

NASA

University Student Launch Initiative Proposal

Lamar University

LUNAR Rocketry Team

4400 S M L King Jr Pkwy, Beaumont, TX 77705

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ACRONYM DEFINITION

Acronym	Definition
AGL	Above Ground Level
AFT	Bureau of Alcohol, Tobacco, Firearms and Explosives
CAD	Computer Aided Design
CAE	Computer Aided Engineering
CDR	Critical Design Review
CFD	Computational Fluid Dynamics
CG	Center of Gravity
CNC	Computer Numerical Control
CP	Center of Pressure
DC	Drogue Chute
FAA	Federal Aviation Administration
FEA	Finite Element Analysis
FMEA	Failure Modes and Effects Analysis
FRR	Flight Readiness Review
GPS	Global Positioning System
JSA	Job Safety Analysis
LCO	Launch Control Officer
LRR	Launch Readiness Review
LUNAR	Lamar UNiversity Association of Rocketry
MC	Main Chute
MOC	Management Of Change
MSFC	Marshall Space Flight Center
NAR	National Association of Rocketry
NASA	National Aeronautics and Space Administration
NHRC	National High Power Rocketry Certification
PDF	Payload Demonstration Flight
PDF	Portable Document Format
PDR	Preliminary Design Review
PHA	Personal Hazard Analysis
PLA	Polylactic Acid
PLAR	Post Launch Assessment Review
PPE	Personal Protective Equipment
RFP	Request for Proposal
ROCKETS	LUNAR'S Sustainability Plan
RSO	Range Safety Officer
SDS	Safety Data Sheet
USLI	University Student Launch Initiative
SLS	Space Launch System
SME	Subject Matter Expert
SOMD	Space Operations Mission Directorate
SOW	Statement of Work
STEM	Science, Technology, Engineering, and Mathematics
TMAC	Texas Manufacturing Assistance Center
TRA	Tripoli Rocketry Association
TRAP	Technology & Rocket Assembly Place
VDF	Vehicle Demonstration Flight
WBS	Work Breakdown Structure



1. GENERAL INFORMATION

LUNAR (Lamar UNIVERSITY Association of Rocketry) is thrilled to present our proposal for the 2024-2025 NASA USLI competition. Building on the team's debut at the 2024 USLI event, our team has been working to foster interest in rocketry and aerospace both within the university and the broader community. For the 2024-2025 competition, our team is comprised of 28 members, organized into special sub-teams each with distinct responsibilities and objectives to fulfill the mission. LUNAR is committed to uniting aspiring engineers to apply their technical knowledge while actively contributing to the future of human spaceflight and supporting the Artemis mission.

1.1 SCHOOL INFORMATION

School Name: Lamar University

Organization: Lamar University Association of Rocketry (LUNAR)

Mailing Address: 4400 S M L King Jr Pkwy, Beaumont, TX 77705

Faculty Advisor: Dr Yao, Chun-Wei, Associate Professor (cyao@lamar.edu)

Faculty Mentor: Dr. Jenny Zhou, Associate Dean (jenny.zhou@lamar.edu)

1.2 TEAM ADVISOR AND MENTORS

Faculty Advisor: Dr Yao, Chun-Wei

Email: cyao@lamar.edu

Phone: (409)-880-7008

Dr. Yao is an Associate Professor at Lamar University within the Department of Mechanical Engineering. He holds his Ph. D in Mechanical Engineering from Texas A&M University, and a M.S. in Engineering Science from National Taiwan University. His research includes investigations into topics such as Hydrophobic Coating and Microdroplets. Yao's academic interest covers a variety of topics including programming, manufacturing analysis, materials science, statics, dynamics, thermodynamics, and fluid mechanics. Dr. Yao has been at Lamar University for 10 years and has had a tremendous impact on his students. He is currently the faculty advisor for the Lamar University AIAA Chapter and the LUNAR Rocketry Team.





Faculty Mentor: Dr. Jenny Zhou Email: jenny.zhou@lamar.edu Phone: (409)-880-7830 Jenny Zhou is currently a professor in the Department of Mechanical Engineering at Lamar University, Beaumont, Texas. Dr. Zhou received both her B.S. and M.S. degree in Mechanical engineering from Chongqing University in 1985 and 1988, respectively. In 2003, she earned a Ph.D. degree in mechanical engineering from University of Maryland, Baltimore County. Her research interests include dynamic responses and vibrations of micro-electronic systems, Plant Biomechanics, multi-scale and multi-physics modeling and research in engineering education.	
Team Mentor: Jacob Ammel Email: jacob.d.ammel@nasa.gov Phone: (832)-472-0422 Level II NAR#:115170 Jacob Ammel is an Alumni from Lamar University where he obtained his B.S. degree in mechanical engineering. Jacob is the founder of the first rocketry club in Spring 2023, exposing Lamar students to high power rocketry. He led his capstone project and obtained his L1 and L2 certifications. He currently works at CACI at Johnson Space Center as a systems engineer. Jacob was the mentor for the 2024 NASA Student Launch.	
Team Tripoli Mentor: Randolph Marek P.E-TX Email: Randym713@gmail.com Phone: (281)-468-3037 Level III TRA# / NAR#: 13568 / 110033 Randy is currently LUNAR's Tripoli mentor and holds his B.S. in Chemical Engineering. In addition, he is a licensed control systems engineer in the state of Texas. Randy is the Tripoli Houston Rocket Club Vice President and a TRA Prefect & NAR Section Officer. His first year mentoring the Lamar University Rocketry Team was 2023-2024 where he provided the team with a launch site for their milestones in the USLI competition and provided design and document review for the team. Randy has also been instrumental in helping the team educate new members on the basics of rocket science by providing information sessions and sharing his experience with rocketry to the club.	



1.3 TEAM LEADS

The team lead contact email is LamarLunar@outlook.com which both team leads have access to and check on a regular basis. If needed, the personal emails of the team leads are listed below.

Co-Team Lead: Ana Morfin

Major: Mechanical Engineering

Year: Senior

TRA: Level II

Email: amorfin1@lamar.edu

Phone: (346)-216-8260

Ana is currently a senior mechanical engineering student and took part in the NASA USLI competition last year as the recovery manager for Lamar's debut year in the competition. This year, alongside Jonah, Ana has made extensive efforts to spread her knowledge to grow the presence of aerospace organizations on campus. Ana is currently the Vice President of the Lamar University AIAA chapter and looks forward to getting a chance to participate in NASA Student Launch again this year with a bigger and better team.

Duties: Team oversight, project management, supervision of the recovery, payload, and business teams, integration of technical requirements outlined in the handbook, responsible for final engineering decisions, implementation of FMEA, CFD, and CONOPS development.



Co-Team Lead: Jonah Watts

Major: Mechanical Engineering

Year: Senior

TRA: Level I

Email: jwatts14@lamar.edu

Phone: (409)-988-4505

Jonah is currently a senior mechanical engineering student and took part in the NASA USLI competition last year as the avionics team manager. This year, alongside Ana, he has contributed to the outreach and growth of the rocketry team at Lamar which has almost tripled in size since last year. Jonah is currently the President of the Lamar University AIAA chapter and looks forward to hopefully competing in Student Launch again this year.

Duties: Team oversight, project management, supervision of the avionics, vehicle, and sub-team support teams, integration of technical requirements outlined in handbook, supervision of testing, implementation of CAE, FEA, and simulations.





1.4 SAFETY OFFICERS

The two following members are the appointed safety officers for the LUNAR team and will be responsible for implementing the safety plan, upkeep of the FMEA and PHA charts, and documenting testing procedures. In addition to the appointed officers, each member has signed and agreed to the LUNAR safety contract.

Safety Officer: Justin Farmer	Email: jfarmer9@lamar.edu
Safety Officer: Connor Hayes	Email: chayes13@lamar.edu

1.5 TEAM MEMBERS

The 2024-2025 team consists of 28 members which are broken into 6 total sub-teams. Each of the sub-teams are made up of a manager and 2-6 additional members. The detailed list of members and their key duties are as outlined below:

TABLE 1: LUNAR MANAGEMENT TEAM

	Name	Classification	Major	Position	Duties
1.	Ana Morfin	Senior	Mechanical Engineering	Co- Team Lead	Listed in section 1.3
2.	Jonah Watts	Senior	Mechanical Engineering	Co- Team Lead	Listed in section 1.3
3.	Lizbeth Villalpando	Senior	Mechanical Engineering	Payload Manager	Design of payload, management of payload team, CFD, Integration of Payload into Vehicle
4.	Matthew Flores	Senior	Mechanical Engineering	Vehicle Manager	Aerodynamics, CFD, Vehicle Design, Management of Vehicle Team, FEA
5.	Kathryn Brown	Senior	Mechanical Engineering	Recovery Manager	Recovery Sub-System Design, Management of Recovery Team
6.	Isabella Sandino	Senior	Mechanical Engineering	Business/Procurement Manager	Financing, Procurement, STEM Engagement Planning, Social Media Upkeep, Scheduling
7.	Jose Luis Vasquez	Senior	Mechanical Engineering	Sub-Team Support Manager	Management of the Sub-Team Support Team, General Design, Mission Support Documentation, Avionics Support
8.	Ryan Bell	Junior	Electrical Engineering	Avionics Manager	Controls, Electronics, Data Analysis, Design of



					all Avionic Systems, Management of the Avionics Team
9.	Connor Hayes	Senior	Mechanical Engineering	Safety Officer & Payload Team	Safety protocol documentation, Ensuring Safety Plan is Followed, FMEA and PHA Analysis
10.	Justin Farmer	Senior	Mechanical Engineering	Safety Officer & Payload Team	Safety protocol documentation, Ensuring Safety Plan is Followed, FMEA and PHA Analysis

TABLE 2: LUNAR MEMBERS

	Name	Classification	Discipline	Team
11.	Jose Sifuentes	Junior	Mechanical	Payload
12.	Wyatt Just	Freshman	Mechanical	Payload
13.	Elickxander Verdulla	Junior	Mechanical	Payload
14.	Jase Gault	Senior	Mechanical	Vehicle / Structures
15.	Joseph Withers	Senior	Mechanical	Vehicle / Structures
16.	Trystan Hays	Freshman	Electrical	Vehicle / Structures
17.	Grace Huckaby	Junior	Mechanical	Vehicle / Structures
18.	Tyler Casey	Senior	Mechanical	Recovery
19.	Ronald Mouser	Junior	Mechanical	Recovery
20.	Diana Rodriguez	Junior	Mechanical	Recovery
21.	Haley Hidalgo	Sophomore	Industrial	Business / Procurement
22.	Gabriel Kirkwood	Freshman	Electrical	Business / Procurement
23.	Dylan Bailey	Junior	Mechanical	Sub-Team Support
24.	Dominick Fox	Freshman	Mechanical	Sub-Team Support
25.	Kayla Anderson	Freshman	Mechanical	Sub-Team Support
26.	Landon Paulino	Junior	Electrical	Avionics
27.	Kirby King	Junior	Mechanical	Avionics
28.	John Rice	Junior	Mechanical	Avionics

1.6 NAR/TRA SECTIONS

The team will continue to work with the Tripoli South Site and Hearne (NAR Section 916) sections. These two launch sites and their staff were instrumental in the success of the team last year and were always willing to lend a helping hand to the team when it came to mentoring, review of designs, documentation, and launch assistance. In addition to the two Tripoli sites, the team has also worked with the Houston Rocket Club at Johnson Space Center (NHRC #365) to fly their subscale vehicle for demonstration. The team plans to continue working with all the listed sections for the competition duration.



1.7 PROPOSAL PREPARATION

The following table documents the amount of time spent on the proposal phase for this competition.

TABLE 3: PROPOSAL PREPARATION HOURS

Phase	Hours Spent
Brainstorming	~50
Meetings	~30
Document Writing	~40
Total	~120

2. FACILITIES AND EQUIPMENT

2.1 SCIENCE & TECHNOLOGY BUILDING / PERSONNEL

Team Facility: The Science and Technology Building Room 189 also known as the “Technology & Rocket Assembly Place for Launch & Advanced Building”

The STEM building and machinery labs working hours are 7:00AM – 5:00PM. All machinery and heavy power labs are locked and if utilized after working hours require supervision of a faculty member which can be completed from 5:00PM – 10:00PM. However, students are free to work on documentation, hold meetings, and perform non-hazardous manufacturing unsupervised from 5:00PM -10:00 PM. Additionally, the team’s dedicated makerspace is locked by keycard access which only the team leads and managers have access to. Lastly, all members of LUNAR have signed a safety contract which states no member shall be working in the makerspace alone and must have at least one other team member present with them to perform work.

The LUNAR team is made up of 12 senior students who are planning to complete the NASA Student Launch competition as a capstone project. Co-Leads and each of the manager roles for five sub-teams is led by a senior except for the Avionics team. In addition, the LUNAR team is made up of 18 underclassmen that underwent an application process to be selected by their determination and dedication that aligns with the LUNAR team mission goals. The co-team leads hold Level 1 and Level 2 TRA certification.



FIGURE 1: LUNAR MANUFACTURING & MEETING FACILITY



2.2 EQUIPMENT

The STEM building offers labs with access to CNC machining, 3D printing, and other services. These labs are offered to all Lamar students, so resources must be prebooked and there may be a waiting list as well as scheduling conflicts. Seniors and Juniors have access to SolidWorks and ANSYS access codes for personal laptops. There are also engineering labs that offer computers with access.

In addition to the labs within the STEM building, the team's makerspace is equipped with a vent-hood for epoxy work, a safety shower, a flammable marked cabinet, multiple fire extinguishers, and a lab-rated ventilation system.

The LUNAR team currently has the tools, materials, and hardware to construct hobby rockets. However, with preliminary design ideas for the proposal, Table 4 lists the items that are currently known to be needed for both subscale and full-scale competition vehicles and payload.

TABLE 4: MATERIALS TO PROCURE

Material/Component	
Subscale	Full-scale
Airframe	GPS (multiple)
Coupling section	Redundancy of new electronics
Bulkheads	Reliable batteries
Nose cone	Motors
Electronics Bay	Airframe (body tube, coupling sections)
Parachute	Nose cone
Motor housing	Electronics bay
Paint/Primer	Shock chords (drogue and main)
Centering rings	Parachutes (drogue and main)
Motor	Components to construct a fin can
Fin Material	Materials to build a bigger work stand
Shear Pins	Payload Electronics
Firewire Ignitors	Shear Pins
Adhesive	Adhesive

3. SAFETY

3.1 SAFETY PLAN

Designing and building a rocket is inherently risky even at its safest. This is why the team appointed two safety officers to oversee the members and the processes used when constructing the vehicle and payload. They are required to be present during every launch. The 2024-2025 safety officers are Connor Hayes and Justin Farmer. The responsibilities of the safety officers include, but are not limited to, being present during all launches, approving work done in the lab, ensuring that all safety procedures are followed, and precautions are taken when handling hazardous materials and equipment. The materials held in the lab are reviewed and inspected by the safety officers, and an SDS is updated or added for each new material or chemical. A hazard and risk assessment meeting will also be held by the officers to identify risks for each component and step of the project, focusing on the likeliness and hazard level each event poses, and will be documented as a hazard identification checklist. In addition, the officers



are responsible for ensuring proper documentation is kept for work being done in the lab. Records are kept for personnel working around potentially hazardous materials in JSA forms.

TABLE 5: HAZARDOUS MATERIALS LIST

Material	Use	Hazard	Mitigation
Fireproof Insulation (Dog Barf)	Ejection protection	Skin and eye irritation, inhalation, cancer risk	PPE, long sleeves and gloves, safety glasses, respirator
Black Powder	Ejection / Separation	Explosive, fire, blast, or projection	PPE, gloves, safety glasses, FR clothes
Epoxy Resin	Permanent binding	Skin and eye irritation/corrosion, aquatic toxicity	Vent/respirator, chemical gloves, safety glasses
Power Tools	Cutting, drilling, binding, etc.	Flying debris, strain (posture/vibration), electric shock, noise, contact with body, improper use	Training, proper use, proper PPE, dead switch, good main., table clamps, isolate work
Electronics	Wireless data/control transmission	Electrocution, burns, fire, failure to operate properly	Assess condition, PPE, shock resistant gloves, isolation
Hand Tools	Measuring, hammering, binding	Contact with body, improper use, eye injury	Proper PPE, proper tool selection and use
Cutting Tools	Cutting	Cuts, abrasions, punctures, eye injuries	Proper PPE, proper tool selection and use
Reloadable Motor	Propulsion	Combustion, explosive, fire, projection	Use in accordance with NAR Safety Code, FAA FAR 101 and NFPA 1127
Disposable Motor	Propulsion	Combustion, explosive, fire, projection	Use in accordance with NAR Safety Code, FAA FAR 101 and NFPA 1127
Ejection Charges	Release sections	Combustion, explosive, fire, projection	Use in accordance with NAR Safety Code, FAA FAR 101 and NFPA 1127
Hot Glue Sticks	Binding	Skin and eye irritation, allergies	PPE, gloves, eye protection
9v Batteries	Power for avionics	Combustion and burn risk	Store and use properly, PPE, gloves
1800 mAh Batteries	Power for avionics	Combustion and burn risk	Store and use properly, PPE, gloves



450 mAh Batteries	Power for avionics	Combustion and burn risk	Store and use properly, PPE, gloves
Fix It Sculpt A	Fin fillets, filling	Skin and eye irritation, allergies	Gloves and eye protection
Fix It Sculpt B	Fin fillets, filling	Skin and eye irritation, allergies	Gloves and eye protection
Acetone	Cleaning, priming	Flammable, skin and eye irritation, respiratory irritation	PPE, gloves, eye protection, respirator

TABLE 6: RISK ASSESSMENT

Hazard	Risk	Mitigation
Materials (Hot Glue, Fiber Glass, Acetone, etc.)	Skin and eye irritation, burns, respiratory	All hazardous materials will be handled properly with Personal Protective Equipment. All unused materials will be stored or disposed of appropriately.
Machinery	Bodily injury, property damage	Students will be trained in all lab equipment and follow established safety procedures and practices with Per. A Job Safety Analysis sheet will be used for each new instance of machine work.
Chemicals	Skin and eye irritation, burns, respiratory	All chemicals will be handled properly by following established safety procedures and practices with Personal Protective Equipment. All chemicals will be stored appropriately in designated and ventilated areas.
Electrical Systems	Shock, fire, system malfunctions	Ensure all electrical work is done by a trained or qualified student with Personal Protective Equipment. Testing of electrical systems will be done regularly.
Ignition & Launch	Combustion, fire, explosion, projectiles	Students will follow all launch safety procedures and practices provided by the NAR/TAR with Personal Protective Equipment.
Environmental Safety	Pollution, discarded components, environmental damage	Students will take time to conduct an Environmental Impact Assessment (EIA) before each launch. The launch



		site will be in a safe, isolated area with the least environmental impact.
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3.2 NAR/TRA PROCEDURES & REQUIREMENTS

LUNAR will adhere to the safety guidelines established by the NAR for high powered rocket launches to ensure safe and responsible operations. This includes using lightweight and high-strength materials such as blue-tube, fiberglass, and carbon fiber for construction. Motors will be handled with care, avoiding any potential heat or exposure risk. We will utilize a reliable electrical launch system with a safety interlock and ensure that ignition occurs only when the rocket is securely positioned on the launch pad. In case of a misfire, the team will follow proper safety procedures before approaching the rocket. During launches, we will use a 5-second countdown, maintain required distances from people and hazards, and verify rocket stability. Launches will be conducted in suitable outdoor areas, with careful attention to site and launcher stability, and adherence to minimum distance requirements based on motor size. The rocket will not exceed the impulse or weight limits, and we will ensure that recovery systems are flame-resistant, and rockets are not recovered from dangerous locations. Compliance with FAA regulations and safe operational practices will be a priority throughout the launch process.

Before construction of the main vehicle begins, proper certifications for the purchase and handling of the proper sized motors will be completed by team members. It is the safety officers' responsibility to ensure that personnel handling and operating motors of any size are properly certified, and precautions are taken before priming the vehicle. The codes and requirements laid out by NAR are studied and known by the safety officers and the team. They will be upheld and reviewed periodically and revisited prior to handling of equipment and attending any launches.

When handling hazardous materials in high powered rocketry, it is crucial to use only certified, commercially made rocket motors and avoid tampering with them. To ensure safety with hazardous materials like fiberglass or plastic binding chemicals, the team will work in well-ventilated areas and use appropriate personal protective equipment (PPE), such as gloves, safety glasses, and respirators. Chemicals will be stored in tightly sealed and labeled containers, away from heat and direct sunlight. The team will follow manufacturer instructions for handling and application. Spills will be managed immediately with proper cleanup procedures, disposal of waste according to regulations, and handlers will be trained and have access to Safety Data Sheets (SDS).

3.3 SAFETY BRIEFINGS

The safety officers, Connor and Justin, will be holding a safety briefing before any work is to be done in the laboratory for the competition year. The briefing covers a variety of topics including general lab safety, how to use the tools within the laboratory, how to create proper safety documentation, and how to recognize and mitigate hazards. The safety officers will also show the team members how to fill out the JSA for any work that is to be done on the vehicle. The JSA process is new to the team and will ensure that any hazards for the specific work being done are recognized and able to be mitigated as much as possible before initiating work. On launch days, the safety officers will hold a pre-launch briefing before any set-up and installation of energetics is to be done.



3.4 CAUTION DOCUMENTATION

Work Documentation

To notify and enforce safety precautions and regulations during each step of the process, we have implemented a form that must be filled out for each new instance of work taking place, known as a JSA form. This form points out common and uncommon hazards that may be present during a job and requires the working party to fill out their expected hazards as well as their mitigations for the potential hazards such as, monitoring teammates or that proper PPE is worn. Before work begins, a safety officer will sign off on the form and be present for the work.

Safety Training

All members of the design and manufacturing teams will be briefed on all expected and regulatory safety requirements prior to handling and using potentially hazardous materials. This training will overview general safety requirements and all regulatory requirements for storing, handling, and disposing of materials that may be used during the project. These safety meetings will be held at regular intervals to keep team members knowledgeable of the safety requirements and maintain a proper safety culture throughout the team.

3.5 COMPLIANCE

To ensure compliance with federal, state, and local laws governing unmanned rocket launches and motor handling, the team will develop a comprehensive plan addressing FAR for airspace usage, explosive commerce, and fire prevention. The plan will align with Federal Aviation Regulations 14 CFR, Sub-chapter F, Part 101, Subpart C: Amateur Rockets, Code of Federal Regulations 27 Part 55: Commerce in Explosives: and fire prevention, NFPA 1127 “Code for High Power Rocketry.”

Airspace Usage

The necessary permits and licensing will be obtained for storage, handling, and transportation of rocket motors. All members handling the propellant will be trained and certified. The motors and propellant storage will be in accordance with ATF regulations in an area that minimizes segregation from other materials. During transportation, the team will adhere to all safety regulations and guidelines provided by the ATF and state regulations and proper labeling of rocket motor packaging and propellant storage boxes.

Fire Prevention

Ensure the launch site is cleared of flammable materials, maintain appropriate fire extinguishing equipment readily available and ensuring all team members are trained to utilize it properly, monitor weather conditions are deemed safe to avoid launching during high winds or dry conditions, ensure post launch procedures are promptly addressed to assess any potential fire hazards.

All team members will receive training on federal, state, and local regulations related to unmanned rocket launches and motor handling, including safety protocols and emergency procedures. The Safety officers will maintain detailed records of all training records, safety inspections, and regulatory compliance activities.

By adhering to a plan, the team will ensure the safe compliance and operations of building and launching unmanned rockets.



3.6 ENERGETICS PURCHASING & STORAGE

The team has two NAR/TRA mentors who can obtain and transport motors and energetic devices. The motors are stored in an ammo box marked with an explosive sticker and SDS sheets accessible on the outside of the box. In addition, the ammo box is stored within a locked fire cabinet in the team's makerspace. Only certified personnel will be able to travel with and handle the motors to ensure no damage is done that could compromise their operability and safety. Also, only members with L2 TRA/NAR certifications or higher can install motors under the team mentor's supervision.

The black powder ejection charges are to be handled by the team mentor and team leads only, under the supervision of the safety team, to ensure all safe practices are being executed.

3.7 TEAM MEMBER WRITTEN STATEMENT

All LUNAR team members have read and signed the safety contract created by the team leads and safety team. This contract ensures that members are following all safety regulations outlined by NAR, Lamar University, and derived regulations from last year's team experience. A copy of the safety contract can be found in "Appendix B: LUNAR Safety Contract."

In addition to the signed safety contract, all team members understand that safety inspections will be conducted on the vehicle prior to flight at competition and the team must comply with the determination of the safety inspection or be removed from the program. The current team leads have experience with the safety inspection process at the USLI competition and will be able to ensure the team is prepared for inspection and that all elements meet the safety requirements.

The team also understands that the RSO has final say on all issues of safety when it comes to the rocket and has the right to deny the launch of a vehicle for safety reasons. The team mentor understands that he is responsible for the review of design and examination of the build to ensure that the vehicle satisfies all rocket needs established in the rocketry design and safety guidelines. Shall the team not comply with all rules and regulations outlined in the handbook; they understand that they will not be allowed to launch their rocket.

4. TECHNICAL DESIGN

4.1 PRELIMINARY VEHICLE DESIGN PARAMETERS

The current vehicle that our team has developed has been designed to reach an apogee of 5900 ft AGL and will utilize a 75mm class L motor, currently expected to be the Aerotech L1940X-PS. This design was created using the Openrocket program and two views of the vehicle are included below.

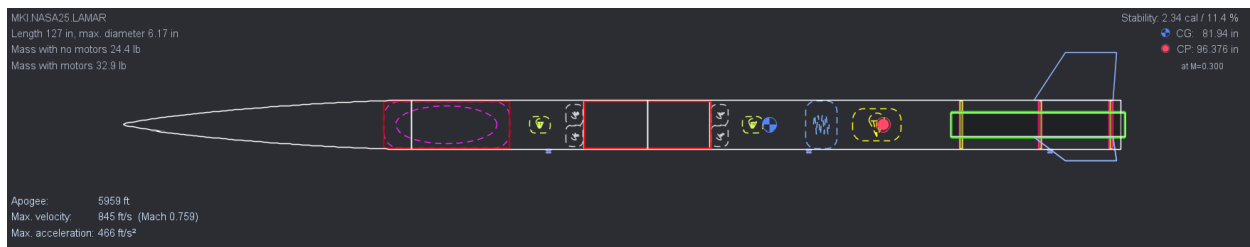


FIGURE 2: OPENROCKET VEHICLE LAYOUT

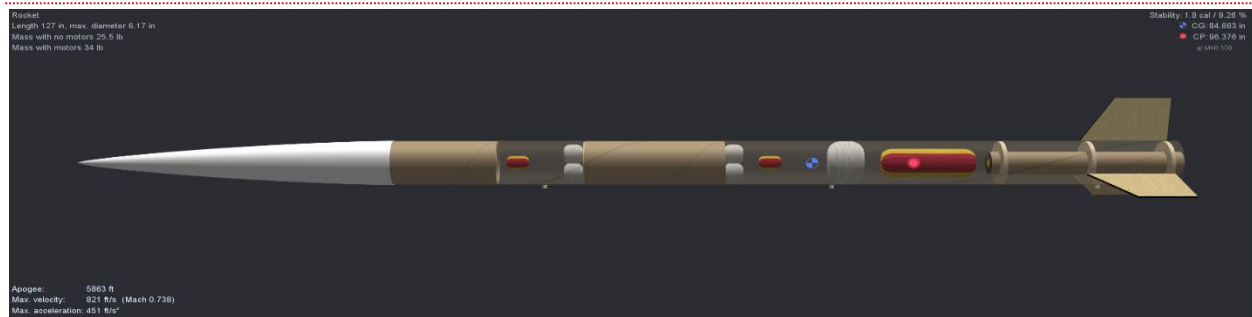


FIGURE 3: 3D OPENROCKET VEHICLE VIEW

The team has decided to utilize fiberglass in the preliminary design due to the material's properties such as high strength and light weight. The overall length of the design is 127 inches, or roughly 10.5 feet, and will have a 6-inch diameter. This diameter was chosen so the team has enough room to incorporate all the necessary components needed for the recovery and payload missions. The diameter choice was also an informed decision based off previous experiences building with a smaller diameter. The rocket's construction consists of using commercially available parts and conventional assembly methods. The use of a coupler will join the fore to the aft and will house the electronics bay. The payload will be located just under the nosecone with its parachute. On either side of the coupler will be ejection charges for separation. The fins will use a fin can system that is currently in development.

TABLE 7: VEHICLE DATA SHEET

Rocket Preliminary data sheet	
Overall length	10.5 ft
Outer Diameter	6.17 in
Inner Diameter	6 in
Mass (Unloaded)	24.4lb
Mass (Dry)	28.88 lb
Mass (Wet)	32.9 lb
Material	Fiberglass
Motor Size	75 mm
Motor	Aerotech L1940X-PS
Projected Altitude	5900 ft AGL

4.2 PROJECTIONS

The projected altitude of the MKI is 5900ft AGL. The software utilized to simulate the current apogee is *OpenRocket v 2022.02*. Hand calculations were also performed utilizing MATLAB to verify the projected altitude and can be seen in Appendix C. Below, the results from the MATLAB preliminary calculations can be seen. In addition to the simulation, the team plans to verify with *Rock Sim 10*.



$$\text{Vehicle Mass } (M) = 14.92319\text{kg}$$

$$\text{Rocket Cross Sectional Area } (A) = \pi(0.0762)^2 = 0.01824\text{m}^2$$

$$\text{Acceleration of Gravity } (g) = 9.81\text{ m/s}^2$$

$$\text{Coefficient of Drag } (C_d) = 0.75 \text{ for average rocket}$$

$$\text{Air Density } (\rho) = 1.22\text{ kg/m}^3$$

$$\text{Motor Burn Time in Seconds } (t) = I/T = 2.2\text{s}$$

$$\text{Motor Thrust in Newtons } (T) = 1,939.3\text{ N}$$

$$\text{Motor Impulse in Newton Seconds } (I) = 4,329.2\text{ Ns}$$

$$\text{Burnout Velocity in } \frac{\text{m}}{\text{s}} \text{ } (v) = 241.7990 \frac{\text{m}}{\text{s}} = 792.478 \frac{\text{ft}}{\text{s}}$$

$$\text{Altitude at Burnout } (y_1) = 284.0085\text{ m} = 937.2282\text{ ft}$$

$$\text{Apogee } (A_g) = 5263.6\text{ft}$$

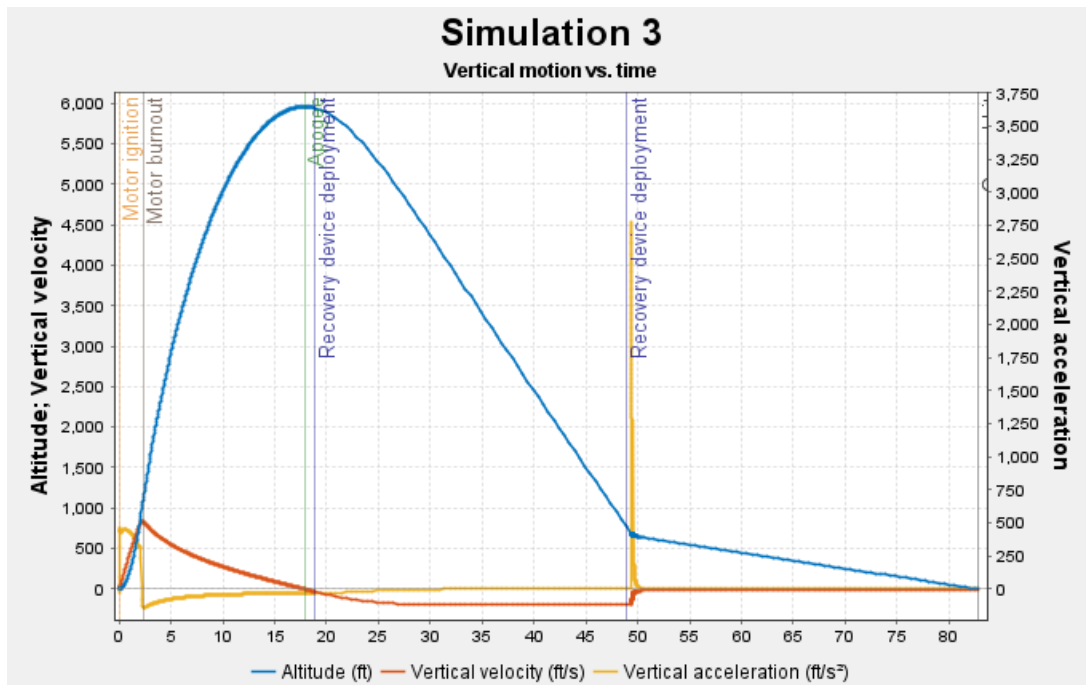


FIGURE 4: OPENROCKET APOGEE PLOT

4.3 RECOVERY

A GPS system, presumably the TeleGPS, will be used to locate the rocket after landing. The team's recovery system will utilize a dual-deployment system that is customized for the rocket's dry weight (about 25 pounds), diameter (6



inches), and a desired descent rate (about 20 feet per second). The payload will have its separate recovery system consisting of its own parachute and GPS. The goal of the recovery system is to safely land the rocket and payload on the ground, within a 2,500 feet radius of the launch pad and a kinetic energy under 75 ft-lbf. Based on preliminary calculations, a 12-inch drogue parachute will be deployed at apogee. At a predetermined lower altitude, the main parachute with a calculated radius of 65-85 inches will deploy. The payload will be equipped with its own independent parachute with a radius of 30-36 inches. The shock cord will be made of Kevlar and will be around 2-3 times the length of the vehicle. This setup will minimize impact forces on the rocket and payload, enhancing the system's overall safety and reusability.

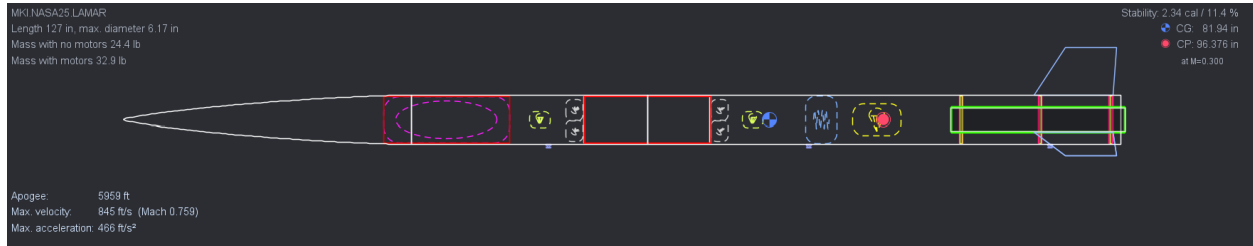


FIGURE 5: PARACHUTE PLACEMENT

The recovery system will have a two-altimeter system that will be used to ensure separation. When the rocket reaches apogee, a primary altimeter will ignite a black-powder charge to separate the fore and aft. The secondary altimeter will be a different manufacturer for redundancy purposes in case the primary altimeter fails to initiate the separation. The primary and secondary altimeters will be the Silicdyne Fluctus and the Altus Metrum Telemega. If the payload jettison is cleared by the RSO, a servomotor will jettison the payload with the 30–36 inch parachute.



FIGURE 6: PRIMARY ALTIMETER: SILICDYNE FLUCTUS



FIGURE 7: SECONDARY ALTIMETER: ALTUS METRUM TELEMEGA

4.4 MOTOR

The current motor the team plans to procure and utilize is the AeroTech L1940X-PS. This motor fits the 75/3840 AeroTech reloadable hardware set. In addition, the motor housing will be incorporated into a fin can system. The L1940's total impulse produced is 4329.2 N/s with a burn time of 2.2s.

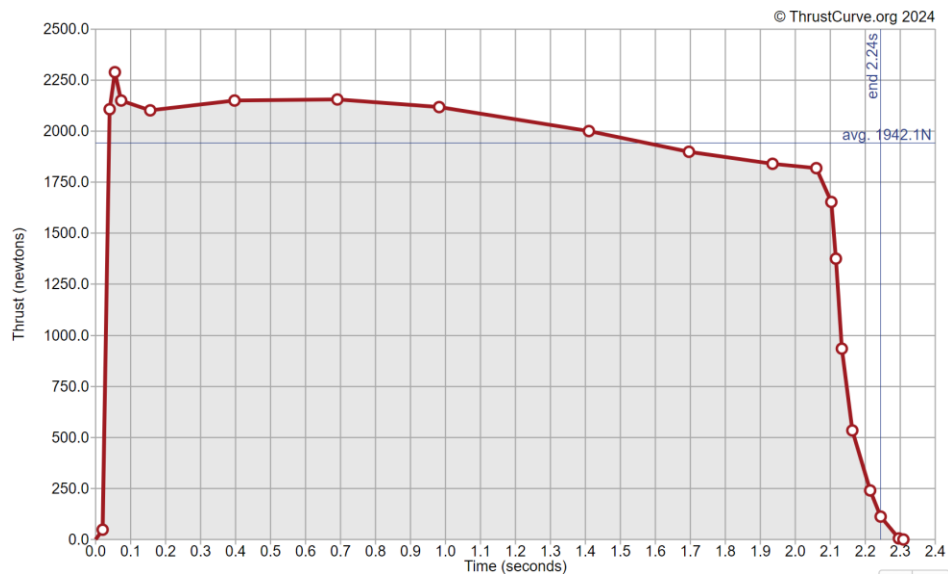


FIGURE 8: AEROTECH L1940X MOTOR THRUST CURVE

4.5 PAYLOAD

The payload team's preliminary design positions the payload within the nosecone coupler. This decision was made because the team found that having the nosecone as a part of the payload alleviated a handful of design challenges, steps, and hazards. The team plans to secure our payload into position using shear pins, which will fix the coupler to the vehicle. The nosecone, along with the coupler and payload, will be released from the rocket using black powder charges as the flight's overall second separation, and will remain attached to the vehicle. The pins will shear when the black powder charges ignite autonomously at approximately 1000 ft AGL, and free the entire nosecone section. The payload will then remain tethered to the vehicle via the manual retention method, attached by a servo-latch.



This servo-latch will allow for our team to manually release the payload when authorized by the RSO. Upon reaching approximately 450 feet AGL, the team will manually dispatch the payload from the vehicle, and a tethered parachute will unravel to safely deliver the payload.

Regarding the payload design, it is currently under the preliminary design and development phase. The dimensions for the current payload design are 6 in diameter, 12 in length, and 3.0 pounds in weight, and will be designed using SolidWorks, OrcaSlicer, and other similar CAD programs. The potential material of the payload will be a PLA filament and will be 3D printed in the Lamar University Science and Technology Building. However, the team strives to utilize more commercially available parts this year to avoid 3D printing wait lists within the university.

4.6 REQUIREMENT VERIFICATION

4.6.1 GENERAL REQUIREMENTS

1.1. Students on the team will do 100% of the project, including design, construction, written reports, presentations, and flight preparation with the exception of assembling the motors and handling black powder or any variant of ejection charges, or preparing and installing electric matches (to be done by the team's mentor). Student team members shall only be a part of one team in any capacity. Teams will submit new work. Excessive use of past work will merit penalties.	The team intends to utilize Microsoft Teams to organize and file documentation. The team mentor will handle any energetics.
1.2. The team will provide and maintain a project plan to include the following items: project milestones, budget and community support, checklists, personnel assignments, STEM engagement events, and risks and mitigations.	The business sub-team will use a Gantt chart to track all milestones for the entire competition and sub- team progress to meet deadlines.
1.3. Team members who will travel to the Huntsville Launch shall have fully completed registration in the NASA Gateway system before the roster deadline. Team members shall 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.	The team will set a date to meet and complete the NASA Gateway registration. The team has selected a TRA mentor and (2) adult educators from Lamar University.
1.4. Teams shall engage a minimum of 250 participants in Educational Direct Engagement STEM activities. These activities can be conducted in-person or virtually. To satisfy this requirement, all events shall occur between project acceptance and the FRR addendum due date. A template of the STEM Engagement Activity Report can be found on pages 40 – 43.	The business sub-team will be tasked with overseeing any STEM engagement or outreach in the local area.
1.5. The team shall establish and maintain a social media presence to inform the public about team activities.	The team currently has social media accounts, such as Instagram, and LinkedIn, that will be managed by a business sub-team member.
1.6. Teams shall 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	The team will submit all documentation in a timely manner to ensure all deadlines are met. In the case the documents are too large, a link will be included to the



of a link to download the file will be sufficient. Late submissions of PDR, CDR, or FRR milestone documents will NOT be accepted. Teams that fail to submit the PDR, CDR, or FRR milestone documents will be eliminated from the project.	email provided to ensure timely submission for all milestones.
1.7 Teams who do not satisfactorily complete each milestone review (PDR, CDR, FRR) will be provided action items to be completed following their review and will be required to address action items in a delta review session. After the delta session, the NASA management panel will meet to determine the teams' status in the program, and the teams will be notified shortly thereafter.	In the event the team does not satisfy a milestone review and receives action items, the team will work extensively to complete the action items to present updates at the delta session.
1.8. All deliverables shall be in PDF format.	All documents will be converted from Microsoft Word to PDF format.
1.9. In every report, teams will provide a table of contents, including major sections and their respective subsections.	The team will include a table of contents in each milestone report.
1.10. In every report, the team shall include the page number at the bottom of the page.	The team will include the page number in every milestone report
1.11. The team shall 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 as a last resort.	The team plans to use a designated room in the College of Engineering which is equipped with a computer that has teleconference capabilities and internet connection.
1.12. All teams attending Launch Week shall 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 – 10 degrees away from the crowd on Launch Day. The exact cant will depend on Launch Day wind conditions.	The team will design the vehicle to utilize the launch pads provided 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 team mentor shall not be a student team member. The mentor shall maintain a current certification, and be in good standing, through the National Association of Rocketry (NAR) or Tripoli Rocketry Association (TRA) for the motor impulse of the launch vehicle and must have flown and successfully recovered (using electronic, staged recovery) a minimum of two flights in this or a higher impulse class, prior to PDR. The mentor is designated as the individual owner of the rocket for liability purposes and must travel with the team to Launch Week. One travel stipend will be provided per mentor regardless of the number of teams he or she supports. The stipend will only be provided if the team passes FRR and the team and mentor attend Launch Week in April.	The team's mentor information is provided in section 1.2 of the proposal document.



1.14. Teams will track and report the number of hours spent working on each milestone.	The team will include hours spent on each milestone utilizing a Gantt Chart.
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4.6.2 VEHICLE REQUIREMENTS

2.1. The vehicle shall deliver the payload to an apogee altitude between 4,000 and 6,000 feet above ground level (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 vehicle will deliver the payload to an approximate apogee of 5900ft AGL.
2.2. Teams shall declare their target altitude goal at the CDR milestone. The declared target altitude shall be used to determine the team's altitude score.	The team's apogee is not finalized but will be declared at the CDR milestone.
2.3. The launch vehicle shall be designed to be recoverable and reusable. Reusable is defined as being able to launch again on the same day without repairs or modifications.	The launch vehicle will be reloadable and reusable.
2.4. The launch vehicle shall 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. 2.4.1. Coupler/airframe shoulders which are located at non-in-flight separation points shall be at least two airframe diameters in length. (One body diameter of surface contact with each airframe section) 2.4.2. Coupler/airframe shoulders which are located at non-in-flight separation points shall be at least 1.5 airframe diameters in length. (0.75 body diameter of surface contact with each airframe section.) 2.4.3. Nosecone shoulders which are located at in-flight separation points shall be at least ½ body diameter in length.	The launch vehicle will have no more than 4 independent sections and meet all requirements 2.4.1-2.4.3.
2.5. The launch vehicle shall be capable of being prepared for flight at the launch site within 2 hours of the time the Federal Aviation Administration flight waiver opens.	The launch vehicle will require less than 2 hours to assemble all systems when fully disassemble.
2.6. The launch vehicle and payload shall be capable of remaining in launch-ready configuration on the pad for a minimum of 3 hours without losing the functionality of any critical on-board components, although the capability to withstand longer delays is highly encouraged.	The team will develop redundant and functional on-board systems. The team will conduct extensive testing to verify simulated delay scenarios.
2.7. The launch vehicle shall be capable of being launched by a standard 12-volt direct current firing system. The firing system shall be provided by the NASA-designated launch services provider.	The team will have launched this system before and the vehicle will be capable of being launched this way.
2.8. The launch vehicle shall require no external circuitry or special ground support equipment to initiate launch (other than what is provided by the launch services provider).	The launch vehicle will have no external circuitry or any special equipment to initiate launch, other than what is provided by launch services.
2.9. Each team shall use commercially available matches or igniters. Hand-dipped igniters shall not be permitted.	The team currently utilizes commercially available matches and igniters.



2.10. 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). 2.10.1. Final motor choice shall be declared by the Preliminary Design Review (PDR) milestone. 7 2025 Student Launch Handbook & Request for Proposal USLI General and Proposal Requirements 2.10.2. Any motor change after PDR shall be approved by the NASA management team or NASA Range Safety Officer (RSO). Changes for the sole purpose of altitude adjustment shall not be approved. A scoring adjustment against the team's overall score shall be incurred when a motor change is made after the PDR milestone. The only exception is teams switching to their secondary motor choice provided the primary motor choice is unavailable due to a motor shortage.	The motor the team will utilize a commercially available solid motor
2.11. The launch vehicle shall be limited to a single motor propulsion system.	The team will design a launch vehicle around a single stage motor propulsion system.
2.12. The total impulse provided by a College or University launch vehicle shall not exceed 5,120 Newton seconds (L-class).	The total impulse of the Aerotech L1940X-PS is 4,329.2 Newton seconds, not exceeding the L-class.
2.13. Pressure vessels on the vehicle must be approved by the RSO and shall meet the 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 shall 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 shall 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.	The team does not intend on using pressure vessels within their design. However, if the team decides to utilize them, they will make sure to follow all requirements outlined in 2.13.
2.14. The launch vehicle shall 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 launch vehicle will have a minimum static stability margin of 2.0 at rail exit.
2.15. The launch vehicle shall have a minimum thrust to weight ratio of 5.0:1.0.	The team's launch vehicle will have a minimum thrust to weight ratio of 5.0:10.
2.16. Any structural protuberance on the rocket shall be located aft of the burnout center of gravity. Camera housing will be exempted, provided the team can show that the housing(s) causes minimal aerodynamic effect on the rocket's stability.	The team will ensure that protuberance will be located aft of the burnout CG.
2.17. The launch vehicle shall accelerate to a minimum velocity of 52 fps at the rail exit.	The launch vehicle will meet this requirement, and the team will ensure so in the design phase through simulations.



2.18. All teams shall successfully launch and recover a subscale model of their rocket. 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. Subscale 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 shall not be used as the subscale model. 2.18.2. The subscale model shall 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.	The team will design, build, test, and launch a subscale rocket to meet the requirements of the subscale launch.
2.18.4.1. Altimeter flight profile graph(s) 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) will 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 is not limited to nosecone, recovery system, airframe, and booster.	The team will provide altimeter flight profile graphs or a quality video showing successful launch, recovery events, and landing as deemed by NASA.
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" diameter, 100" length rocket, your subscale shall not exceed 3" diameter and 75" in length.	The team's subscale vehicle will not exceed 75% of the full-scale vehicle.
2.19. All teams shall complete demonstration flights as outlined below.	The team will complete all demonstration flights.
2.19.1. Vehicle Demonstration Flight— All teams shall 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 (drogue chute at apogee, main chute at the intended lower altitude, functioning tracking devices, etc.). The following criteria shall be met during the full-scale demonstration flight: 2.19.1.1. The vehicle and recovery system shall 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.	The team will complete the VDF and ensure it follows all regulations outlined in section 2.19.1. The team will also ensure the VDF is deemed successful by the NASA panel before continuing to the PDF.



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 shall be used to simulate the payload mass. 2.19.1.3.2. The mass simulators shall 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 will 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 shall 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 shall not be modified without the concurrence of the NASA management team or 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 is not limited to nosecone, recovery system, airframe, and booster. 2.19.1.8.3. Raw altimeter data shall be submitted in .csv or .xlsx format. 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.	
2.19.2. Payload Demonstration Flight— All teams shall successfully launch and recover their full-scale rocket containing the completed payload prior to the Payload	The team will conduct a PDF and ensure it follows all regulations outlined in 2.19.2. The team will also



Demonstration Flight deadline. The rocket flown shall be the same rocket to be flown as their competition launch. The purpose of the Payload Demonstration Flight is to prove the launch vehicle's ability to safely retain the constructed payload during flight and to show that all aspects of the payload perform as designed. A successful flight is defined as a launch in which the rocket experiences stable ascent and the payload is fully retained until it is deployed (if applicable) as designed. The following criteria shall be met during the Payload Demonstration Flight: 2.19.2.1. The payload shall be fully retained until the intended point of deployment (if applicable), all retention mechanisms shall function as designed, and the retention mechanism shall not sustain damage requiring repair. 2.19.2.2. The payload flown shall be the final, active version 2.19.2.3. If the above criteria are met during the original Vehicle Demonstration Flight, occurring prior to the FRR deadline and the information is included in the FRR package, the additional flight and FRR Addendum are not required. 2.19.2.4. Payload Demonstration Flights shall be completed by the FRR Addendum deadline. NO EXTENSIONS WILL BE GRANTED.	ensure the PDF is deemed successful by the NASA panel in order to fly their payload at competition.
2.20. An FRR Addendum shall be required for any team completing a Payload Demonstration Flight or NASA required 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 complete a Payload Demonstration Flight which is not fully successful may petition the NASA RSO for permission to fly the payload during launch week. Permission will not be granted if the RSO or the Review Panel have any safety concerns.	The team understands that an FRR addendum will be required for any team completing a PDF after the FRR report due date.
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 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.	The team's name and contact information will be posted on the exterior of the rocket.
2.22. All Lithium Polymer batteries shall 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.	All the lithium-ion batteries utilized will be protected from impact with the ground and will be marked as a fire hazard. Additionally, the batteries will be protected from other payload hardware.
2.23. Vehicle Prohibitions:	The team will ensure to follow all the following vehicle prohibitions.
2.23.1. The launch vehicle shall not utilize forward firing motors.	The launch vehicle does not utilize forward firing motors.



2.23.2. The launch vehicle shall not utilize motors that expel titanium sponges (Sparky, Skidmark, MetalStorm, etc.)	The launch vehicle will not utilize motors that expel titanium sponges.
2.23.3. The launch vehicle shall not utilize hybrid motors.	The launch vehicle is not designed to utilize hybrid motors.
2.23.4. The launch vehicle shall not utilize a cluster of motors.	The launch vehicle will use a single motor system.
2.23.5. The launch vehicle shall not utilize friction fitting for motors.	The launch vehicle will utilize a motor retainer system.
2.23.6. The launch vehicle shall not exceed Mach 1 at any point during flight.	The preliminary vehicle design does not exceed Mach 1.
2.23.7. Vehicle ballast shall not exceed 10% of the total un-ballasted 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).	The vehicle ballast will not exceed 10% of the total un-ballasted weight of the vehicle.
2.23.8. Transmissions from on-board transmitters, which are active at any point prior to landing, shall not exceed 250 mW of power (per transmitter).	The team will make sure that the transmissions from on board transmitters will not exceed 250 mW of power.
2.23.9. Transmitters shall not create excessive interference. Teams shall utilize unique frequencies, handshake/passcode systems, or other means to mitigate interference caused to or received from other teams.	The team will make sure the transmitters will not create excessive interference.
2.23.10. Excessive and/or dense metal shall 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.	Dense metal will not be utilized in vehicle construction.

4.6.3 RECOVERY SYSTEM REQUIREMENTS

3.1. The full-scale 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 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 shall contain a delay of no more than 2 seconds. 3.1.3. Motor ejection is not a permissible form of primary or secondary deployment.	The full-scale vehicle will follow the general recovery phases outlined in 3.1.
3.2. Each team shall perform a successful ground ejection test for all electronically initiated recovery events prior to the initial flights of the subscale and full-scale vehicles.	The team has experience with ground ejection tests and will continue to test separation before flights.
3.3. Each independent section of the launch vehicle shall 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.	Hand calculations and simulations will be performed to ensure that the vehicle sections do not exceed 75ft-lbf on landing.
3.4. The recovery system shall contain redundant, commercially available barometric altimeters that are specifically designed for initiation of rocketry recovery	The team will make sure that the recovery system will contain redundant commercially available barometric altimeters, that are designed for rocket recovery.



events. The term “altimeters” includes both simple altimeters and more sophisticated flight computers.	
3.5. Each altimeter shall have a dedicated power supply, and all recovery electronics shall be powered by commercially available batteries.	The team will provide each altimeter with their own dedicated power supply that are powered by commercially available batteries.
3.6. Each altimeter shall 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.	The team will design the launch vehicle so that each altimeter can be armed from the exterior of the rocket airframe.
3.7. Each arming switch shall be capable of being locked in the ON position for launch (i.e., cannot be disarmed due to flight forces).	The team will design the launch vehicle so that the switches will be locked in the on position.
3.8. The recovery system, GPS and altimeters, and electrical circuits shall be completely independent of any payload electrical circuits.	The team will design the recovery system to operate separately from the payload system.
3.9. Removable shear pins shall be used for both the main parachute compartment and the drogue parachute compartment.	The team will utilize removable shear pins for both chute compartments.
3.10. Bent eyebolts shall not be permitted in the recovery subsystem.	The team will only utilize machined (closed loop) eyebolts.
3.11. The recovery area shall be limited to a 2,500 ft. radius from the launch pads.	The team will ensure that the vehicle does not drift further than 2,500 ft through simulations, drift calculations, and testing.
3.12. Descent time of the launch vehicle shall be limited to 90 seconds (apogee to touch down). Teams whose launch vehicle descent, as verified by vehicle demonstration flight data, stays under 80 seconds will be awarded bonus points.	The team will ensure the recovery phase of the launch does not exceed 90 seconds.
3.13. An electronic GPS tracking device shall be installed in the launch vehicle and will transmit the position of the tethered vehicle or any independent section to a ground receiver.	The launch vehicle will utilize an electronic GPS to transmit the position of the tethered vehicle, or any independent section to a ground receiver.
3.13.1. Any rocket section or payload component, which lands untethered to the launch vehicle, shall contain an active electronic GPS tracking device.	The team will make sure to include an active electronic GPS device in each rocket section, and payload component.
3.13.2. The electronic GPS tracking device(s) shall be fully functional during the official competition launch.	The team will utilize an electronic GPS tracking device that is fully functional during official launch.
3.14. The recovery system electronics shall not be adversely affected by any other on-board electronic devices during flight (from launch until landing).	The team will make sure that the recovery system electronics will not be affected by any other on board electronics from flight to landing.
3.14.1. The recovery system altimeters shall be physically located in a separate compartment within the vehicle from any other radio frequency transmitting device and/or magnetic wave producing device.	The team will make sure that the recovery system altimeters are in a different compartment from any other radio frequency transmitting device or magnetic wave producing device.
3.14.2. The recovery system electronics shall be shielded from all on-board transmitting devices to avoid inadvertent excitation of the recovery system electronics.	The team will make sure all recovery system electronics will be shielded from all on board transmitting devices.
3.14.3. The recovery system electronics shall be shielded from all on-board devices which may generate magnetic waves (such as generators, solenoid valves, and Tesla coils) to avoid inadvertent excitation of the recovery system.	
3.14.4. The recovery system electronics shall be shielded from any other on-board devices which may	



adversely affect the proper operation of the recovery system electronics.	
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4.6.4 PAYLOAD REQUIREMENTS

4.1. USLI Payload Mission objective: College/University Division — Teams are tasked with designing, building, and flying a STEMnaut flight capsule capable of safely retaining four STEMnauts and transmitting, via radio frequency, relevant rocket and STEMnaut landing site data to a NASA-owned receiver located at the launch site. STEMnauts are physical representations of the crew on-board the rocket. The method(s)/design(s) utilized to complete the payload mission shall be at the team's discretion and will be permitted so long as the designs are deemed safe, obey FAA and legal requirements, and adhere to the intent of the challenge. NASA reserves the right to require modifications to a proposed payload.	The team agrees to the payload mission objective outlined in section 4.1.
4.2. STEMCRaFT Mission Requirements:	The team agrees to follow all STEMCRaFT mission requirements outlined in section 4.2.
4.2.1. Teams shall choose a minimum of 3 pieces of data from the list below to a maximum of 8 to transmit to the NASA receiver. • Temperature of landing site • Apogee reached • Battery check/power status • Orientation of on-board STEMnauts • Time of landing • Maximum velocity • Landing velocity, G-forces sustained • Calculated STEMnaut crew survivability	The team will select and declare a minimum of 3 pieces of data to measure and transmit.
4.2.2. The payload shall not have any protrusions from the vehicle prior to apogee that extend beyond a quarter inch exterior to the airframe.	The payload design will be fully enclosed within the vehicle until jettison and will contain no protrusions.
4.2.3. Payload shall transmit on the 2-M band. A specific frequency shall be given to the teams later. NASA shall use the FTM-300DR transceiver.	The team will design their transmission device to be capable of transmitting data on the 2-M band to the FTM-300DR transceiver.
4.2.4. All transmissions shall start and stop with team member call signs.	The team's data transmission will start and stop with team member call signs.
4.2.5. Teams shall submit a list of what data they will attempt to transmit by NASA receiver by March 17.	The team will submit a list of intended data transmissions to NASA by March 17, 2025.
4.2.6. Teams shall transmit with a maximum of 5W, and transmissions shall not occur prior to landing.	The team's transmission will not exceed 5W and will not occur prior to payload landing.
4.2.6.1. Teams shall not transmit on the specified NASA frequency on launch day prior to landing.	The team will not transmit on the specified NASA frequency on launch day prior to landing.
4.3. General Payload Requirements: 4.3.1. Black powder and/or similar energetics are only permitted for deployment of in-flight recovery systems. Energetics will not be permitted for any surface operations. 4.3.2. Teams shall abide by all FAA and NAR rules and regulations. 4.3.3. Any payload experiment element that is jettisoned during the recovery phase shall receive real-time RSO	The team agrees to follow all general payload requirements outlined in section 4.3 when designing, manufacturing, testing, and integrating the payload into the launch vehicle. In addition, the team will follow all requirements for launching and jettisoning the payload on launch days.



permission prior to initiating the jettison event, unless exempted from the requirement by the RSO or NASA. 4.3.4. Unmanned aircraft system (UAS) payloads, if designed to be deployed during descent, shall 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 UAS's shall abide by all applicable FAA regulations, including the FAA's Special Rule for Model Aircraft (Public Law 112-95 Section 336; 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.	
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4.6.5 SAFETY REQUIREMENTS

5.1. Each team shall use a launch and safety checklist. The final checklists shall be included in the FRR report and used during the Launch Readiness Review (LRR) and any Launch Day operations.	The team will create and utilize a launch and safety checklist for all launches including competition launch.
5.2. Each team shall identify a student safety officer who will be responsible for all items in Section 5.3.	The team has identified 2 safety officers, and they will be responsible for all items in section 5.3
5.3. The role and responsibilities of the safety officer shall 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 components 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. Competition Launch 5.3.1.8. Recovery activities 5.3.1.9. STEM Engagement Activities 5.3.2. Implement procedures developed by the team for construction, assembly, launch, and recovery activities. 5.3.3. Manage and maintain current revisions of the team's hazard analyses, failure modes analyses, procedures, and SDS/chemical inventory data. 5.3.4. Assist in the writing and development of the team's hazard analyses, failure modes analyses, and procedures.	The safety officers, Connor and Justin, have agreed to oversee all of the responsibilities in section 5.3.
5.4. During test flights, teams shall 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 shall communicate their intentions to the local club's President or Prefect and RSO before attending any NAR or TRA launch.	The team will abide by all rules set by local rocketry clubs and their RSO's.
5.5. Teams shall abide by all rules set forth by the FAA.	The team agrees to follow all FAA regulations.



4.6.6 FINAL FLIGHT REQUIREMENTS

6.1 NASA Launch Complex	The team plans to launch at the NASA Launch Complex.
6.1.1. Teams are not permitted to show up at the NASA Launch Complex outside of launch day without permission from the NASA management team.	The team agrees to not show up at the NASA launch complex outside of the launch day without permission from the NASA management team.
6.1.2. Teams shall complete and pass the Launch Readiness Review conducted during Launch Week.	The team agrees to complete and pass the LRR that is conducted during launch week to assure safety is the upmost priority.
6.1.3. The team mentor shall be present and oversee rocket preparation and launch activities.	The team mentor will be present during launch week for all rocket preparation and activities.
6.1.4. The scoring altimeter shall be presented to the NASA scoring official upon recovery. The scoring altimeter shall be one of the altimeters used for recovery events.	The scoring altimeter will be accessible and presented to the scoring official after recovery.
6.1.5. Teams may launch only once. Any launch attempt resulting in the rocket exiting the launch pad, regardless of the success of the flight, will be considered a launch. Additional flights beyond the initial launch will not be scored and will not be considered for awards.	The team understands that they may only launch their vehicle once. The team also understands that any attempt resulting in the rocket exiting the launch pad counts as a launch regardless of flight success.
6.2 Commercial Spaceport Launch Site 6.2.1. The launch shall occur at a NAR or TRA sanctioned and insured club launch. Exceptions may be approved for launch clubs who are not affiliated with NAR or TRA but provide their own insurance, such as the Friends of Amateur Rocketry. Approval for such exceptions shall be granted by NASA prior to the launch. 6.2.2. Teams shall submit their rocket and payload to the launch site Range Safety Officer (RSO) prior to flying the rocket. The RSO shall inspect the rocket and payload for flight worthiness and determine if the project is approved for flight. The local RSO shall have final authority on whether the team's rocket and payload may be flown. 6.2.3. The team mentor shall be present and oversee rocket preparation and launch activities 6.2.4. BOTH the team mentor and the Launch Control Officer shall observe the flight and report any off nominal events during ascent or recovery on the Launch Certification and Observations Report. 6.2.5. The scoring altimeter shall be presented to BOTH the team's mentor and the Range Safety Officer. The scoring altimeter shall be one of the altimeters used for recovery events. 6.2.6. The mentor, the Range Safety Officer, and the Launch Control Officer must be three separate individuals who must ALL complete the applicable sections of the Launch Certification and Observations Report. The Launch Certification and Observations Report document will be provided by NASA upon completion of the FRR milestone and shall be returned to NASA by the team mentor upon completion of the launch.	The team plans to launch at the NASA complex but agrees to all rules outlined in 6.2 if they have to launch at a commercial spaceport launch site.



6.2.7. The Range Safety Officer and Launch Control Officer certifying the team's flight shall be impartial observers and shall not be affiliated with the team, individual team members, or the team's academic institution. 6.2.8. Teams may launch only once. Any launch attempt resulting in the rocket exiting the launch pad, regardless of the success of the flight, will be considered a launch. Additional flights beyond the initial launch will not be scored and will not be considered for awards.	
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4.7 TECHNICAL CHALLENGES

The following are some technical challenges that each sub-team has identified and some potential solutions to them.

VEHICLE/STRUCTURES TEAM

Challenges:

- Designing the rocket to reach targeted apogee of 5,900 ft AGL can be difficult due to factors such as thrust, drag, and weight variability.
- Rocket structure must withstand high G-forces, aerodynamic loads, and thermal stresses during flight.
- Rockets fins must avoid excessive oscillating and vibrations due to aerodynamic forces at high speeds which can cause fin failure or reduce flight stability.

Solutions:

- Use advanced simulation software like OpenRocket, MATLAB, and SolidWorks to model flight dynamics and predict altitude.
- Adjust design parameters such as motor selection, weight distribution and fin configuration.
- Distribute the rockets weight by balancing materials and optimizing the payload.
- Minimize unnecessary weight without compromising structural integrity.
- Use lightweight, high-strength materials such as fiberglass to reduce weight while maintaining strength.
- Test different motor configurations to ensure the chosen motor provides consistent thrust for reaching the desired altitude.

RECOVERY TEAM

Challenges:

- Incorporate a dual-deployment recovery system into our design to minimize drift while still allowing for a controlled landing. Both the drogue and main parachutes need to deploy at specific altitudes.
- Ensure sensitive electronics such as GPS, altimeters, and telemetry systems are well protected from impact forces upon landing.
- Verify any loose components do not reach ground-level at more than 75 ft-lbf, as the mission is to land the payload safely.



Solutions:

- Test the ejections, altimeter settings and parachute deployment design with ground test before the flight. Use redundant altimeters to ensure proper deployment of parachutes. If one system fails, the backup ensures recovery.
- Design the rocket so that high-impact areas (such as the nose cone) absorb most of the landing force.
- Use of software to compute calculations such as drag and its deployable components, G-forces during launch and re-entry, descent rate, and deployment mechanism calculations.

PAYLOAD TEAM

Challenges:

- Payload must meet strict weight and size constraints. Exceeding these limits can affect the rocket's performance, stability, or altitude.
- Payload needs to fit seamlessly into the rocket without affecting its structural integrity and stability. An improperly integrated payload can lead to imbalanced mass distribution during flight.
- Deployment of payload must safely and reliably detach from rocket without damaging the payload or disrupting the rocket's flight path.

Solutions:

- Design a payload bay that securely holds the payload while distributing weight evenly across the rocket. The bay is easily accessible for insertion/removal but secured enough to prevent shifting during flight.
- Use software tools like OpenRocket to model the impact of the payload's weight on the rocket's center of gravity and center of pressure.
- Fine-tune placement and mass distribution to ensure stable flight.
- Perform various ground tests to verify our payload is deploying correctly.

AVIONICS TEAM

Challenges:

- Various avionics systems can interfere with one another, especially if they operate on similar frequencies that can affect other components.
- The avionics system must operate continuously throughout the flight. A power failure could result in loss of data, failed communication, or non-deployment of other systems.
- Telemetry data may fail to reach the ground station due to weak signals, obstructions, or atmospheric interference, especially as the rocket moves away from the ground.
- Data transmitted must be received by the transceiver only once the payload has landed.

Solutions:

- Ensure all wiring and soldering is properly routed and secured to prevent disconnections during launch.
- All electronics will operate on their appropriate frequencies.
- Perform range testing in real-world conditions to assess signal reliability at various distances and altitudes.
- Ensure our barometric altimeter has accurate readings before flight.
- Ensure the Arduino board transmits apogee, temperature, and velocity reliably once the payload has reached ground-level.
- Have systems have their own power sources, and redundant power sources to ensure uninterrupted operation during flight.



5. STEM ENGAGEMENT

To foster a curiosity for scientific discovery in younger generations, LUNAR is dedicated to engaging with local students ranging from K-12th grade and educating them in topics relating to rocketry. There are many opportunities for student engagement and outreach during the fall and spring semester, such as:

Discover Engineering:

Lamar University takes pride in its initiative to serve the community, which includes hosting community wide events for educating children of younger ages. Discover Engineering is one of the biggest events in Southeast Texas that enriches STEM education for children of all ages. LUNAR's goal is to showcase past rockets and group students in teams of 3-4 to launch bottle rockets with the help of a team member to show examples of Newton's 1st and 3rd laws of motion. Our utmost priority is safety, so we will work with Lamar University safety personnel to ensure that our activities align with regulatory and standard practices. This event will take place in April during the spring semester.



FIGURE 9: DISCOVER ENGINEERING EVENT

Beaumont Children's Museum:

As a non-profit museum, the Beaumont Children's Museum's mission is to help children to learn S.T.E.A.M focused topics through playing. LUNAR and B.C.M. both have very closely aligned goals when it comes to advocating for the development of interest in younger generations. We would like to create an interactive experience for younger children to grasp the concepts of force and mass by creating an exhibit with foam rockets that increasingly get heavier/bigger and a pump that would create a force that will thrust the rocket into "propulsion." Our goal is to start the process of creating this exhibit and have its debut in the spring semester.



Rocketry and Aerospace Outreach at Local High Schools:

As a part of LUNAR's goals in outreach and education, the team plans to attend local high schools during engineering periods and other STEM-related classes such as Computer Science and Physics to teach high school students about rocketry and the aerospace field. LUNAR will do this by presenting rockets from past competitions and breaking down the rocket to teach the students about each major part (body tube, avionics, etc), then teaching the students about Newton's laws and how they apply to rocket flight. Next, the team will inform the students on opportunities in the aerospace industry and what kind of engineers they look for. These outreach opportunities further LUNAR's central goal of prioritizing outreach and fostering the next generation of aerospace engineers.

S.T.E.M. Night:

LUNAR is excited to take part in the Hamshire-Fannett ISD STEM Night this spring semester, a fantastic event aimed at sparking students' interest in STEM. As exhibitors, we will be showcasing a deconstructed rocket from one of our previous projects, giving students a hands-on look at the components and how they work together to launch a rocket. We will break down the technical terms and explain the science behind each part, showcasing how components comes together for a successful flight. Our goal is to inspire curiosity, answer questions, and encourage young minds to see the exciting possibilities in STEM fields.

Cardinal Communities/Campus Engagement:

LUNAR is not only focused on spreading knowledge of STEM in neighboring communities, but we would also like to spotlight our own university by reaching out to Cardinal Communities on Lamar University's own campus. These communities are geared towards networking new students and grouping them based on common interests. We would like to establish a strong presence in the university and ensure that incoming students interested in STEM careers know that the LUNAR team is offered as an option for a team to work on as an engineer. We will do this during the fall semester.

6. PROJECT PLAN

6.1 WORK BREAKDOWN STRUCTURE (WBS)

The business team oversees the WBS for the project and will ensure that the team is following the strict schedule required to stay on the proper timeline. The team utilizes Primavera-P6 to track all essential competition milestones and checkpoints. In addition to the overall team milestones, the business team also tracks individual sub team goals to ensure that the sub teams work is complete and not holding back the progress of the entire team.

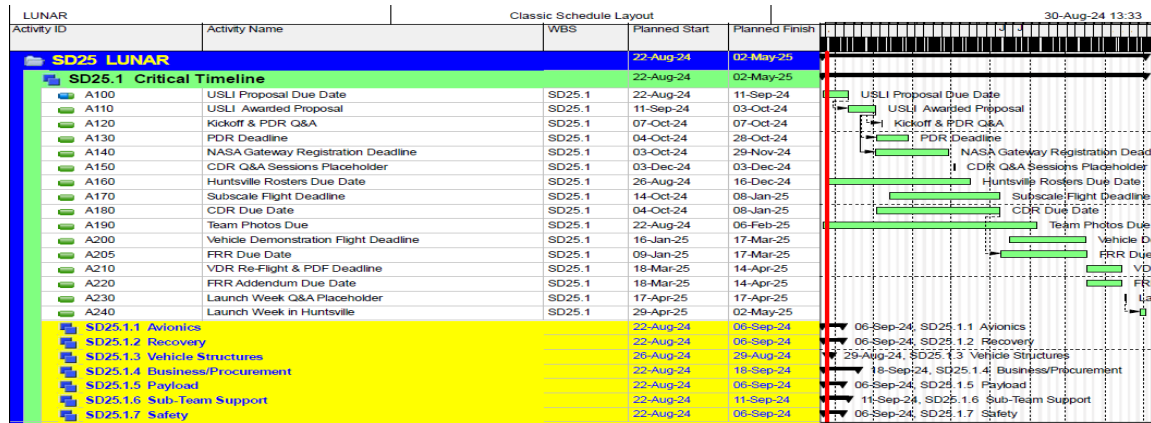


FIGURE 10: WBS STRUCTURE

6.2 DETAILED BUDGET

TABLE 8: MATERIALS BUDGET

Item Description	Manufacturer	P/N	Quantity	Total
Nose Cone (6" Fiberglass filament wound metal tip)	MadCow	FWNC60	1	\$180.00
Forward Airframe (G12 Fiberglass) 2.5ft	WildMan	GSTR-GFW-GIO	1	\$140.36
Aft Airframe (G12 Fiberglass) 5ft	WildMan	GSTR-GFW-GIO	1	\$279.81
Nose Cone Coupler (6"Fiberglass G12) 16"	Wildman	G12CT-6.0	2	\$189.20
Motor Tube (3"/ 75mm G12) 22"	Madcow	FT30-STD-220-NAT	1	\$55.00
Centering Rings (6"/ 75mm G10)	Madcow	FCR6075-RCK2	10	\$130.00
Centering Rings (6"/ 75mm Plywood)	Apogee	13449	3	\$48.45
G10 Fiberglass sheet 1/4" x Sqr feet	Apogee	14154	2	\$157.60
Av-Baylids (6" G10 Fiberglass)	MadCow	AV-bay lid 6 inch	2	\$55.00
Bulkheads (6" Fiber glass bulk plate)	Wildman	FBP6.0	3	\$29.70
Switch Band exterior (6" G12 Switch band)	Madcow	FT6-020	3	\$33.00
Swivels (1000LB)	MadCow	SW-1000	3	\$29.10
Charge Wells (8-gram)	MadCow	RJ002	4	\$35.80
Bulkhead wire retainer (for ejection gasses)	MadCow	RJ003	2	\$29.90



Aerotech RMS-75/3840 Complete Hardware Set	AeroTech	75/3840	1	\$629.99
Aerotech L1940X-PS Reload kit	AeroTech	L1940X	5	\$1,519.95
Aero Pack 75mm Retainer - P (Set)	Apogee	24055	1	\$62.48
Aero Pack 75mm Retainer Flanged (Set)	Apogee	24069	1	\$79.62
Thrust Plate (6" / 75mm)	Apogee	25034	1	\$68.30
Fire Wire Initiator (6/PK)	Apogee	89868	5	\$103.15
Zipper Shield (2/PK)	Apogee	29187	2	\$11.90
Apogee 24in Parachute Protector	Apogee	29375	2	\$35.90
Screw Switch	Wildman	N/A	5	\$20.00
Power Drill	Amazon	NA	1	\$29.99
Payload Electronics Budget	TBD	NA	1	\$400
TOTAL:				\$3,954.20

TABLE 9: TRAVEL BUDGET

Expense	Estimated Cost (\$)	Frequency
Transportation	~825	Per Van
Food	~50	Per Day Per Person
Housing	~4,000	For Airbnb
Mileage	~300	Per Van
Total	~6,850	Entire Trip

The travel budget estimate about is calculated by using the following guidelines:

- 12 members traveling
- 2 rented vans
- 6 members + luggage per van
- 750 miles includes trip to Huntsville, AL, and additional mileage
- 750 miles includes trip to Beaumont, TX, and additional mileage
- Average cost per gallon in AL: \$3.37
- Average cost per gallon in TX: \$3.38
- 3 meals per day per person
- 6 days (April 30-May 5)

The cost of the total mileage expense was estimated using (<https://www.calculator.net/fuel-cost-calculator.html>)

The cost of housing was estimated using average local Airbnb prices for the week of competition.

The cost of van rental was estimated using (<https://www.enterprise.com/en/home.html>)



6.3 FUNDING PLAN

TABLE 10: ESTIMATED BUDGET

Source	Amount (\$)	Status
TMAC	5,000	Approved
LU College of Engineering	5,000	Approved
LU Presidents Office	5,000	Approved
Sponsorships	5,000	Estimated
Fundraising	1,000	Estimated
Total	21,000	Estimated

LUNAR has secured a minimum of \$15,000 for the academic year through the TMAC grant, college of engineering, and presidents office at Lamar University. The team also plans to reach out for smaller sponsorships and do some personal fundraising to cover any additional expenses including building materials, upgraded tools, motors, and travel expenses to competition.

The total estimated usable budget for the team is \$21,000 to allow for late procurement items and any additional needs the team may need throughout the competition.

6.4 SUSTAINABILITY PLAN

While success in the competition is one of the goals of our team, we also strive to keep our project sustainable through building partnerships within our community and ensuring the team can continue to succeed for years to come. We have developed a sustainability plan (ROCKETS) which focuses on recruitment, partnerships, community engagement, documentation, education, and evaluation.

TABLE 11: ROCKETS SUSTAINABILITY PLAN

Acronym	Expanded	Plan
R	Recruitment	Through our collaboration with the AIAA chapter on campus, LUNAR has successfully recruited new members with an impressive turnout. This year, the recruitment process included an application, and the team members were selected based on their skills and interest in the NASA USLI competition. Last year, our team started out with 16 members and dwindled down to 8 members which created a stressful work environment. Through our new recruitment process, we had over 40 applicants for the team and 28 were selected. We plan to continue promoting the team through tabling events, the AIAA organization, and outreach to local high school juniors and seniors.
O	Ongoing Partnerships	The LUNAR organization is committed to maintaining and strengthening its partnerships with both industry partners and the AIAA organization on campus. Through our partnership with AIAA, we gain access to aerospace companies within the Houston area. LUNAR aims to forge and foster new relationships with industry partners to offer internship and career opportunities for our members. Through these partnerships, we will also be able to request additional funding for the team and future projects. Our



		business team is dedicated to nurturing these connections. Additionally, with our affiliation with the AIAA chapter, we will host events at Lamar University to further cultivate interest in the aerospace industry among our peers.
C	Community Involvement	One of our key objectives this year is to strengthen our community engagement with the SETX area and Lamar University. We will actively participate in multiple volunteer events organized by the university including beach cleanups, local parades, STEM night at the children's museum, and volunteering at the food bank. In addition, LUNAR plans to host a "toys for tots" toy drive around the holiday season and collaborate with multiple on campus organizations to host this event. Through these types of events, LUNAR will be able to spread its name through the community while giving back and creating change.
K	Knowledge Documentation	Documentation of knowledge is important to the sustainability of our team for the competition and future generations of LUNAR. Our sustainability plan introduces some new documentation types this year. We have updated meeting minute templates that go more in depth and provide critical updates to members who are not able to attend the weekly meetings. In addition, we have created both JSA and MOC documents for work being done and major changes being made to our design. A sign-in sheet has also been created for the team's designated room to keep track of all activity going on within the makerspace. With these forms of documentation, the team can keep track of brainstorming sessions, official meetings, safety concerns, design changes, manual labor being performed, and training.
E	Expense Plan	To fulfill all the team's goals internally with the project and external in the community, operational needs and educational outreach are crucial. Creating an expense plan that considers the operational costs, such as equipment/supplies, transportation/logistics and educational outreach expenses must be outlined. This organization and project are fully funded by generous sponsorships and grants. The team will effectively budget for all aspects of keeping a sustainable presence in the area.
T	Team Evaluations	LUNAR is beginning to implement regular sub-team evaluations. The team manager, team leads, and advisors will conduct performance reviews for each of the teams and provide constructive feedback on how the team can further align to optimize their specific goals. Through these evaluations, we will ensure that each of our sub-teams stay aligned with each other and can grow and learn from their mistakes. Evaluations also provide critical learning experiences for all members and will strengthen the team's future as we train and build future leaders of our organization.
S	STEM Engagement	STEM engagement is crucial to keeping the organization alive and thriving. Last year was our first year participating in STEM engagement activities, and we have



		seen the results of actively engaging in STEM education. We have significantly increased the number of underclassmen who choose to attend Lamar University and become a member of the team. In addition, we have shown the younger audience that you can do anything you put your mind to and become a rocket scientist even in college! LUNAR plans to continue its participation in all STEM engagement events within the university and hosting its own events for higher engagement. We recognize how important it is to educate the community and get younger generations involved in STEM activities to keep our organization running.
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Through implementation of our R.O.C.K.E.T.S plan, the LUNAR team is prepared to take on the USLI competition and foster the growth of our organization for years to come.

7. CLOSING REMARKS

LUNAR is extremely excited to propose our participation in the 2024-2025 USLI competition. The team has been working extensively to upgrade our management style, improve our technical design approach, create a friendly and safe work environment, foster community relationships, and take on a more organized and professional approach to the student launch competition. Lastly, the team would like to thank NASA for providing an out-of-this-world educational opportunity and inspiring the next generations of Artemis Engineers.



APPENDIX A – NAR SAFETY CODE

1. **Certification.** I will only fly high power rockets or possess high power rocket motors that are within the scope of my user certification and required licensing.
2. **Materials.** I will use only lightweight materials such as paper, wood, rubber, plastic, fiberglass, or when necessary ductile metal, for the construction of my rocket.
3. **Motors.** I will use only certified, commercially made rocket motors, and will not tamper with these motors or use them for any purposes except those recommended by the manufacturer. I will not allow smoking, open flames, nor heat sources within 25 feet of these motors.
4. **Ignition System.** I will launch my rockets with an electrical launch system, and with electrical motor igniters that are installed in the motor only after my rocket is at the launch pad or in a designated prepping area. My launch system will have a safety interlock that is in series with the launch switch that is not installed until my rocket is ready for launch and will use a launch switch that returns to the “off” position when released. The function of onboard energetics and firing circuits will be inhibited except when my rocket is in the launching position.
5. **Misfires.** If my rocket does not launch when I press the button of my electrical launch system, I will remove the launcher’s safety interlock or disconnect its battery and will wait 60 seconds after the last launch attempt before allowing anyone to approach the rocket.
6. **Launch Safety.** I will use a 5-second countdown before launch. I will ensure that a means is available to warn participants and spectators in the event of a problem. I will ensure that no person is closer to the launch pad than allowed by the accompanying Minimum Distance Table. When arming onboard energetics and firing circuits I will ensure that no person is at the pad except safety personnel and those required for arming and disarming operations. I will check the stability of my rocket before flight and will not fly it if it cannot be determined to be stable. When conducting a simultaneous launch of more than one high power rocket I will observe the additional requirements of NFPA 1127.
7. **Launcher.** I will launch my rocket from a stable device that provides rigid guidance until the rocket has attained a speed that ensures a stable flight, and that is pointed to within 20 degrees of vertical. If the wind speed exceeds 5 miles per hour, I will use a launcher length that permits the rocket to attain a safe velocity before separation from the launcher. I will use a blast deflector to prevent the motor’s exhaust from hitting the ground. I will ensure that dry grass is cleared around each launch pad in accordance with the accompanying Minimum Distance table and will increase this distance by a factor of 1.5 and clear that area of all combustible material if the rocket motor being launched uses titanium sponge in the propellant.
8. **Size.** My rocket will not contain any combination of motors that total more than 40,960 N-sec (9208 pound-seconds) of total impulse. My rocket will not weigh more at liftoff than one-third of the certified average thrust of the high-power rocket motor(s) intended to be ignited at launch.
9. **Flight Safety.** I will not launch my rocket at targets, into clouds, near airplanes, nor on trajectories that take it directly over the heads of spectators or beyond the boundaries of the launch site and will not put any flammable or explosive payload in my rocket. I will not launch my rockets if wind speeds exceed 20 miles per hour. I will comply with Federal Aviation Administration airspace regulations when flying and will ensure that my rocket will not exceed any applicable altitude limit in effect at that launch site.
10. **Launch Site.** I will launch my rocket outdoors, in an open area where trees, power lines, occupied buildings, and persons not involved in the launch do not present a hazard, and that is at least as large on its



smallest dimension as one-half of the maximum altitude to which rockets are allowed to be flown at that site or 1500 feet, whichever is greater, or 1000 feet for rockets with a combined total impulse of less than 160 N-sec, a total liftoff weight of less than 1500 grams, and a maximum expected altitude of less than 610 meters (2000 feet).

11. **Launcher Location.** My launcher will be 1500 feet from any occupied building or from any public highway on which traffic flow exceeds 10 vehicles per hour, not including traffic flow related to the launch. It will also be no closer than the **appropriate Minimum Personnel Distance from the accompanying table from any boundary of the launch site.**
12. **Recovery System.** I will use a recovery system such as a parachute in my rocket so that all parts of my rocket return safely and undamaged and can be flown again, and I will use only flame-resistant or fireproof recovery system wadding in my rocket.
13. **Recovery Safety.** I will not attempt to recover my rocket from power lines, tall trees, or other dangerous places, fly it under conditions where it is likely to recover in spectator areas or outside the launch site, nor attempt to catch it as it approaches the ground.

MINIMUM DISTANCE TABLE

Installed Total Impulse (Newton-Seconds)	Equivalent High Power Motor Type	Minimum Diameter of Cleared Area (ft.)	Minimum Personnel Distance (ft.)	Minimum Personnel Distance (Complex Rocket) (ft.)
0 — 320.00	H or smaller	50	100	200
320.01 — 640.00	I	50	100	200
640.01 — 1,280.00	J	50	100	200
1,280.01 — 2,560.00	K	75	200	300
2,560.01 — 5,120.00	L	100	300	500
5,120.01 — 10,240.00	M	125	500	1000
10,240.01 — 20,480.00	N	125	1000	1500
20,480.01 — 40,960.00	O	125	1500	2000

Note: A Complex rocket is one that is multi-staged or that is propelled by two or more rocket motors

Revision of August 2012

FIGURE 11: NAR MINIMUM DISTANCE TABLE



APPENDIX B – LUNAR SAFETY CONTRACT



LUNAR Safety Contract

General Guidelines

- I. Adhere to Regulations
 - a) Team members must comply with all federal, state and local laws as well as university regulations regarding rocketry.
 - b) Team members shall comply with all safety regulations in order to actively work in the Science and Technology building
 - c) Team members must do proper safety walks deemed necessary by the Science and Technology admin as well as comply by the rules stated to work in their building.
 - d) Team members must not utilize any unapproved space or tools/machinery.
 - e) All activities must adhere to safety guidelines established by National Association of Rocketry and Tripoli Rocketry Association.
- II. Personal Protective Equipment
 - a) Appropriate PPE must be worn at all times during manufacturing, testing and launches.
- III. Supervision
 - a) Any activity involving hazardous materials or high-risk operations must be supervised by qualified team lead, sub-team manager.
 - b) Team room will have approved work hours strictly for team members, guests are subject to approval.
 - c) Any damage done by a non-team member will fall on the responsibility of the team member escorting guest.
- IV. Training
 - a) All team members must undergo safety run down in rocketry activities. Training will go over material handling, tools, and any equipment and emergency procedures.

Design and Construction

- I. Tool Usage
 - a) Only trained personnel are permitted to utilize any power tools and machinery.
 - b) Tools must be inspected and maintained in working condition.
 - c) Every tool must be placed back in it's respective storage area after use
 - d) Work area must be kept as clean as possible, clutter free, to prevent accidents.

Testing and Launches

- I. Checklist
 - a) Must review and verify all materials are packed and/or utilized.
- II. Launch procedures
 - a) Essential personnel shall thoroughly follow launch procedures and acquire necessary approvals from safety and all personnel involved.



- b) Safety officer must be present at all times.

III. Emergency

- a) Notify team leads and mentors of any emergencies.

Conduct

- I. Behavior
 - a) Team members must conduct professionally and responsibly any horseplay that may result in injury is prohibited.
 - b) Any safety concerns or incidents must be reported to team leads or safety officer.
- II. Documentation
 - a) All safety sessions, inspections, or incidents must be documented
 - b) Safety hazard analysis is a living document and must be reviewed regularly to ensure continuous improvement in safety practices.

Agreement

By signing this contract, I acknowledge that I have read and understood the safety guidelines outlined above. I agree to prioritize safety and adhere to these guidelines in all LUNAR rocketry activities.

Name: _____ Date: _____



APPENDIX C -MATLAB CALCULATION FOR APOGEE ESTIMATE

```
mm=14.92319; A=0.01824;g=9.81;Cd=0.75;p=1.22;T=1939.3;I=4329.2;
```

```
>>k=(1/2)*p*Cd*A
```

```
>> q=sqrt((T-m*g)/k)
```

```
>> x=(2*k*q)/m
```

```
>> t=I/T
```

```
>> v=q*(1-exp(-x*t))/(1+exp(-x*t))
```

```
v =241.7990
```

```
>> y1=(-m/(2*k))*log((T-(m*g)-(k*v^2))/(T-(m*g)))
```

```
>> y1ft=y1*3.
```

```
y1ft =937.2281
```

```
>> yc=(m/(2*k))*log(((m*g)+(k*v^2))/(m*g))
```

```
yc = 1.3110e+03
```

```
>> ycft=yc*3.3
```

```
ycft = 4.3263e+03
```

```
>> yapg=y1ft+ycft
```

```
yapg =5.2636e+03
```

```
yapg= 5,2636 ft
```