2. Teams shall abide by all FAA and NAR rules and regulations.	The team leads will ensure to read the FAA and NAR regulations and keep them in mind during development and tests. Besides the TTRA launch site does a safety briefing, ensuring the team complies with these regulations before attempting flight.
4.3.3. Any secondary payload experiment element that is jettisoned during the recovery phase will receive real-time RSO permission prior to initiating the jettison event, unless exempted from the requirement of the CDR milestone by NASA.	No secondary payload experiment is currently projected to be performed
4.3.4. Unmanned aircraft system (UAS) payloads, if designed to be deployed during descent, will be tethered to the vehicle with a remotely controlled release mechanism until the RSO has given permission to release the UAS. *4.3.5. Teams flying UASs will abide by all applicable FAA regulations, including the FAA's Special Rule for Model Aircraft (Public Law 112–95 Section336; see https://www.faa.gov/uas/faqs).* *4.3.6. Any UAS weighing more than .55 lbs. Shall be registered with the FAA and the registration number marked on the vehicle.*	SOAR's payload current design doesn't implement a UAS.
SAFETY REQUIREMENTS	**VERIFICATION STATUS**
5.1. Each team will use a launch and safety checklist. The final checklists will be included in the FRR report	The most updated checklist will be completed during each and every launch. The Safety Officer will supervise all

and used during the Launch Readiness Review (LRR) and any Launch Day operations.	operations using the checklist.
5.2. Each team shall identify a student safety officer who will be responsible for all items in section 5.3.	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.
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.	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.
5.5. Teams will abide by all rules set forth by the FAA.	Teams will abide by all regulations and testing requirements of all Inspection

vii. Major Technical Challenges and Solutions

Challenge	**Projected solution**
Ensuring that the payload's main computer remains operational from launch to landing	Improving internal structure that supports the computer to better protect the electronic components from colliding with

	the payload walls
Getting accurate sensor data consistently	Acquiring good quality sensors and routinely use calibration software tools to re-calibrate before tests and launch
Clear acrylic tubes will not be able to withstand tensile forces upon descent and with sudden releases of the parachutes.	Thin ribs spanning the length of the tube.
The parachute falling on top of the camera system, obstructing the view.	Extend the paracord length to allow more time for the parachute to blow to the side after the payload has landed vertically.
Attaching the landing legs to the side of the airframe.	Using a combination of epoxy and through bolts to secure mounts allowing the legs to be easily interchanged.
Determining proper landing leg length and where to pivot the links.	Prototype many variations and see which configuration works the best.

5. 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 ac- tivities 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 presen- tations and activities.

Table 1: Outreach events that SOAR plans to participate in.

Date	Participants projected	Description
February 2023	500+ (Based on 2022 participation)	**USF Engineering Expo** 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 Engineering opportunity to teach local students about our Expo organization and how the value of a STEM education and experience. We plan to engage these students with interactive activities that will inspire them to seek a future in STEM and hopefully rocketry.
TBD	TBD	**Local High School Visit** 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 partner with a local school to introduce students to career options, hobbies and activities that they may never otherwise experience. This will be demonstrated through a PowerPoint presentation and hands-on safe activities with the students.

6. PROJECT PLAN

a. Development schedule

NSL USF Gantt Chart

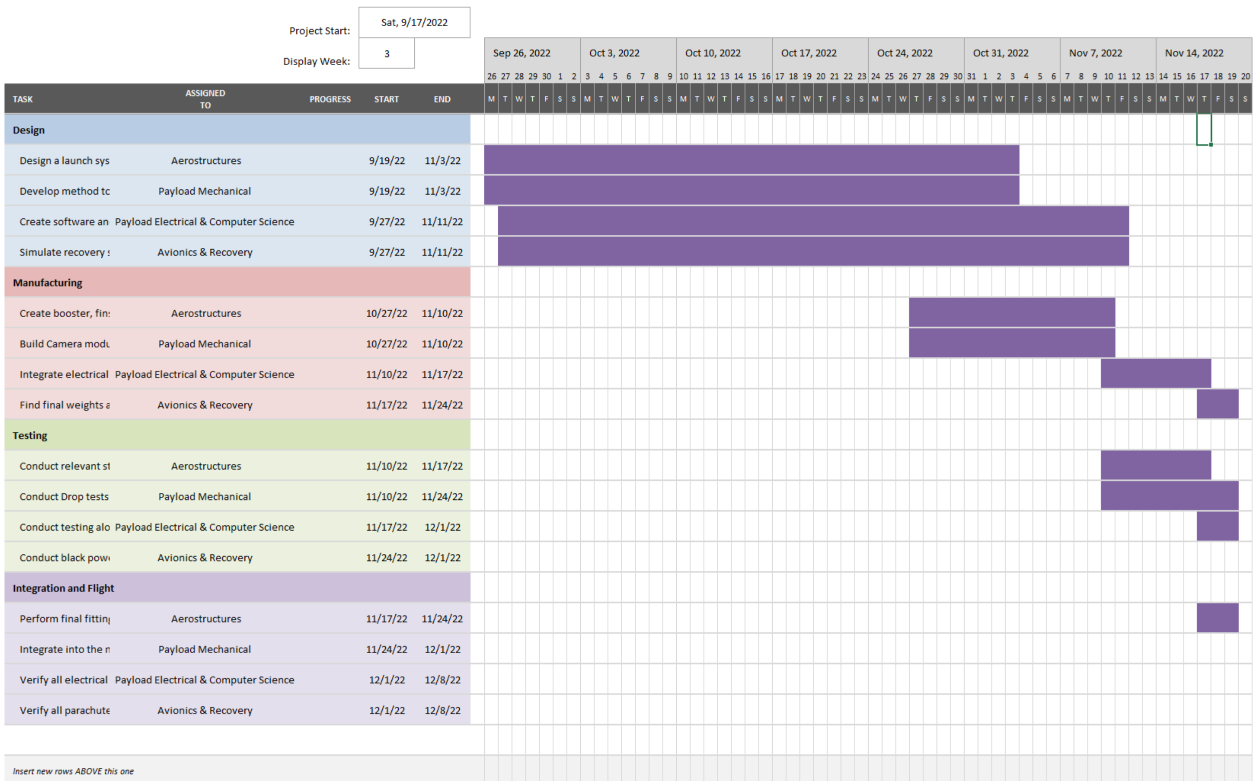

Figure 3: *Proposed Gantt Chart for subscale production.*

b. Detailed budget:

This year, SOAR has been allocated $30,755 from Student Government for the 2022-23 school year. This has been further divided to provide $8,457.63 for the NSL project. $3,000 has been allocated to payload, which is the same amount as expended on payload supplies last year in the NASA Student Launch project. $4,000 has been allocated to the aerostructures and launch supplies in order to fund the construction and preparation of the launch vehicle. The remaining budget is allocated to recovery and avionics endeavors. The $30,755 budget also has independent categories to fund "general" mixed-project use materials in the club such as epoxy, fiberglass, and carbon fiber stock which would not impinge on the NSL budget. There are also existing materials such as fiberglass tubing, altimeters and wiring, and tooling within the ENR workshop which have been leftover from previous years and projects which may be repurposed for NSL needs this year.

c. Detailed funding plan:

USF's Student Government is our primary source of funding; however we are actively seeking other sources of income. This year, SOAR has been allocated a budget of $30,755 from USF Student Government. We are also 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.

d. Plan for sustainability of the rocket project:

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. The successive classes of students participating in SOAR will have opportunities to engage with rocketry programs through this initiative.

In terms of recruitment efforts, early Fall is used as a recruitment timeframe within SOAR. Events such as Racing and Rocketry, a collaborative effort with a fellow ENR engineering club for recruitment and showcasing purposes, and our General Body Meeting serve to bolster recruitment, especially among freshmen and sophomores who are looking to join active clubs to strengthen their engineering skills. In addition to these yearly events, SOAR is looking to take advantage of Bull Market, a weekly open-air market organized by the University of South Florida to allow organizations and vendors to aggregate in a common area. It is hoped that SOAR's participation in this tabling event will help to advertise our projects to students who were not able to attend other recruitment events and students outside of the College of Engineering, which is where much of our official communication with the student body occurs. Another added benefit of participating in Bull Market is that SOAR's reputation as a dependable, reliable student organization is strengthened among the Student Government and Center for Leadership and Civic Engagement offices, which helps to justify our budgeting allocation requests at the end of the fiscal year.

Building and maintaining industry relationships and rapport with the community is also another important goal of SOAR. In terms of community and STEM engagement, SOAR takes part in a variety of outreach events yearly in order to contribute to our community. These events include the Great American Teach-In, where SOAR leaders visit Hillsborough County Schools to teach public school audiences important aspects of our work and share our enthusiasm for aerospace technology. The USF College of Engineering also holds an annual event, Engineering Expo, in which students from ages ranging from elementary to middle school visit the college to attend an event consisting of different engineering and science clubs, departments, and organizations.