The Terra Nova Project

NASA University Student Launch Proposal

Florida State University - Panama City

4750 Collegiate Dr

Panama City, FL 32405

September 22nd, 2025

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Figures and Tables

Acronym Bank

ATF – Bureau of Alcohol, Tabacco, Firearms and Explosives

CAD – Computer Aided Design

CAM – Computer Aided Manufacturing

CDR – Critical Design Review

CFR – Code of Federal Regulations

CNC – Computer Numerical Control

DDS – Digital Design Studio

EMI – Electromagnetic Interference

FAA – Federal Aviation Administration

FAMU – Florida Agricultural and Mechanical University

FMEA – Failure Modes and Effects Analysis

FRR – Flight Readiness Review

FSU – Florida State University

GCSC – Gulf Coast State College

HAUS – Habitat for Agricultural Utilization Study

HOL – Holley Building

HPR – High Powered Rocketry

ICT – In-Circuit Testing

InSPIRE - Innovation, Sustainability, and Preeminent Research & Education

LRR – Launch Readiness Review

NAR – National Association of Rocketry

NASA – National Aeronautics and Space Administration

NFPA – National Fire Protection Association

OSHA – Occupational Safety and Health Administration

PC – Panama City

PCB – Printed Circuit Board

PDF – Payload Demonstration Flight

PDR – Preliminary Design Review

PHA – Preliminary Hazard Analysis

PhD – Doctor of Philosophy

PLA – Polylactic Acid

PLAR – Post Launch Analysis Report

POC – Point of Contact

PPE – Personal Protective Equipment

RAM – Rocketry & Mechatronics

RSO – Registered Student Organization

SDS – Safety Data Sheet

SEARS – SouthEast Alabama Rocketry Society

SAIC – Science Applications International Corporation

STEM – Science Technology Engineering and Math

TRA – Tripoli Rocketry Association

UAS – Unmanned Aircraft System

USLI – University Student Launch Initiative

1. General Information

1.1 Faculty Educator/s

Dr. Twan Capehart
Mechanical Engineering Senior Design Professor
Email: tcapehart@pc.fsu.edu
Phone: (850)-770-2208

Dr. Twan Capehart is a Teaching Faculty member in the Department of Mechanical Engineering, teaching core dynamics courses at FSU Panama City. He obtained his undergraduate degree in Mechanical Engineering at Florida A & M University and his master's and doctorate degrees at the FAMU-FSU College of Engineering with a research focus of bioinspired robotics, and variable stiffness mechanisms. He has six years of previous experience in teaching engineering at the undergraduate level. Dr. Capehart has also worked for the past five years as a mechanical engineering consultant in the private sector on multiple projects, with a specialty in innovation, ideation, product development and prototyping of mechatronic systems. He currently serves as the advisor of the Rocketry & Mechatronics (RAM) and Nole Navigators registered student organizations (RSOs) for the FSU Panama City Campus.

1.2 Mentor Information

Team Mentor
Elizabeth Gildersleeve
Email: Elizabeth.gildersleeve00@gmail.com
Phone: (850) -775-8483
FSU PC Mechanical Engineering Alumni
NAR #: 119990
HPR Certification Level: Level 2

Our Team Mentor, Elizabeth Gildersleeve, is a Mechanical Engineer who works for Science Applications International Corporation (SAIC) as a navy contractor. She received her undergraduate degree in the Summer of 2025. Since then, she has been working on providing innovative ideas to help solve problems. She currently has a Level 2 rocket certification which she received in the Spring of 2025. She has been a part of the FSU rocketry team for the past two years and continues to help foster the knowledge and drive that other students have in the pursuit of rocketry and engineering.

1.3 Team Composition & Organization

1.3.1 Team Members

There will be six students primarily responsible for the Terra Nova Project throughout the year:

Team Leader
Krieg Conrad
Email: kc22bq@fsu.edu
Mechanical Engineering Senior
Responsibilities:

- Manage and update the project schedule.
- Ensure design compatibility across subsystems.
- Assist any portion of the design when necessary
- Allocate finances and oversee the budget and fundraising processes.
- Coordinate and acquire required hardware and supplies.
- Oversee preparation and submission of all deliverables.
- Main point of contact with the Nasa Team.
- Oversee all construction of the Terra Nova Rocket.

Safety Officer
Jonathan Serbest
Email: jss24@fsu.edu
Mechanical Engineering Senior
Responsibilities:

- Create and enforce the team's safety plan.
- Have competency of, and enforce, NASA and NAR/TRA safety codes.
- Identify, analyze, and mitigate any potential hazards.
- Oversee the purchase, handling, and storage compliance of any hazardous materials.
- Oversee safety during construction of the Terra Nova Project.
- Assume authority during safety-related concerns.
- Intimate involvement with all processes of the Terra Nova project to ensure compliance with the defined safety plan.

Recovery Officer
Austin Zaal
Email: az24f@fsu.edu
Mechanical Engineering Senior
Responsibilities:

- Design and analyze recovery system for decent rate, time to ground, and impact energy
- Size and test drogues and main parachutes.
- Design and fabricate bulkheads, couplers, and attachment hardware for recovery systems.
- Design and validate sub-scale and full-scale recovery systems
- Design and fabricate custom shock cord
- Design and assemble avionics bay housing
- Construction of the Terra Nova Rocket

Payload System Officer
Case Dyer
Email: cd23bc@fsu.edu
Mechanical Engineering Senior
Responsibilities:

- Design and manufacture a flight capsule to hold four STEMnauts for an extended excursion.
- Design ground decoupling separation
- Design and manufacturing of HAUS payload components.
- Design HAUS system to collect and test soil sample.
- Testing of payload to meet NASA requirements.
- Airframe transition tube design and manufacturing.
- Boat-tail design and manufacturing.
- Construction of the Terra Nova Rocket.

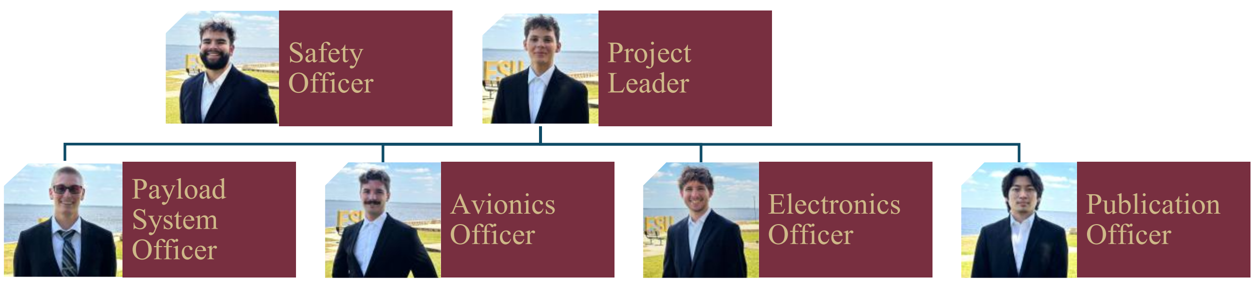
Electronics Officer
Matthew Wilson
Email: mtw23@fsu.edu
Electrical Engineering Senior
Responsibilities:

- Select and integrate flight computers/altimeters and redundant avionics system.
- Design and test electrical systems for payload experiments (sensors, soil testing hardware, etc.)
- Collaborate with the Recovery Officer on avionics procedure & electrical components
- Collaborate with the Payload System Officer for HAUS payload electronic system.
- Ensure no Electromagnetic Interference (EMI) in data logging.

Publications Officer
Jayden Duarte
Email: jjd23d@fsu.edu
Business Administration Senior
Responsibilities:

- Lead and manage team social media presence (Instagram, YouTube, LinkedIn, etc.).
- Coordinate public-facing communications including event promotion, sponsor recognition, and community updates.
- Organize and document STEM engagement events for NASA deliverables.
- Ensure consistent branding and visibility of the team and project.

1.3.2 Team Member Hierarchy



1.4 NAR/TRA Section Support

The Terra Nova Project is planning to attend multiple launches for the model rockets created by the team and to gather information and data from outside launches. This will be conducted with the SouthEast Alabama Rocketry Society (SEARS). SEARS is a rocketry society affiliated with the National Association of Rocketry (NAR) located in Sampson, Alabama. All launch and data acquisition dates are in section 55.1 Project Timeline.

1.5 Time Allocation on Proposal Preparation

In total, this proposal took approximately 118 hours to create. This includes team meetings, meetings with our team educator Dr Capehart, and meetings with our mentor Elizabeth Gildersleeve. It also includes various time spent by individual team members researching, creating, and reviewing the various sections of this proposal.

2. Facilities and Equipment

For this project we will have access to multiple facilities both at and outside the FSU PC campus. The facilities on campus that we will be using for this project are primarily in the Holley Building and include the Senior Design Lab, Machine Shop, Digital Design Studio (DDS), Electrical and Computer Engineering Lab, Materials Lab, Thermal Fluids Lab, and Mechatronics Lab. Facilities outside the campus we plan to use are Maritech Machine Inc and Gulf Coast Advanced Technology Center.

2.1 On-Campus Facilities

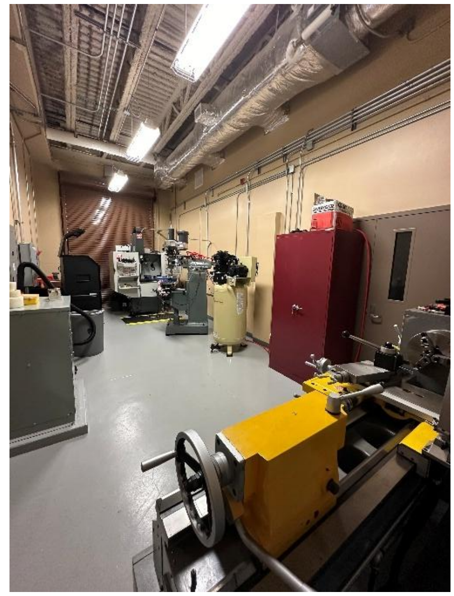
2.1.1 Senior Design Lab

The Senior Design Lab is a room designated for the senior design projects of mechanical engineering students at FSU PC. There are many tools, components, mechanisms, and past projects. This abundance of tools and parts will be helpful in the construction of the sub-scale and full-scale rockets as well as the HAUS payload and Excursion Habitat for the STEMnauts. This room will also be used for the storage of all our nonvolatile materials following the required safety procedures outlined in Section 3.Safety.

Personnel Required: No special personnel required
Access: Swipe Card Access
Hours: 24/7
Equipment:

- *Siglent 4-channel oscilloscopes* (3 stations)
- *Siglent Arbitrary Waveform Generators* (3 stations)
- *Agilent and Siglent Power Supplies* (3 stations)
- Agilent Benchtop Multimeters (3 stations)
- Whiteboards
- Computers
- Hand tools
- Mounted vice grips

2.1.2 Machine Shop



The machine shop at FSU PC contains a lathe, CNC machine, and milling machine. Due to the limited equipment and available time of required personnel, we are in communication with a local machine shop for the manufacturing of any parts that our project requires to be outsourced, prioritizing cost and time effectiveness. The partnering with our local machining industry will be outlined later in this section.

Personnel Required: Instructor James Keith
Access: Swipe Card Access
Hours: Monday – Thursday 5pm – 7pm
Equipment:

- *Enco Model 328-1312* – Lathe
- *Ingersoll Rand Model 2475* – Milling Machine
- *Ingersoll Rand 2475N5 Grainger* – Air Compressor
- *HAAS Model SMINIMILL* – CNC Machine

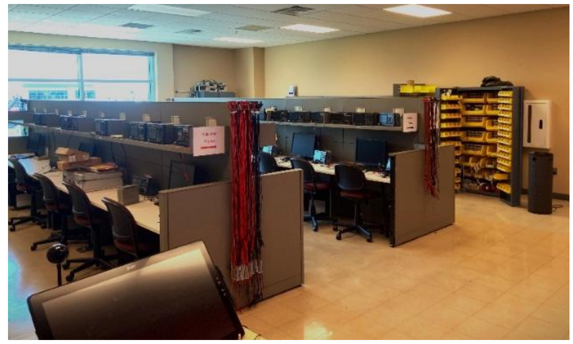
2.1.3 Digital Design Studio

The DDS is located in the Robins Center for Academic Excellence and Innovation. It is open to all FSU PC students and is used for studying, working on school projects, or hanging out. The DDS equipment includes printers, many Dremel 3D printers, poster board printer, and a laser cutter engraver.

Personnel Required: DDS Employee
Access: N/A
Hours: 9:00am – 10:00pm
Equipment:

- *Dremel Digilab 3D Printers* (8 available)
- *Epson SureColor P9570* – Poster Board Printer
- Cricket machine & Hot Press – Shirt Maker
- Industrial embroidery machine
- Sewing machines (12 available)

2.1.4 Electrical and Computer Engineering (ECE) Laboratory Capabilities



Access to the Electronics Lab at FSUPC provides students with the means to design, prototype, and test a wide range of electrical systems. The lab is well equipped for analog system analysis, and equally capable with digital communication systems.

Personnel Required: No special personnel required
Access: Swipe Card Access
Hours: 24/7
Equipment:

- *Siglent 4-channel oscilloscopes* (30 stations)
- *Siglent Logic Analyzers* (6 stations)
- *Siglent Arbitrary Waveform Generators* (30 stations)
- *Agilent and Siglent Power Supplies* (30 stations)
- *Agilent Benchtop Multimeters* (30 stations)
- Electrical components for prototyping i.e. resistors, transistors, capacitors, inductors, diodes, operational amplifiers, etc.

2.1.5 Materials Lab

The Materials Lab is under the supervision of Dr. Yvonne Traynham. The lab has a variety of equipment sufficient to thoroughly test the mechanical properties of any material we select for this project. This equipment includes but is not limited to tensile, torsion, hardness, Charpy, and Izod testers. We plan on this lab playing a major role in the designs of our project and the testing of the new additive manufacturing, 3D metal printing.
Through our agreement with our local machining industry, we are allowed to design many components of our rocket using 3D printed metals. Due to this methodology of manufacturing being so new, we considered it necessary to thoroughly test our materials to ensure there are no anomalies in their mechanical properties. This will ensure our 3D printed metal is able to

withstand the forces and conditions under which it will be subjected. Two members of our group, Safety Officer Jonathan Serbest and Payload System Officer Case Dyer, are involved in a special project particularly involving the testing of the mechanical properties of the 3D printed metals we desire to use. The usage of this lab will also be important in the final selection of other materials for the project.

Personnel Required: Dr. Yvonne Traynham
Access: Swipe Card Access
Hours: 8:00am – 4:00pm
Equipment:

- *MTS Criterion 43 (Model C43-504)* - Universal Electromechanical Testing Machine
- *Tinnius Olsen Torsion Tester*
- *Mark 10 Tester with EM303* Test Stand and *M3-500 Series 3* Force Gauge
- *Qualitest (Model QPI-IC-12J)* - Izod Impact Tester
- *Wilson (Model VH1102)* - Vickers Microhardness Tester
- *Laxco XD30M* - Metallurgical Microscope
- *Laxco SeBaCam5 external digital camera* – Micrograph Images
- *Buehler Simplmet 4000* – Metallurgical Mounting Equipment
- *Buehler Ecomet 30* - Polishing Equipment
- *Laxco Stereo Zoom Head Microscope*
- *Tinnius Olsen HTK5* – Tension, Compression, or Cycling Tester (2 available)
- *Wilson Charpy Impact Tester*

2.1.6 Thermal Fluids Lab

The Thermal Fluids Lab is under Dr Mauricio Chagas. This lab contains equipment for the testing of fluid and heat transfer systems. The equipment that especially pertains to this project is the Open Wind Tunnel which can be used for the testing of various airframe components.

Personnel Required: Dr. Mauricio Chagas
Access: Swipe Card Access
Hours: 8:00am – 4:00pm
Equipment:

- *Gunt ET 405* – Heat pump for cooling and heating operation
- *Gunt WL 430* – Heat conduction and convection
- *Gunt WL 202* – Fundamentals of temperature measurement
- *Gunt HM 283* – Experiments with a centrifugal pump
- *Gunt HM 150.11* - Losses in a pipe system
- *Gunt HM 170* – Open wind tunnel
- *Gunt WL 203* – Fundamentals of Pressure measurement
- *Turbine Technologies Rankine Cycler*
- *Gunt HM 150.13* Methods of flow measurement

2.1.7 Mechatronics Lab

The Mechatronics Lab is a classroom for the Mechanical Engineering department, housing the majority of the small electronics and tools for mechatronic projects. This lab will particularly be used for 3D printing polymer-based parts because it has two of our best 3D printers, Bamboo Carbon X1s. It also houses many oscilloscopes, arbitrary waveform generators, and other components for mechatronics systems.

Personnel Required: No personnel required
Access: Swipe Card Access
Hours: 24/7
Equipment:

- *X-1 Carbon Bambu Lab 3D printers* (2 available)
- *Dremal Digilab 3D printers* (4 available)
- *Siglent 4-channel oscilloscopes* (6 available)
- *Siglent Arbitrary Waveform Generators* (6 stations)
- *Agilent and Siglent Power Supples* (6 stations)
- *Agilent Benchtop Multimeters* (6 stations)
- Mechatronic Components for prototyping i.e. sensors, microcontrollers, etc.

2.2 Off-Campus Facilities

2.2.1 Maritech Machine Inc

Maritech Machining Inc. is a 21,000 square foot, Panama City based, precision machining facility. It is a key external partner in FSU-PC's InSPIRE (Innovation, Sustainability, and Preeminent Research & Education) Program. InSPIRE is working to foster collaborative innovation by connecting students with industry-grade advanced manufacturing and aerospace testing facilities and resources. Maritech houses new metal additive manufacturing systems including a GE Concept Laser PBF (powder bed fusion) and a GE ARCAM EBM Q10Plus, enabling high-precision metal 3D printing and materials testing. These capabilities alongside multi-axis CNC, heat treating, and waterjet cutting. This equips our team to fabricate complex flight components and evaluate mechanical properties efficiently.

Personnel Required: Maritech Employee
Access: With Employee
Hours: Monday – Friday 7:30am – 4:00pm
Equipment:

- *DMG Mori CNC NLX2500/700 – Y-Axis* live tooling lathe with milling and sub spindle
- *DMG Mori CNC NLX2500/1250* - Y-Axis live tooling lathe with milling
- *DMG Mori CNC NLX1500/500 – Y-Axis* live tooling lathe with milling and sub spindle
- *Flow Mach 500 5-Axis CNC waterjet*
- *Femco CNC Turning Center 24" x 49" capacity*
- *Brideport EZPathII CNC lathe 20" x 40" capacity*
- *Doosan CNC Turning Center 12" x 20" capacity*
- *Doosan CNC Turning Center 10" x 20" capacity*
- *Monarch Engine Lathe 40" dia. x 22' between centers*
- *Okuma Genos M560-V 4-Axis CNC Milling Center 20" x 40" capacity*
- *Haas VF5 CNC Milling Center 50" x 26" capacity*
- *Doosan CNC Vertical Milling Center 40" x 20" capacity*
- *Brideport EZ Track CNC Milling Center 9" x 49" capacity*
- *WMW Heckert 450 x 1800 Horizontal Vertical Mill* 3500 lb Table capacity, travels: X 52", Y 34", Z 24.75"
- Assorted Manual Vertical and Horizontal Knee Mills, Engine Lathes, Keyseaters, Shapers, and Surface Grinders
- 5 Ton overhead crane
- *CNC Plasma Cutter FabMaster-II Plate Pro*
- *Miller 600 AC/DC Welder:* Mig, Flux core
- *Miller 300 AC/DC Welder*: Mig, Flux core, Stick
- *Miller Syncrowave 250 DX*: Tig, Stick
- *Miller Millermatic 250 DX*: Mig, Flux core
- *Hypertherm 1250 Plasma Cutter*
- *Schindler Electric Furnace*: Temperature Range +2000°, capacity: 18" x 12" x 18" programmable Honeywell DCP 100
- *Starrett Hardness Tester 3814*: Basic Rockwell comparisons on the A,B, anc C scale
- *Keyence Laser MDX-2*
- *Mitutoyo Crysta-Plus M7106 Coordinate Mearsuring Machine, Measuring* volume: 27.56" x 39.27 x 23.62" with 1,762 lb table capacity
- *Mitutoyo Crysta-Apex CNC CMM 9108*, Measuring volume: 34.4" x 39.37" x 31.49" Table capacity 2,600 lbs
- *Keyence WM-3500 Wide Area CMM*, Measuring volume: 25 feet radius, ability to transport to customer site
- *GE Concept Laser PBF* (powder bed fusion)
- *GE ARCAM EBM Q10Plus*

2.2.2 Gulf Coast State College – Advanced Technology Center (ATC)

The GCSC ATC serves as a partner facility for FSU students through cross campus collaboration. The 93,000 sq. ft engineering and manufacturing center provides professional grade machining, fabrication, and additive manufacturing equipment.

> **Personnel Required:** Faculty/staff supervision for CNC, welding, and heavy equipment; student operation permitted for basic fabrication and 3D printing.
> **Access:** Swipe Card Access
> **Hours:** 8:00am - 5:00pm weekdays; extended access possible with arrangement.

Equipment:

Fabrication Capabilities

- CNC Machining
  - *Haas VF-2 CNC Mill* – high-precision milling with multi-axis capabilities for airframe and bulkhead components.
  - *Haas ST-10 CNC Lathe* – precision turning for custom aluminum and steel parts.
  - *Lucifer RD7-KHE24 Furnace* – enables post-machining heat treatment for strengthening critical load-bearing components.
- Conventional Machining
  - *Vertical/horizontal band saws, drill press, manual mills, and bench lathes* – support for custom fittings, couplers, and small-batch parts.
  - *Surface grinders and buffers* – ensure proper tolerances and smooth finishes on recovery and payload hardware.
- Welding & Cutting
  - *Lincoln MIG/TIG welders* – assembly of steel support rigs, test fixtures, and recovery hardware.
  - *Thermal Dynamics Econopak50 Plasma Cutter* – precision cutting for sheet-metal components.
  - *Avani Welding Booths* – controlled environment for safe welding operations.
- Heavy Handling
  - 5-ton overhead crane – allows safe lifting of heavy fabricated assemblies and test rigs.
  - 4-column vehicle lift – used for ground support and transport test systems.

Additive Manufacturing & Prototyping

- Polymer Printing
    - *Stratasys Dimension Elite* – high-resolution ABS parts for avionics mounts and payload housings.
    - *Objet Connex260* – multi-material polymer printing, useful for complex payload geometries.
    - *MakerBot Replicators (multiple units)* – rapid iteration of small-scale components for subscale testing.
- Powder & Specialty Printing
    - *ZCorp 310 Plus* – powder-based prototyping for lightweight mockups and wind tunnel test models.

Support & Safety

- *Snap-On tool carts and cabinets* – fully stocked for fabrication support.
- *Captair Flex fume hood* – ensures safe handling of volatile materials.
- *PhysiciansCARE First-Aid station* – for compliance with OSHA lab safety requirements.
- *Portable generator* – supports field-testing avionics and recovery subsystems in off-grid conditions.

2.3 Required Equipment & Resources

Required Tools in Possession

- *Laser Woodcutter* – shaping balsa wood
- *3D Printers* – fabricating CAD components
- *Sewing Machines* – fabric design and repair
- *CNC Machines* – make complex geometry cuts
- *Drill Press* – create attachment points and holes
- *Milling Machine* – create rounded symmetrical cuts
- *Handheld Tools* – variety of uses
- *Multimeter* – electrical development
- *Soldering Station* – connecting electrical components

Required Software in Possession

- *Microsoft Office* – documentation & organization
- *SolidWorks* – computer aided design
- *MATLAB* – calculation and simulation
- *MechAnalyzer* – designing payload mechanism
- *OpenRocket* – rocket design & simulation
- *CLion* – multilingual coding

- *Bambu Studio* – communication with Bambu printers
- *Arduino IDE* – communication with Arduino devices
- *KiCad* – printed circuit board (PCB) design
- *MultiSim* – testing circuit diagrams

Required Supplies in Possession

- *PETG Filament*
- *Fastening Supplies*
- *Electrical Supplies*
- *Solder*
- *RMS 75/5120 Housing*
- *JB Weld Epoxy*
- *Tape & Other Basic Adhesives*
- *Lubricants for Machining*

Required Tools to be Obtained

- Any niche tool for a specific purpose
- Given two previous years of Rocketry Projects we have all commonly required tools.

Required Supplies to be Obtained

- *Body Tubing*
- *Nose Cone*
- *Flight Computers*
- *Primary Motor*
- *Secondary Motor*
- *Deployment Hardware*
- *Separation Materials*
- *Shock Cord*
- *Parachutes*
- *Balsa Wood*
- *Fiberglass Cloth*
- *Fiberglass Sheets*
- *Aluminum (for boattail)*
- *Inconel 718 (for bulkheads)*
- *Payload Sensors*
- *Payload Materials*
- *Protective Masks/Respirators*
- *Protective Glasses/Goggles*
- *Protective Gloves*

3. Safety

3.1 Safety Plan Overview

To ensure the safety of team members and all involved during the full progression of this project, a safety plan must be developed and implemented. The Safety plan will show a team-wide comprehension of the guidelines and expectations that must be upheld. While facilitating and implementing the safety plan is the main responsibility of Jonathan Serbest, our Safety Officer, all team members and those involved must show an understanding and compliance of the plan outlined below.

3.2 Hazard Analysis Methodology

Risk identification is necessary as this will be the backbone of our safety procedure moving forward. Identifying the possible risks in and around the progression of our rocket helps all involved to suppress the chance of a major hazard happening. To begin, the criteria on how the analysis of probability is weighted is in Table 3-1 below.

Probability Levels Table 3-1		
Definition	Value	Probability of Occurrence
Unlikely	1	<1%
Uncommon	2	1% to 15%
Occasional	3	15% to 50%
Probable	4	50% to 80%
Likely	5	Above 80%

Now that the metrics for our probabilities are defined, the criteria for assessing risks and hazards will be handled through both the severity of the hazard and its likelihood. Table 3-2 below illustrates this.

Hazard Severity Criteria Table 3-2					
Description	**Value**	**Personnel Health**	**Equipment Health**	**Launch Vehicle**	**Mission Health**
Negligible	1	No injury	Insignificant damage	Insignificant damage/ minor reconstruction	Mission success not impacted
Moderate	2	Minor injury	Moderate damage	Moderate reconstruction	Possible mission success
Critical	3	Severe injury	Major damage	Major reconstruction required	Partial mission success
Disastrous	4	Life-threatening injuries	Complete destruction	Complete loss	Mission failure

With the hazard severity visually defined, the point hierarchy from both graphs combine to give us a comprehensive understanding of the risk analysis. Defined in color and number notation, is the risk level. The risk level is found by multiplying the corresponding number rating of x-plane identifier with the intersecting y-plan identifier. This gives us the ability to score risks across our two identifiers.

Risk and Hazard Assessment Matrix

Table 3-3

		Severity			
		Negligible (1)	Moderate (2)	Critical (3)	Disastrous (4)
Probability	Unlikely (1)	1	2	3	4
	Uncommon (2)	2	4	6	8
	Occasional (3)	3	6	9	12
	Probable (4)	4	8	12	16
	Likely (5)	5	10	15	20

The Consolidated Hazard Assessment Matrix simplifies the numerical results of the hazard analysis by grouping the full range of values into four categories. Each category provides clear guidance on risk level, assists the team in making informed decisions per the severity of hazards, the intensity of required mitigations, and overall safety measures necessary for project activities.

Consolidated Hazard Assessment

Table 3-4

Definition	Value
Minimal	1-6
Tolerable	6-10
Immediate Attention	11-15
Failure	16-20

List and meaning of hazard groups:

Minimal (1–6):

Hazards of this caliber are small and can be easily avoided by using standard safety procedures.

Tolerable (6–10):

Hazards of this caliber require the implementation of mitigation measures as the average severity for these cases is moderate. Mitigations like training, proper PPE, spatial awareness, etc. must be constantly enforced.

Immediate Attention (11–15):

Hazards of this caliber must be dealt with swift and rigorous mitigation. Before proceeding, Safety Officer must be notified and holds the authority to stop activities if deemed necessary.

Failure (16–20):

Hazards of this caliber are unacceptable and will not be attempted. The Safety Officer must be notified and a new technique, design, safety mitigation, etc. must be implemented to lower the risk level before proceeding.

3.3 Laboratory & Field Safety Procedures

All locations will provide their own unique safety concerns; this requires that all team members know the correct procedure to follow depending on the surrounding environment. Below is a table providing the risk level of all locations and individual mitigation procedures.
Note: P’ & S’ (Probability & Severity respectively)

Facility Hazards
Table 3-5

Facilities	P’	S’	Value	Causes	Mitigations
Senior Design Lab	3	2	6	The room serves storage: • Variety of hand and power tools • Chemicals • Variety of raw material. • 3D printers • Soldering irons.	• Keep room organized and clean • Label and safely store chemicals. • Provide PPE for all cases (gloves, safety glasses, face mask or respirator). • Maintain good ventilation for soldering and 3D printing.
Machine Shop	2	3	6	Houses: • Heavy machinery • Hand and power tools • Variety of raw material.	• Mandatory PPE in the case of machine operation including safety glasses, hearing protection, closed-toe shoes. • Knowledge of emergency stop locations. • Operator instructions near each machine. • Regular maintenance and inspections of equipment. • Limit occupancy in the event of machine operation.
Digital Design Studio	1	1	1	Serves as a center for: • 3D printing • Laminating • Printing	• Proper ventilation for 3D printers. • Keep materials (paper, resin, etc.) away from heat sources. • Maintain workspace.
Electrical Engineering Laboratory	1	2	2	Houses: • Wavelength generators • Hand and power tools • Electronics & soldering tools	• Provide PPE for all cases (gloves, safety glasses, face mask or respirator). • Proper ventilation for soldering. • Review lab safety procedures according to the Electrical Engineering Department. • Knowledge of emergency stop locations. • Fire extinguishers for electrical fires (Class C).
Materials Lab	1	3	3	Houses: • Material property testing machines • A variety of material samples	• Provide PPE for all cases (gloves, safety glasses, face mask or respirator). • Maintain clear zones around testing machines. • Properly label and store samples.

				• Power/Hand tools	• Knowledge of emergency stop locations for material testing machines. • Review lab safety procedures according to the Mechanical Engineering Department.
Thermal Fluids Lab	1	2	2	Houses: • Material property testing machines • A variety of material samples • Power/Hand tools	• Provide PPE for all cases (gloves, safety glasses, face mask or respirator). • Use spill containment for fluids. • Ensure proper ventilation. • Knowledge of emergency stop locations. • Review lab safety procedures according to the Mechanical Engineering Department.
Mechatronics Lab	1	2	2	The room serves storage: • Variety of hand and power tools • Variety of raw material. • 3D printers • Soldering irons. • Electronic components	• Provide PPE for all cases (gloves, safety glasses, face mask or respirator). • Provide fume extraction for soldering/3D printing. • Require PPE for tool use. • Emergency shutoff for robotics/electrical equipment. • Review lab safety procedures according to the Mechanical Engineering Department.
Advance Technology Center	2	3	6	Large space that holds: • Heavy Machinery • 3D printers • Laser cutters • Additive manufacturing machinery • Hand/Power tools • Variety of raw material.	• Provide PPE for all cases (gloves, safety glasses, face mask or respirator). • Knowledge of emergency stop locations. • Review lab safety procedures according to the Gulf Coast State College.

Note: All students shall be required to receive proper training before using any high-risk equipment.

3.4 Safety Data Sheets (SDS): Chemicals and Materials

Material Hazards Table

Table 3-6

Material	P’	S’	Value	Use	Effects	Mitigations
Adhesives	2	2	4	Adhesives will be used for bonding airframe parts and other structural components together.	• If handled improperly, symptoms including eye and skin irritation, and respiratory problems are possible	• Follow the safety instructions described by the manufacture

Aluminum	1	3	3	Mainly used for bulkheads, and payload components.	• Material Surface may be rough or sharp. May require machining for shaping or finishing.	• Team members shall be required to use gloves when working with any tools or material.
Black Powder	2	4	8	Means of vehicle separation after apogee.	• Black power is prone to hazards including fire and explosions.	• Black powder must be stored in dry, ignition-free areas. • Stored in accordance with NFPA standard. • Transported in accordance with ATF
CO2 Cartridges	1	2	2	The main means of separation after apogee.	• High pressure gases can be volatile in extreme heat.	• Follow the safety instructions described by the manufacture.
Epoxy	2	2	4	Bonding of internal and external vehicle components.	• Most epoxy has a two-step reaction that causes volatile gas to fill the area.	• Follow the safety instructions described by the manufacture.
Wood	2	2	4	Material for fins	• All wood parts will be laser cut.	• Team members shall be required to use gloves when working with any tools or material.
Fiberglass	3	2	6	Material for airframe and fin reinforcement	• Fiberglass air frame will be cut and finished with tools like band saws, dremels, sanders, and hand saws. These will present hazards.	• Team members shall be required to use gloves when working with any tools or material.
Fiberglass Cloth	2	2	4	Material for airframe, fin reinforcement, and transition body tube shaping.	• Fiberglass cloth will need a bonding epoxy to form the cloth into a rigid shape. Epoxy will present hazards.	• Follow the safety instructions for epoxy described by the manufacturer.
Greases	1	2	2	Grease will be needed for oiling mechanisms of payload.	• Most commercial greases have carcinogenic hydrocarbons.	• Follow the safety instructions described by the manufacture.

Inconel	1	3	3	Will be used in the bulkheads of the rocket	• Due to additive manufacturing, surface finish on aluminum parts will be rough and sharp. This will require machining to obtain a finished part.	• Team members shall be required to use gloves when working with any tools or material.
Isopropyl Alcohol	1	2	2	Used for prepping the surface of our airframe for painting.	• Can produce skin and eye irritation.	• Follow the safety instructions described by the manufacture.
PETG	1	2	2	Various costume parts	• Can produce burns and blisters from hot plate or material.	• Waiting ample time to allow the area to cool before
PLA	1	2	2	Various costume parts	• Can produce burns and blisters from hot plates or material.	• Waiting ample time to allow the area to cool before
Solid Propellant motor	1	4	4	Used for rocket propulsion	• Black power is prone to hazards including fire and explosions.	• Black powder must be stored in dry, ignition-free areas. • Stored in accordance with NFPA standard. • Transported in accordance with ATF • Train team in proper emergency plan in the event of a fire.
Spray Paints	3	2	6	Will be used in painting the sub-scale and the full-scale models.	• Product will produce toxic inhalants when used.	• Follow the safety instructions described by the manufacture.
Steel	1	3	3	Material will be used throughout the payload.	• Material is prone to being machined or used in tandem with other hand-held/power tools.	• Handle sharp or rough material with safety equipment. • If using tools in tandem with material, safety equipment such as rugged heavy-duty gloves, eye-protective wear shall be used to prevent injury. • In the event that small metal shavings or sparks are being thrown, protective were like long sleeve wear, pants, masks, and a fire extinguisher should be easily accessible.

Thread Lock	1	2	2	Produce used in payload and airframe miscellaneous components to prevent future movement.	• If handled improperly, symptoms including eye and skin irritation, and respiratory problems are possible	• Follow the safety instructions described by the manufacturer.

Notice: All products will be used for their intended purpose and in their scope of material capability.

3.5 Construction Safety Procedures

During the construction of the rocket, team members will be exposed to a plethora of tools and machinery. It is imperative that all team members are competent of each tool's inherent risks and their hazard mitigations.

Construction Hazard Table
Table 3-7

Hazard	e.g.	P'	S'	Value	Cause	Effects	Mitigation
Compressed Air Systems	Air compressor and accessories.	1	4	4	- Faulty hose and fittings - Over-pressurization - Negligent use of tool according to provided owner's manual	- Hearing damage - Flying debris and shrapnel causing possible cuts, lacerations, and possible death.	- Make sure that equipment is well maintained and clean before using. This includes procedures like inspecting hoses and fittings. - Use ear protect when using compressor at all times. - Do not use equipment improperly. Ex. Pointing spray nozzle at others or yourself.
Construction Hand Tools	Pliers, screwdrivers, hammers, clamps, wrenches.	4	2	8	Unclean or oily hands while working, Sharp edges, blunt forces.	- Cuts - Bruises - Skin pinching - Puncture wounds	- Maintain and clean all tools after use. - Gloves are required when working with all tools. Depending on the tool, use of ear and eye protection

							shall be enforced in junction. - Store and procure tools safely when using.
Cutting Tools (Hand & Powered)	Knives, box cutters, scissors, hacksaws, chop saws, table saws.	3	3	9	- Unclean or oily hands while working - Negligent handling - Open wires - Dull blades - Leaving powered tools unattended	- Severe lacerations - Eye injury from debris -Electrocution - Puncture wounds	- Heavy duty gloves should be used - All wires shall be inspected before and after use. - Storage of tools safely away from heavy occupied zones and safe to hold in their stored state.
Electronics & Soldering Tools	Soldering irons, wire cutters/ strippers, crimpers.	3	2	6	- Leaving hot or powered tools unattended - Toxic fumes - Exposed wires	- Burns - Blistering - Skin pinching Cuts	- Area shall be properly ventilated - Safety glasses shall be used
Heat Tools & Adhesive Applicators	Heat guns, hot glue guns.	2	2	4	- Leaving energized tools unattended. - Hot material - Toxic fumes	- Burns - Blistering	- Heat-resistant gloves shall be required when operating. - Face mask capable of filtering chemical and partial inhalants shall be used.
Machining Tools (Heavy Equipment)	Mill and Lathe.	2	4	8	- Unclean machine - Improper maintenance - Lack of operation knowledge, - Loose material in tool grips. - Negligent use of tool according to provided owner's manual. -Exposed wires - Some Machining tools need coolant for material shaping. This coolant can be hot and contain contaminants.	- Cuts or nicks from material edges. - Metal shavings in eyes. - Limb caught in machine resulting severe wounds and even death.	- Knowledge of emergency stop locations is required. - Non-essential personal shall not be in the area while being operated. - Proper clamping of billet or part shall be confirmed Safety glasses shall be required
Power Drilling & Fastening Tools	Cordless drills/drivers, torque wrenches, tap & die sets.	2	3	6	- Unclean or oily hands while working - Negligent handling - Leaving energized tools unattended Open wires	- Cuts, lacerations, and puncher wounds from tool head. -Electrocution from open wire	- Heavy duty gloves should be used - All wires to powered tools shall be inspected before and after use. - Storage of tools safely away from heavy occupied

							zones and safe to hold in their stored state. - Safety glasses shall be required
Rotary & Abrasive Tools	Grinders, rotary tools (Dremel), sanders.	2	3	6	- Leaving energized tools unattended. - Negligent handling Rough, tool head. Exposed wires	-Electrocution from exposed wire - Flying debris can cause eye and skin injury. - Inhalants caused by sander can cause respiratory irritation.	- Storage of tools safely away from heavy occupied zones and safe to hold in their stored state. - Face mask capable of chemical and partial inhalants shall be used. - Safety glasses shall be required

Notice: All tools require that the user is well informed on the use and maintenance of any tool before use and tools shall be used for their intended purposes. During the operation of heavy machinery or high-risk tools, only essential personnel shall be permitted in the immediate area.

3.6 Methodology for Management of Rocket Motors and Energetics

Motor Acquisition

According to the NAR High Power Rocket Safety Code and the 2025-2026 NASA USLI Handbook, all motors acquired by the team are to be commercially manufactured and certified by NAR/TRA. These motors must be purchased by the team mentor as students cannot directly obtain them. Motors purchased must be of the same level as the mentor's certification allows. Motors purchased shall be the same as prespecified to NASA.

The team will follow this acquisition process:

- All motor selections must be approved by the Project Lead and Safety Officer and pre-cleared with the team mentor prior to purchase. If the mentor indicates that a motor requires an ATF permit or exceeds allowed on-site storage limits, an alternate compliant motor will be specified.
- Motors will be purchased only from reputable, licensed vendors. When possible, the team will use on-site purchases at sanctioned launches from licensed vendors to avoid long-term storage requirements.
- If the primary or secondary motor choice becomes unavailable, the team will document the reason and submit an updated motor specification in the next deliverable for NASA review and approval.

Motor Storage

All subjects of motor storage will be under the control and supervision of the team mentor. Storage shall comply with NFPA 1127 and ATF 27 CFR regulations. Rocket motors will be kept in their original state and will not undergo any tampering or be used for any purpose other than what is defined by the manufacturer (NFPA 1127 - Note: link may not work as NFPA is proprietary and requires a user account).

Storage Location:
Using (NFPA 1127 - 2026 edition)

- Motor storage location shall be in a climate-controlled area. This will ensure that the motors will not experience any natural ailments like high humidity or temperature. These product limitations will be specified through the recommendations of the manufacturer.
- Storage will be located at a minimum of 25 ft from smoking, open flames, or any other heat source (4.19.1)
- Motor magazines shall be stored based on the net weight of rocket propellent and accordingly with the storage requirements of 27 CFR 555. (4.19.2)
- Indoor magazines shall be painted in red with the words, “EXPLOSIVES—KEEP FIRE AWAY” in white letters and to the proper dimensions specified by NFPA. (4.19.2.1)
- Indoor Magazine shall not be stored in residence (4.19.2.2)

Fire and Energetic Ignition Control:

- Detonators are not to be stored in the same magazine with other explosive materials, except during explicit circumstances. (27 CFR 555.213)
- Smoking, matches, open flames, and spark producing devices shall not permitted in or around the storage magazine. (27 CFR 555.212)

Motor Handling

Motors shall be transported and handled with mentor supervision. Team members are prohibited from loading their own motors before or on launch day. This must be done by the NAR team mentor, Elizabeth Gildersleeve. If the motor is being transported in or across states, students and personnel will show full understanding of and comply with local, state, and federal laws and regulations concerning the transportation of explosives.

Regulation of motor accessibility:

- Access to storage of all motors will be always limited to the team mentor.

Documentation:

- Motor location and movement will be documented at all times. Documented information includes the motor model number, serial number, date of storage and movement, and date of launch use.

- The Team mentor (Elizebeth Gildersleeve) and Safety Officer (Jonathan Serbest) shall write a summary of motor preparation, transport, and motor loading. This will be done at the end of launch day, documented, and dated.
- All team members will have a copy of all safety requirements during rocket handling.
- If any incident might occur during the preparation, transport, or loading of the motor, team members shall report immediately to the Safety Officer and the Team Mentor. An incident shall be implemented into the day’s final report.

Motor Defect and Instability:

- In the event of a faulty motor, all team members, team mentor, and facility owners must be informed immediately.
- The motor shall not be tampered with, and proper authorities must be notified for motor disposal.

Emergency plan

In the event of a motor fire, team members must be trained and prepared to react in accordance with safety procedures.

Immediate action:

1. Make all team members aware of the present danger by yelling load and clear, “Fire, evacuate now”
2. The Safety Officer must ensure that all team members are at a minimum distance of 300’. This is in accordance with NAR safety code for L class motors.
3. All team members must be accounted for by the safety officer.
4. The Safety Officer must ensure that all team members are unharmed. In the case of injury, emergency services must be called immediately and the tending to the victim must be the top priority until emergency personnel arrive.
5. Notify the proper fire authorities and do not attempt to tame or quench the fire.

3.7 Student Safety Briefings Plan

Prior to all risk-prone activities, students must demonstrate a full understanding of, and ability to comply with the pre-described safety plan. The team Safety Officer (Jonathan Serbest) and Project Lead (Krieg Conrad) hold responsibility for informing students of assigned tasks and the desired outcomes. All situations are unique and require careful safety consideration; therefore, students must demonstrate an understanding of the specific safety requirements for the task at hand before beginning work. After briefing, team members will sign an attendance document including an acknowledgment and understanding of the material discussed, general and task-unique safety hazards, and a pledge to comply with safety plan.

Examples of briefing types depending on situation:

- Planned training sessions and topics
- Design phase safety
- Fabrication safety practices
- Storage and transportation of energetics
- Launch-day procedure

3.8 Compliance with Federal, State, and Local Regulations

Due to the nature of this project, all team members understand the need for, and are compliant with, all federal, state, and local regulations. All members have read, understood, and pledge to implement the safety plan at all times. We understand that failure to comply with these requirements endangers the project and presents a potential to be acquitted from the 2025-2026 NASA USLI project.

All team members acknowledge the governing authorities over all procedures regarding the USLI project.

These include:

- NASA Student Launch Handbook (2025–2026).
- NAR/TRA Safety Codes
- FAA Regulations — 14 CFR Part 101, Subpart C (Amateur Rockets).
- ATF Regulations — 27 CFR Part 555
- NFPA 1125 & 1127
- University / Local Safety Policies

3.9 Safety Agreement Statement

In compliance with RSO authority, NAR Safety Code, and mentor oversight,
All team members understand the safety expectations and regulations required by NASA, NAR safety code, and the team mentor. An on-site Range Safety Officer (RSO) will conduct an inspection of the vehicle before flight and holds the authority to veto vehicle launch in the event of non-compliance. Team mentor is responsible for the safety of the team throughout the duration of launch day. This includes the preliminary inspection of the rocket to ensure compliance with established amateur rocketry design and the safety guidelines provided and the safety of the team in the launch and recovery of the rocket. All team members will be required to sign the following document before launch of any rocket.
NASA USLI Team Safety Compliance Agreement

4. Preliminary Technical Design

4.1 Mission Statement & Success Criteria

The mission of the Terra Nova Project is to design and manufacture a high-powered rocket with commercially available and in-house manufactured components. Design of the recovery system will be with the intention of landing within 80 seconds of apogee and all individual rocket sections sustaining no more than 65 ft-lb of energy. The design and manufacturing of all recovery system components shall meet all specified safety criteria and NASA launch rules and guidelines. Custom bulkheads will be used to absorb forces imparted on the recovery system and manufactured using the new form of additive manufacturing, 3D metal printing. We will design and construct the HAUS payload with the capabilities to collect, store, and analyze at least 50mL of soil. Logging the sample data with proper time stamps within 15min of landing.

4.2 Vehicle Overview

4.2.1 General Dimensions and Justification

General Dimensions:

Preliminary design (detailed in Figures 4-1 and 4-3 – 4-6) estimates the total length of the rocket to be 124” and the overall estimated weight of the rocket is 43.44lb. This estimation includes all airframe and components listed in Figure 4-3 and 4-4 but excludes the motor weight. With the weight of our current primary motor, the weight of the rocket is 53.5lb. The dimensions of all airframe components are described in Table 4-1. Important factors to note are our nose cone, transition airframe, and the use of a boat-tail. Nose cone selection will be a commercially available, 4:1 ogive nose cone, based on the FNC6.0-FW-MT. The custom airframe transition will reduce the outer diameter (OD) of the rocket from the initial, 6.17” to 5.15” and the inner diameter (ID), reduced from 6” to 5”. The transitioning length of the airframe tube will be 8”. This makes a reducing angle of 3.68°. The total length of the transition airframe will be 19”. The last major external component is the boat-tail, which will be 4” long and used to reduce the 5.15” OD to 4.5” OD.

General Dimensions
Table 4-1

Airframe Component	Measurement
Nose Cone	• Shape: 4:1 Ogive • Base ID: 6” • Length: 24”
Body Tube 1	• ID: 6” • OD: 6.17” • Length: 8”
Custom Transition Airframe	• Overall length: 19” • Transitions OD from 6.17” to 5.15” OD • Transitions from 6” ID to 5” ID • Transition length: 8” • Transition angle: 3.68°
Body Tube 2	• ID: 5” • OD: 5.15” • Length: 25”
Body Tube 3	• ID: 5” • OD: 5.15” • Length: 24”
Body Tube 4	• ID: 5” • OD: 5.15” • Length: 18”
Fins	• See Figure 4-6 for detailed drawing
Boat-Tail	• Length: 4” • Transitions from 5.15” OD to 4.5” OD

Justifications for special components:

Nose cone

The nose cone’s primary purpose is to minimize drag at the front of the rocket. A 6-inch diameter, 4:1 ogive nose cone was selected in the preliminary design for two main reasons. First, it is commercially available through Wildman Rocketry. Second, the aerodynamic characteristics of an ogive profile provide reduced drag and help prevent flow separation at the expected flight speeds, making it well suited to the team's performance requirements (1).

Custom Transition Airframe

Three primary purposes were identified for the selection of a custom transitional airframe. First, the larger diameter provides a greater area to house the HAUS payload. Secondly, it reduces weight by decreasing the material required after transition. Thirdly, it reduces base pressure drag by reducing overall surface area.

The reduction in weight can be estimated by the comparison between both volumes of material required and the material of construction.

$$V_{Shelled\ Cylinder} = \pi L \times \left[\left(\frac{OD}{2}\right)^2 - \left(\frac{ID}{2}\right)^2\right]$$

$$Weight = \rho V$$

Volume of all airframe tubes from Body Tube 1 and after without the transition:

$$V = \pi(124in - 32in)\left[\left(\frac{6.17}{2}\right)^2 - \left(\frac{6}{2}\right)^2\right] = 149.6in^3$$

Density of G-12 is $\frac{1.8g}{cm^3} = 1.04\frac{oz}{in^3}$ (2).

$$W_1 = 1.04\frac{oz}{in^3} \times 149.6in^3 = 155.5oz$$

Volume with the reduction in diameter:

$$V = V_{transition\ airframe} + V_{shelled\ cylinder} = 115.7in^3$$

($V_{\text{transition airframe}}$ was calculated from a SolidWorks design of the transition)

$$W_2 = \frac{1.04oz}{in^3} \times 115.7in^3 = 120.4oz$$

$$\Delta W = 155.5oz - 120.4oz = 35.1oz \times \frac{1lb}{16oz} = 2.2lb$$

As proven, the reduction of diameter will decrease the weight of our rocket by 2.2lb. This is a substantial reduction, allowing extra design room for other heavier components like the boat-tail, HAUS, Avionics Bay, etc.

The reduction of weight is not the only advantage to diameter reduction. Base drag can account for around 30% of the total drag acting on the rocket (1). This is due to the low pressure behind the base of the rocket caused by separation of air flow. This flow separation or "wake" from the rocket is directly related to the pressure drag acting on the shape. By reducing the diameter at the end of the rocket, there is a reduction in area for the low-pressure wake to act upon. In addition to this, the overall pressure of the wake is increased because of the reduction of flow separation. This increase in wake pressure reduces the pressure differential acting on the rocket, thus reducing drag. The last advantage of the transition is due to the air pressure acting on the angled section of the transition. This causes a component of the pressure to act as a thrust for the rocket (1).

Boat-tail

The reason to use a boat-tail is based on similar principles for the transition. The boat-tail further reduces the area at the base of the rocket and thus reduces the area that the wake pressure can act upon. It also further reduces the pressure differential acting on the rocket, thus reducing the overall pressure drag. In the report “TR-11 Model Rocket Technical Report”, Dr. Gerald Gregorek estimates the reduction of drag through empirical correlations from experiments outlined in his report. Through this data he created a figure outlining the percent reduction of base drag compared to the ratio of the diameters.

$$Diameter\ Ratio = \frac{diameter\ at\ end\ of\ boat - tail}{original\ diameter}$$

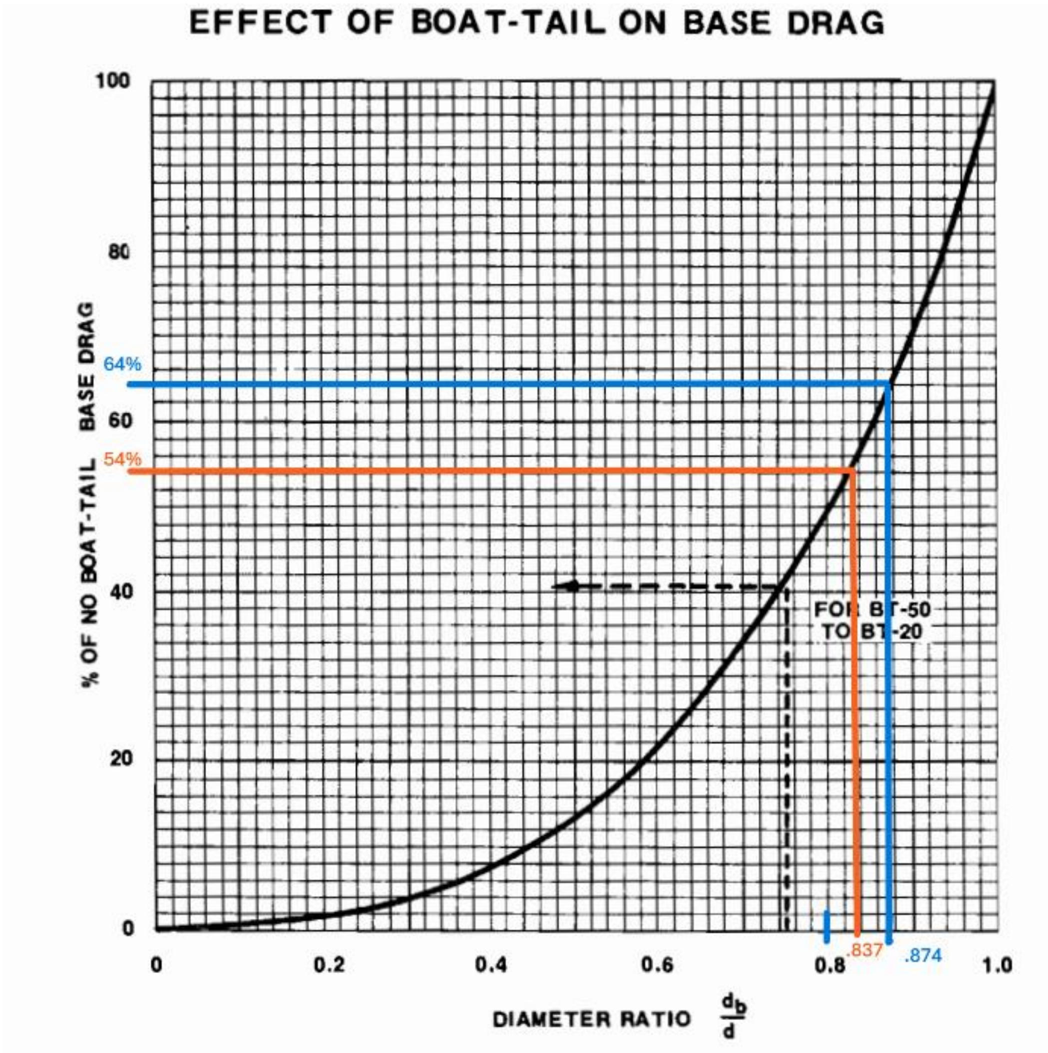


Figure 4-2 **Effect of Boat-tail on Base Drag** (1).

Our boat-tail design gives a $Diameter\ ratio = \frac{4.5"}{5.15"} = .874$. According to Figure 4-2, when following the lines in blue, this equates to 64% of base drag without boat-tailing. This means that by boat-tailing, the base drag is reduced by 36%.

The base drag reduction would be similar for the transition since the OD has been reduced from 6.17" to 5.15". The assumption that a transition airframe functions similar to a boat-tail is justifiable because the principle behind the boat-tail is reduction of the diameter at the end of the rocket. This is achieved by a smooth diameter transition that is sloped less than 5 degrees to prevent flow separation (1). A transition accomplishes the same goal but at a location above the base of the rocket. With this assumption, we can estimate the advantages of including the reducing transition in our design using the figure above. Following the orange lines on the figure above, using a $Diameter\ ratio = \frac{5.15"}{6.17"} = .837$, the new drag would be 54% of the original base drag. This would mean a reduction of 46% of the original base drag.

4.2.2 Preliminary CAD drawing

Figures 4-3 – 4-6 are drawings, detailing the layout of the Terra Nova Project (designed in the OpenRocket software). Figure 4-6 is a drawing that specifically details the design of our fins (designed in SolidWorks).

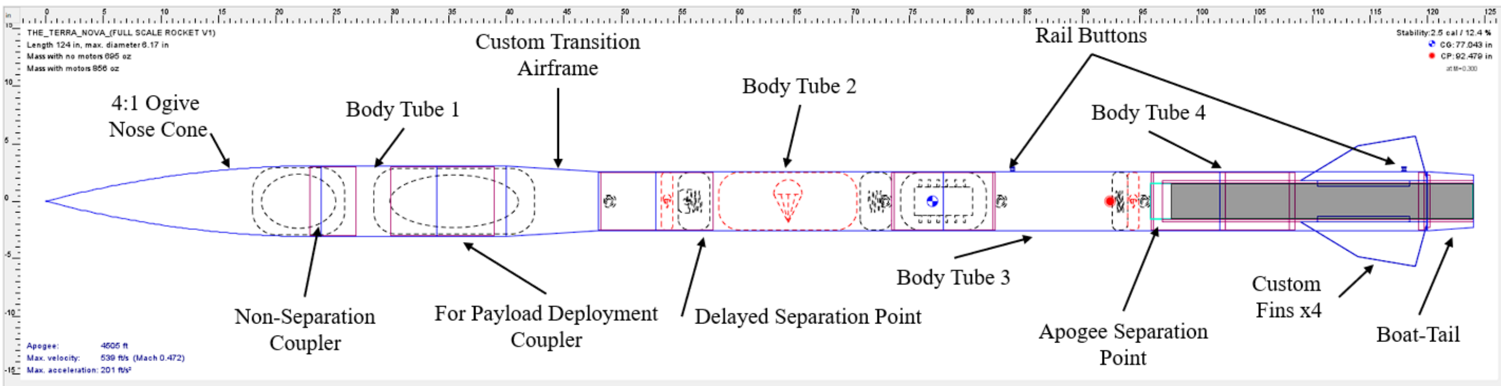


Figure 4-3 **External Components** (designed in OpenRocket)

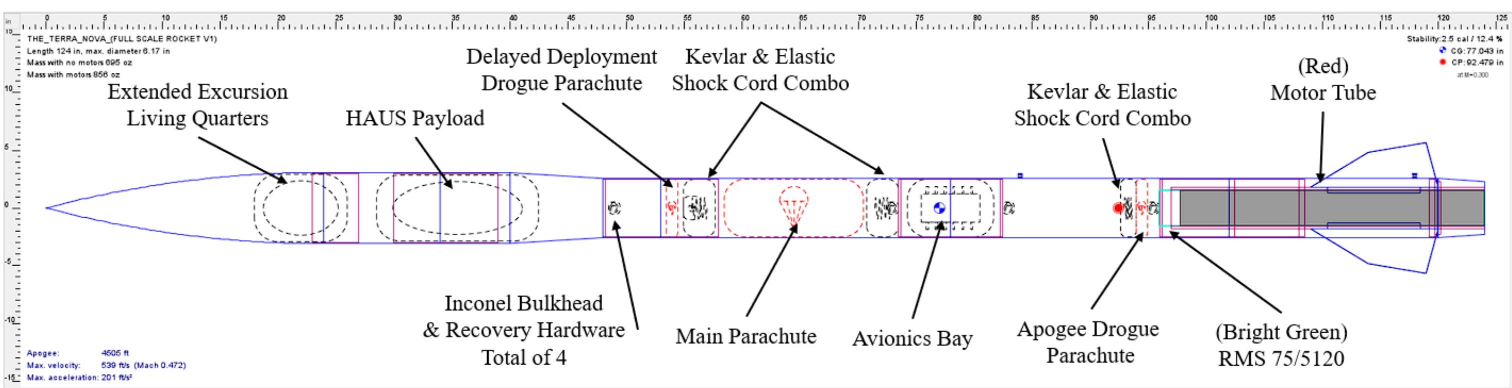


Figure 4-4 **Internal Components** (designed in OpenRocket)

Figure 4-5 **3D Image** (designed in OpenRocket)

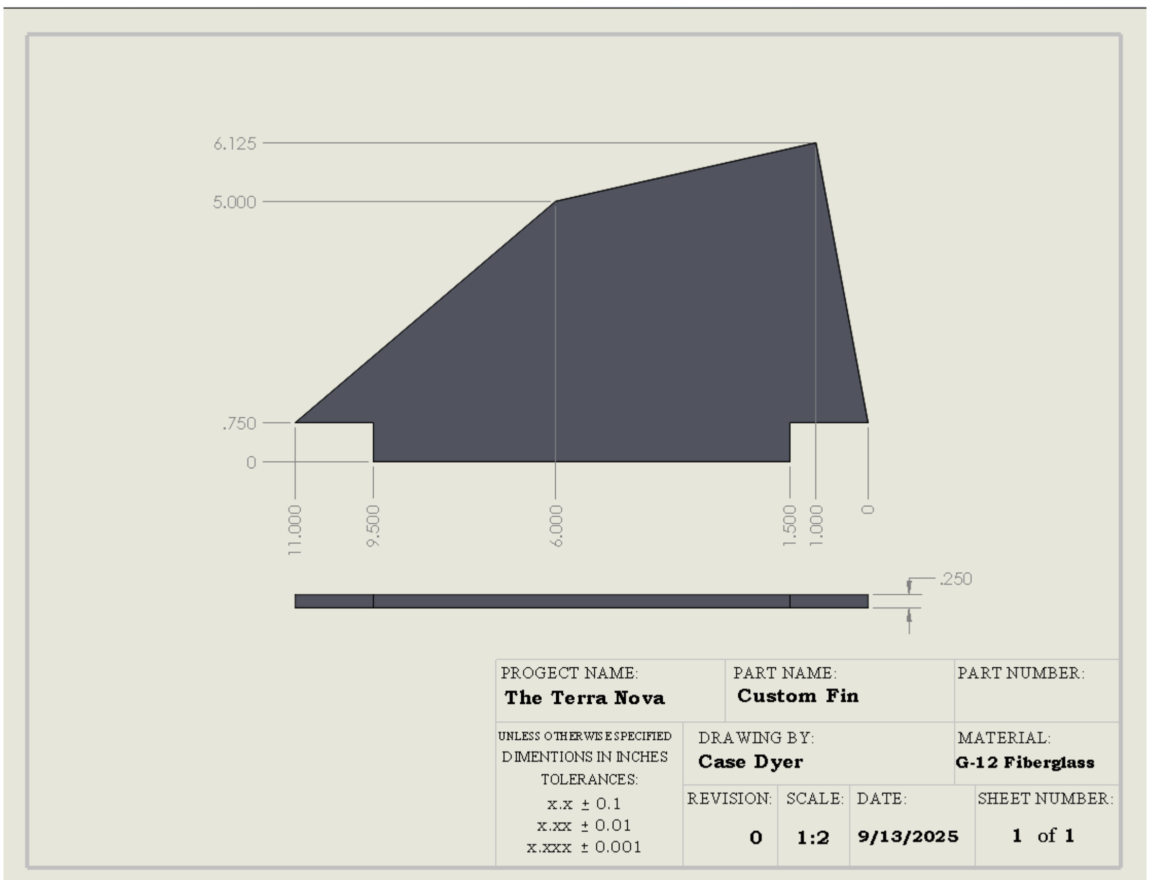


Figure 4-6 **Fin Detail Drawing** (designed in SOLIDWORKS)

4.2.3 Material Selection & Justification

Fiberglass: Nosecone, Body, Couplers, and Fins

Fiberglass is a lightweight and strong material, commonly used in the structure of rocketry. These materials allow us to prioritize the strength to weight ratio for the body of the vehicle. Fiberglass is also commercially available due to the common use of these materials for rocketry.

Inconel 718: Bulkheads

Inconel 718 is a high strength material capable of withstanding the high forces experienced during the deployment of our recovery systems. It is one of our primary goals to use the new additive manufacturing technology, 3D metal printing. Through the InSPIRE program's partnership with Maritech Machining Inc. we have access to 3D print Inconel 718. This material, when un-heat-treated, has an ultimate tensile strength of 958 MPa (3 - Table 5), and a density of around .296 $\frac{\text{lb}}{\text{in}^3}$ (4). Aluminum 6061-T6 has an ultimate tensile strength of 260 MPa (5) and a density of around .0982 $\frac{\text{lb}}{\text{in}^3}$ (this density was calculated using the percentages of all alloying elements (5) and the densities of each element (6)). Assuming a 1in cube of material:

The strength to weight ratio of Inconel 718 = $\frac{958\ MPa\ x \frac{1\ ksi}{6.895\ MPa}}{.296 \frac{\text{lb}}{\text{in}^3} x\ 1\ in^3} = 469 \frac{ksi}{lb}$.

The strength to weight ratio of Aluminum 6061-T6 = $\frac{260\ MPa\ x \frac{1\ ksi}{6.895\ MPa}}{.0982 \frac{\text{lb}}{\text{in}^3} \text{ x } 1 \text{ in}^3} = 384 \frac{ksi}{lb}$.

The ratio between the two materials = $\frac{469 \frac{ksi}{lb}}{384 \frac{\text{ksi}}{\text{lb}}} = 1.22$.

Based on these calculations, Inconel 718 is 1.22 times stronger per pound than a heat-treated aluminum. Therefore, using Inconel 718 for our bulkheads would reduce the overall weight of the rocket without compromising its strength. In addition to this, we would not incur additional material costs because it is funded through our school's InSPIRE program.

Kevlar/Elastic: Shock Cord

Our initial concept design involves a unique, custom-made shock cord made of both Kevlar and an elastic material. The length of the cord will be Kevlar, with relatively short sections of elastic. This design allows us to take advantage of the Kevlar's rigidity while also providing an initial energy dissipation through the elastic material. The design will be explained in more detail later in the proposal.

Ripstop Nylon: Parachutes

While most of our recovery system involves high strength materials for the anticipated high deployment loads, ripstop nylon is satisfactory for the parachute material. We have considered using Kevlar for our chutes, however based on our current estimates, ripstop nylon parachutes should be sufficient. While Kevlar is known to be used primarily in high heat applications, it also is known to have complications in deployment. Because of the niche uses of Kevlar parachutes, ripstop nylon is the current selection.

JB Weld Epoxy: Component Adhesion

While some components will be held in place by screws or other physical fasteners, many will require adhesion for a more simplified hold. The use of an adhesive can also help create a seal in areas like the HAUS Habitat. JB Weld will play a pivotal role in ensuring a secure hold on certain stationary components such as the centering rings and fins.

Aluminum: Boat-tail

Part of our concept involves the use of a boat-tail, to help mitigate base pressure drag, machined out of Aluminum. This material was selected because the boat-tail does not require much strength. Aluminum is lightweight, relatively cheap and is able to withstand the high temperatures created by the motor.

Balsa Wood: Fin Base

While fiberglass is the primary consideration for fin material, balsa wood may act as a base for construction. With laser cutting, a precise shape can be made from balsa wood, that would then be coated in fiberglass. This material is weak, but it is also lightweight and would help reduce weight.

PETG Filament: 3D-Printed Components

For the fabrication of several components that are not structurally critical, we will 3D-print components made from PETG filament. These components include, but are not limited to, avionics bay housing, HAUS habitat housing, HAUS payload components, etc. and will not be subjected to any significant load.

4.2.4 Construction Methods

Cutting Body Tubes

- The body tubes will be cut to the specified lengths using a ban saw. Access to the tool will be through GCSC facilities.

Notice: Members will follow the proper safety protocols and wear the appropriate PPE as outlined in the pervious section, 3. Safety.

Formation of Custom Transition

There are a few different methods being considered to fabricate the custom transition airframe:

Method 1:

- 3D-print the full transition airframe using a Carbon X1 with a slightly reduced OD to allow for fiberglass reinforcement.
- Coat the transition in fiberglass cloth and epoxy to ensure strength and proper adhesion between the printed layers.

Method 2:

- 3D print a transition airframe mold in 3 separate sections (detailed in Figure 4-7)
- Combine transition pieces using the interference fit slots
- Cover each mold section with wax cloth (The purpose of the wax cloth is to be able to remove the upper and lower portions of the mold. This is to ensure that our resulting airframe is lightweight, and the couplers can be inserted into the transition.)
- Repeatedly wrap and coat the transition mold with more layers of fiberglass cloth and epoxy until the outer diameter meets our previously specified dimensions.

Notice: Whenever handling the fiberglass cloth or epoxy, the proper PPE will be used and will be done in a properly ventilated room as noted in the previous section, 3. Safety.

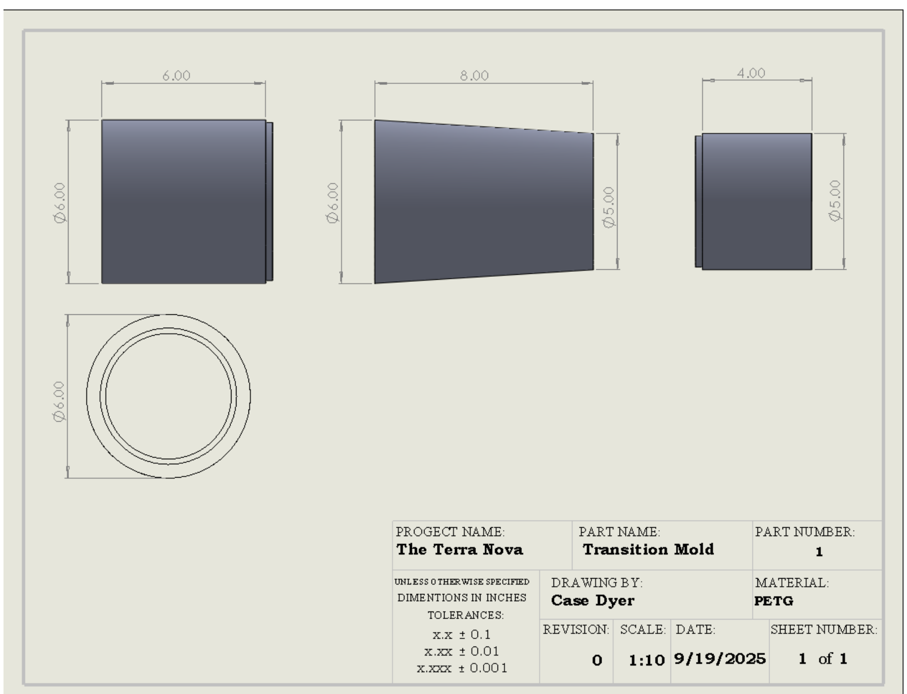


Figure 4-7 **Custom Transition Airframe Mold** (designed in SolidWorks)

Special Shock Cords

- The custom shock cords will require a strong connection between two materials that behave very differently. The best options for construction are the use of knots and physical limits to prevent sliding, or quick links to provide a much stronger and interchangeable connection.
- Kevlar will be the main length of the cord, with sections of elastic throughout. The elastic sections will run parallel to the Kevlar, with the Kevlar leaving slack until the elastic is stretched in tension.

Boat-tail

- The boat-tail will be manufactured by Maritech Machining Inc., our local manufacturing partner, using the model we have designed in SolidWorks.
- It will be secured by threading onto a threaded ring epoxied to the rocket motor tube.

Notice: Whenever handling the fiberglass or epoxy, the proper PPE will be used and will be done in a properly ventilated room as noted in the previous section, 3. Safety.

Motor Securing

- Motor tube will be secured to the rocket frame using three centering rings made of fiberglass.
- The centering rings will be glued to the motor tube and the rocket airframe.
- The RMS will then be inserted into the motor tube and fastened to the centering ring at the bottom of the rocket.

Notice: Whenever handling the fiberglass or epoxy, the proper PPE will be used and will be done in a properly ventilated room as noted in the previous section, 3. Safety.

Joining of Body Tubes

- The body tubes will be joined via fiberglass couplers.
- For any section that will separate during recovery, the coupler length will be 2.125x the ID of the airframe.
- For any section that will not separate during recovery, the coupler length will be 1.625x the ID.
- For sections designed to separate during parachute deployment, shear pins will be used to hold the body tubes together until the ejection charge is set off and the shear pins fail as designed.

Fasteners and Drilling

- Various screws and fasteners will be used throughout the construction of the rocket.
- Screws will be used to fasten the bulkheads to the body frame of the rocket and to their respective couplers.
- A drill press will be used to create uniform holes, perpendicular to the surface of the body tubes, so that the screws will thread through the bulkheads and flush with the body of the rocket.

Notice: When using the drill press the proper protocols will be followed and appropriate PPE will be worn by all involved as noted in the previous section, 3. Safety .

Pressure Seal for Bulkheads

- Grooves will be machined into bulkheads to fit O-Rings. These will create a quality pressure seal between the bulkheads and the couplers. This will be to ensure that when pyrotechnic events occur, the release of the pressurized CO_2 will pressurize the appropriate sections and cause the shear pins to fail as designed.

Fins Construction

We are currently considering two methods of construction for the fins:

Method 1:

- Laser cut the fins out of balsawood. (Lazer cutting provides an accurate and consistent method of producing the fins.)
- Coat fins in fiberglass cloth and epoxy. (Produces a lightweight result with sufficient strength provided by the fiberglass reinforcement.)
- Fins would then be sanded to produce uniform surfaces.

Method 2:

- Cut fins out of fiberglass sheets using a CNC machine or lathe. (This method would be quicker due to decreased manufacturing steps and less post processing, however this will increase the weight.)

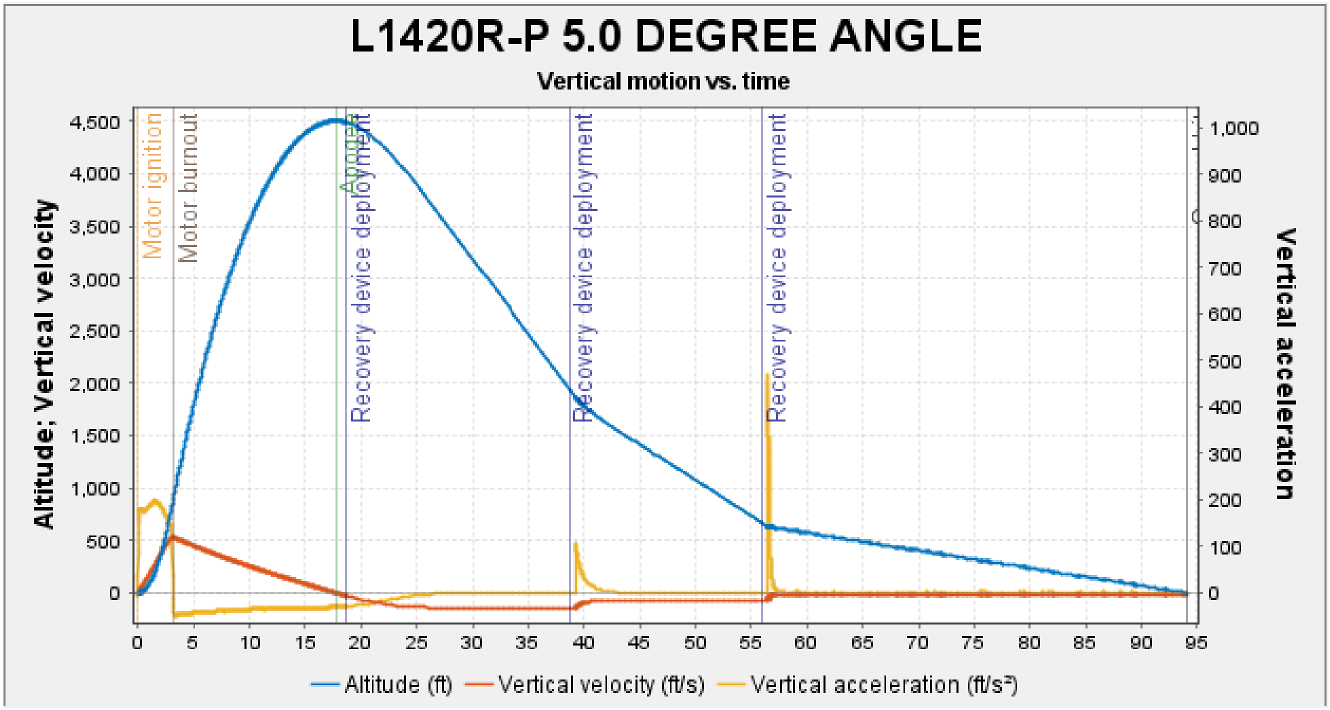
In either case, the fins will be secured to the rocket by insertion into their respective fin slots, then epoxied in place by epoxy fillets.

Notice: Whenever handling the fiberglass or epoxy, the proper PPE will be used and will be done in a properly ventilated room as noted in the previous section, 3. Safety.

4.3 Predicted Performance & Motor Selection

Predicted Performance for Primary Motor Choice (L1420R-P)

Figure 4-8 **L1420R-P Simulation Data** (generated by OpenRocket)



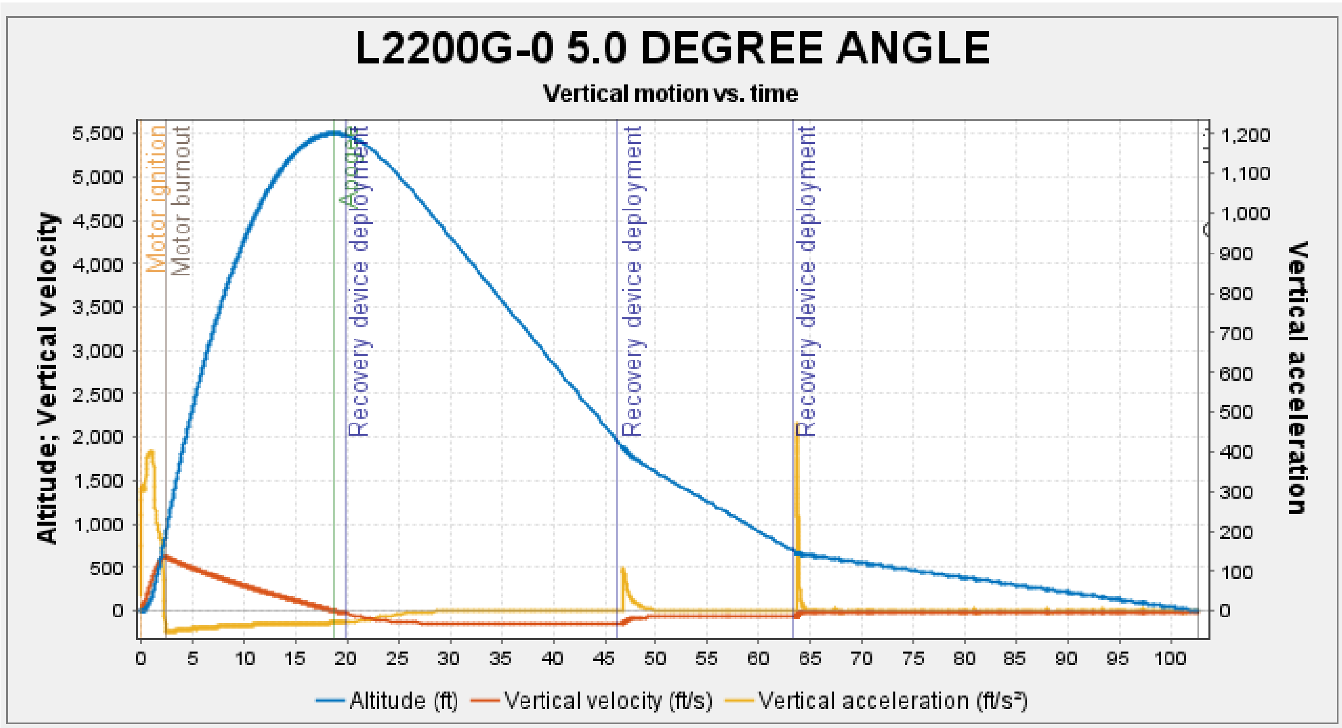
The L1420R-P motor is our primary choice with an impulse of 4,616 Ns. The Terra Nova Project's projected apogee is 4,504ft, meeting the required apogee range of 4,000ft-6,000ft. One of our primary goals is to hit ground from apogee in under 80s. A lower predicted altitude helps limit the time to ground, while allowing room for error without risking an apogee below the minimum.

Using this motor, the Terra Nova has a stability margin of 2.5 cal, which is above the NASA required minimum of 2.0 cal. It meets the NASA required 52 fps velocity off the rod with 60.3fps off a 12 ft 1515 rail. The predicted time to apogee of 17.8s and a total flight time of 94.4s achieves our goal with a margin of 3.4s for a sub 80s flight time.

The predicted peak acceleration due to parachute deployment is roughly 470 ft/s^2 and deployment velocity for our main parachute of 67.4 fps are both manageable. Using this data, we can verify that the deployment hardware concepts are capable of handling these loads. The thrust to weight ratio for this rocket design and motor combination is 6.09:1.0. This exceeds the minimum specified thrust to weight ratio of 4.0:1.0. This motor fits the 75/5120 RMS system already in our possession from previous years. The motor is currently in stock at our preferred retail site, Chris's Rocketry.

Predicted Performance for Secondary Motor Choice (L2200G-0)

Figure 4-9 **L2200G-0 Simulation Data** (generated by OpenRocket)



The L2200G-0 motor is our secondary choice with an impulse of 5,104 Ns. The projected apogee with this motor is 5,496ft, meeting the required apogee range of 4,000ft-6,000ft. While this secondary choice gives a significantly higher apogee, it increases the total flight time to 103s, which is why this motor is not our first choice.

The stability margin of this concept is very similar to the first at 2.48, which is a negligible difference and within our stability requirements. This concept meets the NASA requirement of velocity off the rail at 81.7 fps.

With a time to apogee of 18.7s, this simulated design would exceed our goal of 80s from apogee to ground by 4.3s; however, this motor allows a different margin if the weight of our fully constructed rocket is significantly more than our current estimate. The thrust to weight ratio for this rocket is 9.35:1.0 which is also well above the required minimum of 4.0:1.0. This motor fits the 75/5120 RMS system already in our possession from previous years. The motor is currently in stock at our preferred retail site, Chris's Rocketry.

4.4 Recovery System Concept

Dual Separation Hardware & Procedure

To achieve our goal of apogee to ground in less than 80s, we will need to design and implement a unique recovery system. This system involves an initial drogue parachute (20in) deployed 1 second after apogee, followed by a second drogue (30in) between 2500-1500 ft, and finally the main (108in) between 900-700 ft. With a single drogue setup, this would lead to a high velocity descent from apogee that would result in an aggressive main parachute deployment. The tensile force created in the shock cord could pose a threat to the structure of the rocket and the main parachute. Implementation of a second, larger drogue before the opening of the main to slow down the rocket enough to decrease the load created by the main parachute.

Shock Cord Design

Due to the high forces expected during deployment, a strong shock cord is needed to prevent the line from being severed. With Kevlar's high strength properties, it's able to withstand any force we expect it to be subject to during recovery; however, with an increase in strength comes added rigidity. If not addressed, the brunt of force experience will be transferred into the body of the rocket. To solve this potential issue, we plan to use several short sections of strong elastic cord that will stretch to dissipate energy along its length. We propose to have the elastic attached at two points along the Kevlar line for each section, giving slack to the Kevlar over all elastic section. This will allow the elastic to stretch, but prevent it from overstretching, and pass the force into the next elastic section. This will, in effect, dissipate some of the overall energy over time through the stretching of the cord.

Method for Deploying two Parachutes from one Separation

The first separation will occur at apogee, releasing our primary drogue; however, the second separation will release the pilot drogue, followed by the main parachute. To achieve this seamlessly, we need to deploy the pilot and main chutes at separate predetermined altitudes to successfully open both chutes with the goal of mitigating peak force. The pilot chute will be deployed first via the "riser" section of the cord. The use of a tender descender will restrict the rest of the cord from deploying until after the predetermined altitude. The tender descender will be attached to the pilot riser in front of the bag, containing the main chute and the remaining packed cord. The tender descender will be held in place by physical limits on the shock cord. After the predetermined altitude, black powder charges in the tender descender will detonate and separate allowing the pilot chute to pull out the rest of the packed parachute cord and the main parachute along with it.

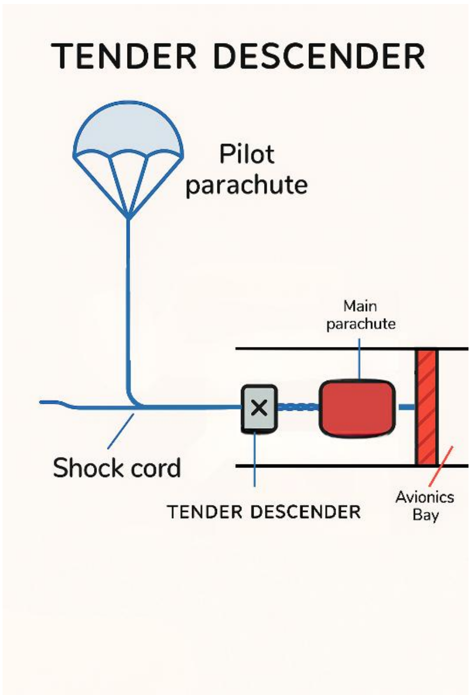


Figure 4-1010 **Tender Descender**

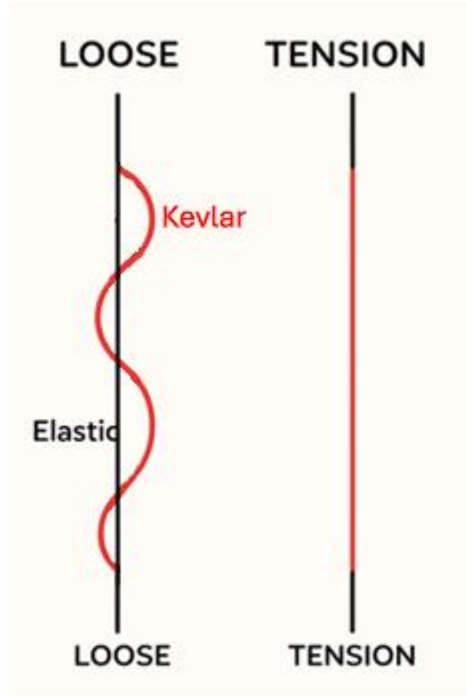


Figure 4-1111 **Kevlar & Elastic Shock Cord**

Avionics Bay

The Avionics Bay electronics will consist of two flight computers, each powered by its own lithium battery. The flight computers will be programmed to control the three separate events contributing to the recovery system. The timing of these events will be based off the data provided by the altimeter and the accelerometer. The first event (the initial drogue parachute) will occur one second after apogee, with the second and third events occurring at separate altitudes. The flight computer will initiate each event with a surge of current to an e-match. A 9 Volt lithium battery will be a low enough voltage to power the flight computer but high enough to provide enough current to ignite the e-matches. Each e-match will be wired into each circuit separately for redundancy in the case that one flight computer is unable to initiate an event.

4.5 HAUS Payload Concept

Payload Objectives

Our payload, the Terra Inquisitor (Earth Inspector), will initiate its autonomous soil testing protocol after landing without being ejected into the air as an unmanned aircraft system (UAS). The HAUS design is a rover like vehicle. Once autonomously deployed, the HAUS will obtain a soil sample and test the soil for bulk electrical conductivity, pH, and provide time stamps for all the tests. This protocol of the deployment and soil testing will be completed in less than 15 minutes after landing. The HAUS will save this data in its own memory banks.

Payload Separation

Our method of deployment is a rail and gear rack mechanism will "uncouple" the section above the transitional airframe from the nose cone after landing. During flight, this system will be locked in place using a solenoid to ensure the rocket cannot separate during any stage of the flight or descent of the rocket. After landing, the solenoid will be activated to unlock the rail mechanism. The rocket will then separate using the rail and gear rack mechanism on the inside of Body Tube 1 and the coupler connecting Body Tube 1 and the transition airframe. The coupler will be fixed to the transitional airframe. The separation mechanism will be attached to both the coupler and Body tube 1 and an outer rail guide will be attached to the coupler. The gear rack will be inserted through the outer rail and attached to Body Tube 1. The system will then be able to separate Body Tube 1 from the coupler by turning a worm or spur gear in contact with the gear rack moving the geared rack forward and Body Tube 1 relative to the coupler. The worm or spur gear would be powered by a stepper motor. A stepper motor is the current selection due to its high output torque at low rpm. This mechanism would be duplicated to provide a mirrored mechanism on both sides of the interior of the rocket airframe. The geared rack would have a hole drilled into it for the solenoid armature to lock the rack from moving during flight.

Payload Propulsion and Structure Design

The Terra Inquisitor will be designed like a tank. For propulsion, it will use a dual track system powered by stepper motors. The track system enables the Terra Inquisitor to handle the variety of terrain it must traverse and provides reliable direction control with the ability of speed variation between tracks to turn the tank. Stepper motors are the current propulsion selection due to their high input torque and accurate motion capabilities. Its frame will primarily be made from 3D printed PETG. This filament has many advantages due to its temperature resistance, toughness, durability, and impact resistance (7). The impact resistance is especially important for our application. This will ensure that the Terra Inquisitor is able to withstand the forces of flight and recovery. Additionally, PETG also has many 3D printing advantages of layer adhesion, warp resistance, and reduced shrinkage (7). It is readily available and has proven to be reliable when used in the Carbon X-1 printers available to us. With regards to safety, PETG is non-toxic and environmentally friendly (8).

This preliminary design for the Terra Inquisitor is estimated to require a housing area of around 12 inches in length and 5 inches in width.

Payload Soil Collection and Testing Concept

Our current concept for obtaining the soil is using a dual Archimedes screw powered by a stepper motor. The stepper motor a first choice due to its high torque at low speeds. The Archimedes Screw is commonly used for transporting materials and has been used many times to drill and collect samples on lunar missions (9). Most of the screw will be contained in an outer shroud. This allows for the transport of soil samples into the containment section of the HAUS before being tested. The Terra Inquisitor will be equipped with sensors to measure bulk conductivity and, as redundancy, pH of the soil. We will collect a soil sample size of 60mL for some redundancy in case any damage was sustained by the system from its flight.

4.6 Anticipated Technical Challenges & Mitigation

Recovery

Our recovery system poses many significant challenges. With our goal of reaching ground from apogee within 80s, we will face high deployment velocities and powerful forces on the cord/body of the rocket. Should our recovery system fail, the rocket will be falling with high kinetic energy and pose a danger to persons on the ground. To mitigate this risk, a custom-made Kevlar/elastic shock cord will be implemented to mitigate the energy transmitted through the cord to the body. The custom shock cord will be attached to Inconel bulkheads providing a strong base to attach the separated bodies and the parachutes together. Additionally, a unique recovery method will be used to mitigate the peak force experienced by all bodies at any point during flight. This section of the design proposes the most risk and will require the closest attention to detail regarding safety. We will account for any forces experienced during recovery, and that the design is fully capable of handling the worst-case scenario. To choose the type and length of cord, damping and stiffness parameters of these materials must be identified by applying the vibration equation to model the specific reaction of the elastic cord under load.

Structural

As previously stated, there will be a significant challenge to ensure that our unique recovery system does not exceed our determined safety factor and potentially damage the body of the rocket during recovery. Another main challenge we will face is the design and fabrication of our transition section. This component is not commercially available and will need to be custom made. It poses a significant manufacturing challenge for both the full-scale and subscale, as well as creating a discontinuity on the body of the rocket, and thus a structural weak point. To mitigate this issue, an outlined plan for fabricating the transition airframe (for both the full-scale and subscale) is described in section 4.2.4 Construction.

Propulsion

While propulsion data is frequently simulated in OpenRocket, it is one of the most varying parameters of our simulation data. Our simulations are consistent with one another, but wind conditions, pressure conditions, and the angle of the launch causes variance in these simulations. It is critical that we account for all possible conditions throughout our design process, as well as using our own hand calculations for verifying accurate flight predictions of accent and decent. It is imperative to constantly account for changes in weight of the rocket's internals as it will directly affect the apogee and flight times.

Payload Mechatronics

There are several risks involving the electromechanical systems within the payload. The first event with inherent risk is the payload separation. Including mechanical locking and end of travel sensors will help ensure there are no early separations before the vehicle has landed. In the case of separation failure, including separation hardware on either side of the rocket will mitigate the risk of the payload failing to detach. One rail on its own will be able to separate the payload in the case the other side is unable to do so. We must also ensure all electronics are well mounted within the rocket so vibration during flight will not dislodge them. This can be accomplished by using an energy absorbing mounting structure, extensive vibration testing, and preforming test drops in the worst-case landing orientation. The payload will include many different sensors which introduce the risk of noisy sensor readings or sensor failure. We will include low pass filters within the sensor circuits to decrease the chances of this as well as on-board calibrations that can ensure consistent readings.

5. Project Plan

5.1 Project Timeline

Below is our timeline breaking down into weekly goals. Specific System Officers and their teams will work on specific tasks while also working on the Documentation Deliverables. We will be moving forward with our community engagement on Fridays and Weekends, depending on the availability of the schools in the area, hoping to visit K-12 schools at least once a month. We will also attend Tech days and Discovery days that are held on campus. As stated later the leadership team will meet weekly to ensure timeline compliance. The current scheduled time is Tuesdays at 9:30am but is due to change in the next semester as our class schedules change. Below is the timeline for the Terra Nova Project starting after the proposal is submitted.

Week 1: September 22–28, 2025

- Documentation:
    - Draft PDR deliverables (Report, Presentation Slides, Flysheet)
    - Project Lead creates outline for PDR and transfers information from Proposal:
        - Facilities & Equipment.
        - Team Organization, mentor, safety plan.
        - Engagement Plan.
        - Preliminary vehicle/payload design.
    - Payload Design initialization through Pugh chart.
    - Subscale design finalized for PDR.
- Build/Fabrication:
    - None Scheduled.
- Testing/Verification:
    - Receive first round of Inconel 718 tensile test specimens.
    - Label, document, and define process for testing.
- Outreach/Administrative:
    - Schedule preliminary school visits for outreach

Week 2: September 29–October 5, 2025

- Documentation:
    - Insert Morphological charts and design iterations for full-scale rocket in PDR Report.
    - Enter Payload design and Pugh chart into PDR Report.
    - Begin preliminary hazard analysis and Failure Modes and Effects Analysis (FMEA)
    - Document recovery subsystem details (altimeter plan, parachute sizing calculations, wiring diagrams).
- Build/Fabrication:

  - None Scheduled.
- Testing/Verification:
  - None Scheduled.
- Outreach/Administrative:
  - Continue to Schedule visits.

Week 3: October 6–12, 2025
- Documentation:
  - Draft "Changes made since Proposal" section. (1-2 pages)
  - Complete mission performance predictions.
- Build/Fabrication:
  - None Scheduled.
- Testing/Verification:
  - None Scheduled.
- Outreach/Administrative:
  - 7th – Awarded proposals announced.
  - Begin funding outreach.
  - 9th – Kickoff and PDR Q&A.

Week 4: October 13–19, 2025
- Documentation:
  - Transfer draft content from Report into Presentation and Flysheet.
  - Make aesthetic edits and continue unfinished PDR sections.
- Build/Fabrication:
  - None scheduled.
- Testing/Verification:
  - None scheduled.
- Outreach/Administrative:
  - Based on school and community availability.

Week 5: October 20–26, 2025 (PDR Due Oct. 27)
- Documentation:
  - Final Revisions to PDR deliverables.
  - Submit PDR deliverables.
- Build/Fabrication:
  - None scheduled.
- Testing/Verification:
  - None scheduled.
- Outreach/Administrative:
  - 27th – PDR Deliverables due.

Week 6: October 27–November 2, 2025
- Documentation:

  - Project Lead outlines CDR structure.
  - Carry forward content from PDR:
    - Vehicle/Payload designs.
    - Risk, safety, hazard analysis, FMEA.
- Build/Fabrication:
  - None scheduled.
- Testing/Verification:
  - None scheduled.
- Outreach/Administrative:
  - Based on school and community availability.

Week 7: November 3–9, 2025

- Documentation:
  - Continue to finalize Vehicle Design details
- Build/Fabrication:
  - None scheduled.
- Testing/Verification:
  - None scheduled.
- Outreach/Administrative:
  - Based on school and community availability.

Week 8: November 10–16, 2025

- Documentation:
  - Draft redundant electronics layout and concept of operations.
  - Payload System Officer drafts verification/test plan.
  - Team Lead drafts "Changes since PDR" section.
  - Safety Officer expands hazard analysis.
- Build/Fabrication:
  - Begins bench prototyping Payload system.
- Testing/Verification:
  - Gather and itemize avionics bay materials.
- Outreach/Administrative:
  - Based on school and community availability.

Week 9: November 17–23, 2025

- Documentation:
  - Implement CAD drawings into CDR draft.
  - Draft recovery system diagram.
- Build/Fabrication:
  - Continue Payload prototyping.
- Testing/Verification:
  - None scheduled.

- Outreach/Administrative:
  - Based on school and community availability.

Week 10: November 24–30, 2025 (Gateway Registration Due Nov. 28, Thanksgiving Week)

- Documentation:
  - Proofread current CDR draft.
  - Subsystem leads refine individual sections.
- Build/Fabrication:
  - Inventory received parts.
  - Continue Payload prototyping.
- Testing/Verification:
  - None scheduled.
- Outreach/Administrative:
  - 28th – Gateway registration due.

Week 11: December 1–7, 2025 (Finals Week, CDR Q&A Dec. 3)

- Documentation:
  - Light workload due to finals.
  - 3rd – Attend CDR Q&A session.
  - Incorporate NASA clarifications into CDR draft.
- Build/Fabrication:
  - None scheduled.
- Testing/Verification:
  - None scheduled.
- Outreach/Administrative:
  - Based on school and community availability.

Week 12: December 8–14, 2025 (Subscale Launch Window, Launch Dec. 13)

- Documentation:
  - Add placeholders for Subscale Flight Results in CDR.
- Build/Fabrication:
  - Finalize subscale build.
  - Integrate avionics.
  - Prepare and integrate recovery system.
- Testing/Verification:
  - 13th – Subscale Launch
    - Launching L1 certification flights for RAM as described in Section 5.7.
- Outreach/Administrative:
  - Based on school and community availability.

Week 13: December 15–21, 2025

- Documentation:
  - Begin drafting Subscale Flight Results (apogee, graphs, error analysis).

  - Document Payload lessons.
  - Update recovery section (parachute protection, redundancy).
  - Compile CDR draft into near-final format.
- Build/Fabrication:
  - Begin Full Scale preparation.
  - Payload: start redesigning prototype based on lessons learned
    - Using PCB design & Multisim
- Testing/Verification:
  - None scheduled
- Outreach/Administrative:
  - Based on school and community availability.

Week 14: December 22–28, 2025 (Christmas Week)

- Documentation:
  - Add "Changes made since PDR" following Subscale launch results.
  - Subsystem leads polish writeups during holiday downtime.
- Build/Fabrication:
  - Payload: Finalize technical Design.
- Testing/Verification:
  - None Scheduled.
- Outreach/Administrative:
  - Based on school and community availability.

Week 15: December 29, 2025–January 4, 2026 (New Year's Week)

- Documentation:
  - Final integration of subsystem sections into CDR.
  - Proofread and format draft.
  - Team checks compliance against NASA requirements.
- Build/Fabrication:
  - Recovery: send bulkheads designs for fabrication.
  - Airframe: send Boat-tail design for fabrication.
- Testing/Verification:
  - None scheduled.
- Outreach/Administrative:
  - Based on school and community availability.

Week 16: January 5–11, 2026 (CDR Due Jan. 7)

- Documentation:
  - Submit CDR deliverables (report, slides, flysheet).
  - Conduct Internal debrief.
  - Project Lead outlines FRR structure.
- Build/Fabrication:

  - Airframe: motor mount/fin can assembly.
- Testing/Verification:
  - Payload: Begin fabrication of final version.
  - Airframe: Begin constructing transition airframe.
- Outreach/Administrative:
  - Based on school and community availability.

Week 17: January 12–18, 2026

- Documentation:
  - Draft FRR skeleton.
  - Subsystem leads begin writing integration descriptions.
  - Payload drafts verification steps for flight.
- Build/Fabrication:
  - Airframe: finish motor mount/fin can assembly.
  - Recovery: finish wiring.
  - Payload: bench system test (if PCB ready).
- Testing/Verification:
  - Continue Payload testing.
- Outreach/Administrative:
  - Based on school and community availability.

Week 18: January 19–25, 2026

- Documentation:
  - Draft “Changes since CDR” section.
  - Vehicle updates CAD drawings with as-built measurements.
  - Recovery and avionics sections updated with ground-test procedures.
  - Payload finalizes operational description.
- Build/Fabrication:
  - Airframe: finalize coupler bulkheads, integrate payload bay.
  - Recovery: conduct first ground ejection test.
  - Avionics: perform manual In-Circuit Testing (ICT) for voltage outputs.
- Testing/Verification:
  - Continue Payload testing.
- Outreach/Administrative:
  - Based on school and community availability.

Week 19: January 26–February 1, 2026

- Documentation:
  - Integrate subsystem updates into FRR draft.
  - Input recovery document redundancy plan.
  - Payload drafts data collection and soil analysis methodology.
  - Team begins launch checklists.

- Build/Fabrication:
  - Payload: vibration testing and manual ICT.
  - Recovery: second ejection test with dual deployment.
  - Airframe: sanding, rail guide mounting.
- Testing/Verification:
  - Continue Payload and Recovery testing.
- Outreach/Administrative:
  - Based on school and community availability.

Week 20: February 2–8, 2026

- Documentation:
  - Update hazard analysis with test data.
  - Vehicle documents structural verification and material justification.
  - Avionics drafts wiring diagrams and battery calculations.
  - Draft final launch procedures.
- Build/Fabrication:
  - Complete full integration (final build).
  - Parachute packing and electrical system checks.
- Testing/Verification:
  - Continue Payload and Recovery testing.
- Outreach/Administrative:
  - Based on school and community availability.

Week 21: February 9–15, 2026 (Team Photos Due Feb. 9, FRR Q&A Feb. 11)

- Documentation:
  - Submit team photos.
  - Attend FRR Q&A (11th).
  - Compile subsystem content into FRR draft.
  - Subsystem leads update with integration test results.
- Build/Fabrication:
  - Conduct final checks.
  - Buffer for catch-up tasks.
- Testing/Verification:
  - Continue Payload testing.
- Outreach/Administrative:
  - Based on school and community availability.

Week 22: February 16–22, 2026 (Full-Scale Flight Test Feb. 21)

- Documentation:
  - Draft Full-Scale Flight Results section.
  - Recovery lead’s write deployment sequence.
  - Payload leads draft demo results.
- Build/Fabrication:

  - Finalize full-scale assembly.
- Testing/Verification:
  - Feb. 21: Full-scale flight test + payload demo.
- Outreach/Administrative:
  - Community involvement in Full-scale launch.

Week 23: February 23–March 1, 2026 (Backup Flight Test Feb. 28)

- Documentation:
  - Insert Full-Scale Flight Results if flown Feb. 21st.
  - Finalize FRR with flight data.
  - Update launch checklists.
- Build/Fabrication:
  - Conduct disassembly and post-flight inspection.
- Testing/Verification:
  - Feb. 28: Full-scale flight test + payload demo (if delayed).
- Outreach/Administrative:
  - Community involvement in Full-scale launch (if delayed).

Week 24: March 2–8, 2026

- Documentation:
  - Proofread and format FRR.
  - Mentor reviews Safety section.
- Build/Fabrication:
  - Recovery: repack parachutes, inspect harness.
  - Payload: finalize soil test preparation.
  - Avionics: analyze flight logs.
- Testing/Verification:
  - Continue Payload testing (if needed)
- Outreach/Administrative:
  - Based on school and community availability.

Week 25: March 9–15, 2026 (FRR Due Mar. 9)

- Documentation:
  - Submit FRR deliverables.
  - Team debrief and checklist for FRR Addendum (if required).
- Build/Fabrication:
  - Begin final rebuild/reintegration based on NASA feedback.
- Testing/Verification:
  - Continue Payload/Recovery testing as needed.
- Outreach/Administrative:
  - Based on school and community availability.

Week 26: March 16–22, 2026 (Spring Break)

- Documentation:

  - Prepare FRR Addendum placeholders (if required).
  - Continue STEM engagement reporting.
- Build/Fabrication:
  - Touch-up work, repainting, reassembly.
  - Pack spare parachutes, e-matches, electronics.
- Testing/Verification:
  - As needed
- Outreach/Administrative:
  - Based on school and community availability.

Week 27: March 23–29, 2026

- Documentation:
  - Draft logistics section for Launch Week.
  - Update outreach report.
- Build/Fabrication:
  - Continue final rocket prep.
- Testing/Verification:
  - Re-test ejection system and payload.
- Outreach/Administrative:
  - Based on school and community availability

Week 28: March 30–April 5, 2026

- Documentation:
  - Draft logistics section for Launch week.
  - Update outreach report.
- Build/Fabrication:
  - Continue final rocket preparations.
- Testing/Verification:
  - As needed.
- Outreach/Administrative:
  - Based on school and community availability.

Week 29: April 6–12, 2026 (FRR Addendum Due if required)

- Documentation:
  - Submit FRR Addendum (if required).
- Build/Fabrication:
  - Continue final prep.
- Testing/Verification:
  - As needed.
- Outreach/Administrative:
  - Based on school and community availability.

Week 30: April 13–19, 2026 (Launch Week Q&A Apr. 15)

- Documentation:
  - Attend Launch Week Q&A (15th).
  - Final proofread of flight checklists.
  - Finalize travel prep documents.
- Build/Fabrication:
  - Conduct final readiness tests (ejection, continuity).
  - Pack rocket for travel.
- Testing/Verification:
  - As needed.
- Outreach/Administrative:
  - None scheduled.

Week 31: April 20–26, 2026 (Launch Week — Launch Apr. 25)

- Documentation:
  - None scheduled (focus on launch execution).
- Build/Fabrication:
  - Field tests and inspection in Huntsville.
- Testing/Verification:
  - 25th – Competition launch in Huntsville
- Outreach/Administrative:
  - 22nd – Teams arrive in Huntsville.
  - 23rd–24th – Launch Week events.

Week 32: April 27–May 3, 2026

- Documentation:
  - Draft PLAR outline.
  - Subsystems insert flight data, payload soil analysis, lessons learned.
- Build/Fabrication:
  - Conduct post-flight disassembly
- Testing/Verification:
  - Analyze final payload data and flight data.
- Outreach/Administrative:
  - None Scheduled.

Week 33: May 4–10, 2026 (PLAR Due)

- Documentation:
  - Proofread PLAR, finalize formatting.
  - Submit PLAR to NASA.
- Nothing else scheduled.

5.2 Budget and Financial Allocation

As required, attached is our preliminary budget. While most of the project systems are still being refined, we were able to approximate our costs given the current design and average market values for materials. While it will change with the refinement of the design, it should offer an accurate assessment of the costs. This is not a final budget, but a template of estimates given market values for items, while having more certain pricing for definite costs. Please review below.

Terra Nova Project Budget						
Item	**Description**	**Quantity**	**Price ea.**	**Total**	**Link**	**Ordered**
Full Scale Airframe and Motor						
Nose Cone	FNC6.0-FW-MT	1	$180.29	$180.29	(Click Here)	No
6in ID Body Tube	6" fiberglass airframe 60in	1	$140.36	$140.36	(Click Here)	No
5in ID Body Tube	5" fiberglass air-frame 30in	2	$129.67	$259.34	(Click Here)	No
Rocket Motor	RMS-75/5120 Reload Kit (1 Pack) - 12142P	2	$376.99	$753.98	(Click Here)	No
Couplers		1	$120.00	$120.00	(Estimates)	No
Motor Retainer		1	$60.00	$60.00	(Estimates)	No
Fin & Centering ring material (G10 shee	Fiberglass	2	$80.00	$160.00	(Estimates)	No
Adhesives	Epoxy fillers	1	$100.00	$100.00	(Estimates)	No
Paint / finishing supplies	Used for both rocket airframes	1	$150.00	$150.00	(Estimates)	No
Fasteners & hardware (bolts, screws)	Used for both rocket airframes	1	$75.00	$75.00	(Estimates)	No
Rail guides		1	$40.00	$40.00	(Estimates)	No
Sub-Scale Airframe and Motor						
Nose Cone		1	$55.00	$55.00	(Estimates)	No
4in ID Body Tube		1	$90.00	$90.00	(Estimates)	No
3in ID Body Tube		1	$90.00	$90.00	(Estimates)	No
Rocket Motor		1	$120.00	$120.00	(Estimates)	No
Couplers		1	$40.00	$40.00	(Estimates)	No
Motor Retainer		1	$70.00	$70.00	(Estimates)	No
Fin & Centering ring material (G10 sheets)		1	$60.00	$60.00	(Estimates)	No
Recovery Systems						
Kevlar Shock Cord		1	$80.00	$80.00	(Estimates)	No
Elastic Sections		1	$40.00	$40.00	(Estimates)	No
Tender descender		2	$160.00	$320.00	(Estimates)	No
Black Powder / E-matches		1	$60.00	$60.00	(Estimates)	No
C02 Canisters		2	$25.00	$50.00	(Estimates)	No
Flight Compuer		2	$150.00	$300.00	(Estimates)	No
Flight Compuer Redundancy		2	$75.00	$150.00	(Estimates)	No
Sub Scale Apogee Drouge		1	$50.00	$50.00	(Estimates)	No
Sub Scale Delayed Drouge		1	$75.00	$75.00	(Estimates)	No
Sub Scale Main Chute		1	$150.00	$150.00	(Estimates)	No
Full Scale Apogee Drouge	16" Low Power Parachute - 0.9lb @ 20fps	1	$50.32	$50.32	(Click Here)	No
Full Scale Delayed Drouge	30" Elliptical Parachute - 3.3lb at 20fps	1	$97.91	$97.91	(Click Here)	No
Full Scale Main Chute	108in. (9ft.) Rocketman High Performance CD 2.2 Parachute	1	$300.00	$300.00	(Click Here)	No
Battery packs		3	$25.00	$75.00	(Estimates)	No
Wiring, connectors, switches & small electronics	Electronic Sytems for Both Subscale and Full	1	$75.00	$75.00	(Estimates)	No
3D print Filiment		8	$25.00	$200.00	(Estimates)	No

(Continuation of budget on following page)

Payload System						
Sensor modules		1	$200.00	$200.00	(Estimates)	No
PCB Building		1	$175.00	$175.00	(Estimates)	No
Microcontrollers & electronic componen	Anything extra we don't have in lab	1	$100.00	$100.00	(Estimates)	No
Prototyping parts	Anything extra we don't have in lab	1	$40.00	$40.00	(Estimates)	No
Soil Sampling Kit	To compare data to	1	$50.00	$50.00	(Estimates)	No
Transportation, Lodging, Community Outreach, & Misc.						
Campus Veihcle	Provided by Florida State University - Panama City	1	$0.00	$0.00	(Estimates)	No
Gas	Estamite For all Travel both community events and launches	1	$400.00	$400.00	(Estimates)	No
Lodging		1	$2,800.00	$2,800.00	(Estimates)	No
Shirts	Custom designs incorporationg University branding, team logo, and team sponsers	8	$25.00	$200.00	(Estimates)	No
Food		1	$600.00	$600.00	(Estimates)	No
Miscellaneous Supplies		1	$200.00	$200.00	(Estimates)	No

Fundraised			
Company	**Description**	**Given Funds**	**Contact**
		$0.00	
		$0.00	
		$0.00	
		$0.00	
		$0.00	
		$0.00	

NOTE: The variance is set to add 10% to help mitigate any unexpected price changes throughout the year.	Subtotal:	$9,402.20
	Variance:	$940.22
	Total:	$10,342.42
	Amount Spent:	$0.00
	Fundraised:	$0.00
	Remaining Funds:	$0.00

Table 5-1 **Temporary Budget**

5.3 Funding Plan

The Terra Nova Team has identified three primary funding sources to support our project: institutional backing from our university, partnerships with industry sponsors, and targeted fundraising initiatives.

University Support:

Florida State University – Panama City has committed to supporting our efforts through the Dean's office, providing $2,000-$3,000 in seed funding. This institutional investment establishes our foundation for essential materials and travel expenses.

Industry Partnerships:

We are collaborating with FSU-PC's Office of Advancement to develop strategic sponsorship relationships. Upon competition acceptance, we will engage local STEM organizations including Tech Farms, Booz Allen Hamilton, Maritech Machining Inc., and VSC Fire & Security. We will also expand our outreach through the Bay County Chamber of Commerce to include non-STEM businesses. Our sponsorship program offers tiered recognition opportunities, with company logos featured on team apparel using a grid system where $500 contributions secure individual placement squares and $1,500 contributions secure full row positioning (Example shown below). Additional benefits include social media recognition and acknowledgment at public STEM engagement events (Launches, Community Presentations, etc.).

Fundraising and Community Outreach: Our team will leverage Chamber of Commerce networking events, including First Friday gatherings, to expand our sponsorship base and build community connections. We are also exploring crowdfunding platforms to enable broader community participation in our mission.

Figure 5-22 **Team Apparel**

5.4 Risk Management Plan

Risks associated with project management include scheduling, technical, financial, and resource allocation challenges.

Schedule Management Risks

Risk Identification: When a project timeline is either too strict, preventing flexibility for unforeseen changes, or too ambiguous, failing to provide adequate direction for project completion, scheduling issues arise. Weather-related test date changes, technological issues necessitating more development time, team member availability conflicts, and facility access restrictions are examples of typical scheduling challenges.

Mitigation Strategies: Our schedule addresses these risks by:

- Including a buffer period in critical path tasks, especially around important deliverables.
- Among other things, fewer tasks during finals weeks and holidays when team availability is lower.

- To enable iterative improvements, recovery system testing will begin many weeks prior to launch windows.
- Keeping non-time restrictive tasks flexible while adhering to strict timeframes for NASA deliverables.
- Clearly defining task ownership and designating backup team members for important tasks.

Technical Risk Management

Risk identification: Delays in component delivery, manufacturing issues, system integration difficulties, or performance problems found during testing are examples of technical challenges. The construction of the transition airframe, the intricacy of the three-stage recovery system, and the autonomous payload deployment mechanism are specific challenges for our project.

Mitigation Strategies:

- By January 2026, the proof-of-concept payload system will be finished allowing us to avoid issues with the finalized payload system.
- Thorough ground testing procedures begin weeks prior to flight tests.
- Partnerships with Maritech Machining and on-campus facilities offer redundancy in manufacturing.

Budget and Resource Risks

Risk identification: Increases in component prices, design modifications that call for more materials, or unforeseen testing or fabrication expenses can all lead to cost overruns. The scope or timeline of a project may be affected by resource constraints.

Mitigation Strategies:

- The overall project budget includes a 10% variance.
- To lessen reliance on a single source of funding, we are acquiring several sources, including industrial sponsors, universities, and fundraising.
- Early vendor communication and significant component pricing confirmation.
- Including in our designs a clear understanding of how it will be fabricated to ensure ease of fabrication.
- The project lead conducts reviews and routine budget monitoring.

Team and Resource Management Risks

Risk Identification: Team member availability, facility access conflicts, equipment failures, or key personnel changes could disrupt projected timeline.

Mitigation Strategies:

- To avoid single points of failure, team members should receive cross-training on essential systems.
- We have redundancy in our facilities, so in the case of access conflicts we have other facilities to complete project.
- Clearly defined documentation procedures to facilitate knowledge transfer in the event of team structure changes.

Risk Monitoring and Response

Weekly risk assessments are carried out by the project lead. Updates on risk status are discussed during team meetings, and mitigation plans are modified in response to project developments and new difficulties.

5.5 Team Management & Documentation Process

5.5.1 Communication Methods

Our team employs a modular structure, with each subsystem managed by a designated System Officer. Communication within each subsystem is coordinated by the respective System Officer. For overarching team coordination, we utilize Microsoft Teams, facilitating seamless communication across all team members.

The Leadership Team convenes weekly, chaired by the Project Lead. The Project Lead is responsible for creating the meeting agenda, recording meeting minutes, and uploading them to our SharePoint site. These minutes are subsequently shared with our mentors and faculty educators to ensure transparency.

5.5.2 Documentation storage/version control

As can be seen in the accompanying diagram, the SharePoint that we made for our team is organized in a thorough manner in which all the information is easily accessible. In addition to being visually appealing, the home page lists all our planned events, meetings, and community service activities. Along with important contacts, such as the NASA Points of Contact (POC) and the Team Officers, mentors, and faculty educators. It also features a countdown to the next delivery deadline. Included on the page are sub-pages: “Documentation and Deliverables”, “Airframe and Propulsion”, “Recovery System”, “Payload”, and “Resources and References”, with each sub-page describing what information should be uploaded. This methodology is used to organize information and documentation as needed. The home page also includes a planner where specific tasks are delegated, and progress measured. We will also incorporate a Gannt chart to ensure we are on schedule. We also have a template for any CAD drawings, documentation, meeting agendas, etc. to have clear uniformity in all projects and design so that information is easily transferred.

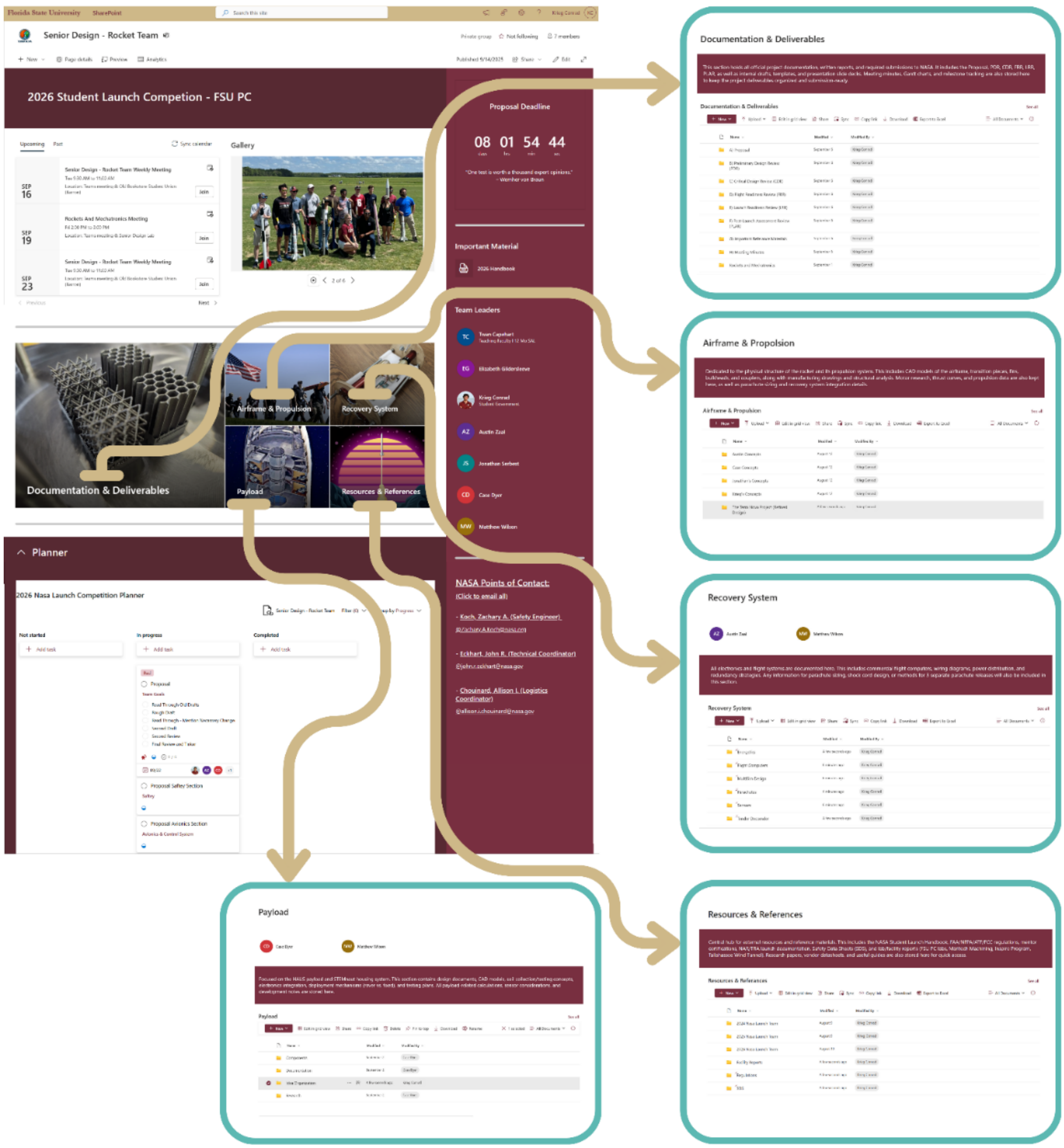


Figure 5-33 **SharePoint for Documentation Control**

5.6 Community STEM Engagement Plan

5.6.1 Outreach Locations

The Terra Nova Team will be engaging with schools and community groups across Bay and Walton Counties, reaching students from elementary through high school. Confirmed and target partners include:

North Bay Haven Charter Academy (K–12), Arnold High School , A. Crawford Mosley High School, Dune Lakes Elementary School, Surfside Middle School, The Collegiate School at FSU-PC, Blue Angels STEAM Event (Pensacola, November 2025) - regional showcase coordinated with NAS and FSU InSPIRE, FSU-PC Discovery Days & Tech Days - on-campus STEM events designed specifically for K-12 students and families

5.6.2 Planned Activities

The team will provide age-appropriate, safe, and interactive activities designed to inspire future explorers

1. Water Bottle Rockets – students design and launch pressurized water rockets to learn about stability and thrust.
2. Paper/Straw Rockets – simplified design and launch activity for elementary students.
3. Rocketry Demonstrations – hands on showcases of avionics bays, recovery systems, and payload elements.
4. Team Launch Dates – Community involvement in launch days, sending invites to launch days.
5. STEM Workshops – targeted lessons on rocketry fundamentals for high school groups.
6. On-Campus Experiences – during Discovery Days and Tech Days, visiting K–12 students will participate in guided rocket demos and interactive displays hosted by the Terra Nova team.

Target Impact: At least 200+ K–12 students reached across 5–7 schools and community events

5.6.3 Safety

Our Safety Officer will give a safety briefing before each activity starts. All launches, demonstrations, and workshops will be overseen by team members and supporting faculty to guarantee safe distances and appropriate material handling throughout operations.

5.6.4 Documentation & Reporting

The team will track engagement through:

- Student participation counts
- Photos and video (with school permission)
- Short feedback surveys from students/teachers
- Summaries included in each milestone report

5.7 Future Plans for Sustainability

In addition to K–12 STEM engagement, the Terra Nova team will host workshops through RAM for FSU-PC and Gulf Coast State College students. These internal sessions build long-term capacity on campus.

Starting Sept. 26th, we will begin our first project. This will be our “Rover Competition” which will last till midterms. We will lead the club in workshops in Arduino, CAD, Breadboarding, & even PCB Design. Following Midterms we will begin our second project. We will run workshops in model rocketry and cover the cost for the participating members level 1 rockets. We hope to launch them during our subscale launch date to help them receive their Level 1 rocketry certifications. We hope to lead more workshops and projects in the spring pending member input.

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NASA USLI Team Safety Compliance Agreement

Team Name: ____________________________

University: ____________________________

Project Name: ____________________________

Compliance with RSO Authority, NAR Safety Code, and Mentor Oversight

All team members understand the safety expectations and regulations required by NASA, the NAR/TRA Safety Codes, and the team mentor.

- An on-site Range Safety Officer (RSO) will conduct an inspection of the vehicle prior to flight and holds the authority to veto launch in the event of non-compliance.

- The team mentor is responsible for the overall safety of the team throughout launch day. This includes preliminary inspection of the rocket to ensure compliance with amateur rocketry design requirements and applicable safety codes, as well as supervising team safety during launch and recovery operations.

- All team members agree to follow the instructions of the Safety Officer, Mentor, and RSO at all times.

- All team members affirm that they have attended a Safety Briefing and understand the requirements and procedures for safe participation in the USLI project.

Acknowledgment & Agreement

By signing below, I acknowledge that I:

1. Have read and understand the team’s safety plan.

2. Will comply with the NAR/TRA Safety Codes, NASA USLI Handbook, mentor oversight, and RSO authority.

3. Accept that failure to comply with these rules may result in removal from project activities.

Name (Print)	Signature	Date of briefing	Date of Signature

Mentor Verification:

I, the undersigned NAR/TRA certified mentor, verify that the above-listed students have completed the required safety briefing and have acknowledged compliance with all applicable safety codes and regulations.

Mentor Name (Print): ____________________________

Mentor Signature: ____________________________

Date: ____________________________