Level 2 Certification

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1 Introduction

The Level 2 certification project undertaken through the Tripoli Rocketry Association challenges the rocketeer to design, build, fly, and safely recover a high-power rocket whose total impulse lies between 640.01 N·s and 5 120.00 N·s (equivalent to rocket motor classes J through L). This report details the conception, construction, and flight verification of my Level 2 certification vehicle. The primary objective is twofold: first, to demonstrate a comprehensive understanding of high-power rocketry principles—ranging from structural design and stability analysis to recovery-system deployment—and second, to satisfy all safety and regulatory requirements specified in the Tripoli Unified Safety Code (TUSC) and FAA Regulation FAR 101.25. By meeting the written-and-flight requirements defined by Tripoli's certification authorities, this project serves both as an educational culmination of my rocketry experience and as the formal proof of my capability to operate at this advanced level.

From the outset, the rocket's design followed Tripoli's recommended best practices. The airframe was laid out with sufficient structural margin to withstand the increased motor impulse, and stability computations were performed to ensure a positive margin across all phases of flight. Recovery separation and deployment sequences were carefully engineered: an 18-inch dual-deploy system was selected to minimize descent rate under a pilot chute and to provide a safe touchdown velocity under the main parachute. All hardware—body tubes, centering rings, bulkheads, shock cords, and attachment points—was specified per industry-accepted materials and bonded using high-strength adhesives. Dimensional tolerances, materials traceability, and workmanship standards were maintained at each fabrication step to ensure consistency and reliability.

In parallel with the physical construction, critical procedural guidelines were followed to align with Tripoli certification procedures. Prior to any flight attempt, the motor (certified J–L) and its installation were inspected for proper casing condition, propellant grain integrity, and nozzle alignment. Predicted flight characteristics—including maximum expected altitude, range, and descent profile—were reviewed by the certifying authority to verify compliance with TUSC and FAR 101.25, as well as any site-specific considerations. The certification authority's oversight extended through preflight checks, in-flight observation, and post-flight recovery inspection. This systematic approach ensures that every aspect of vehicle performance and safety is accounted for before awarding Level 2 certification.

2 Air Frame

2.1 Forward Assembly

2.2 Aft Assembly

This section summarizes the components in the aft section of the subassembly process. All epoxied parts used 2-ton epoxy by XXX. The subassembly process began with the 38mm motor tube and the 4" to 38mm centering rings. To the forward centering ring, a hook for the shock cord was screwed to the forward side of the forward centering ring. Each centering ring was epoxied to the motor tube as shown in Figure 2.1

Figure 2.1: Caption

The next component that was prepared was the 4" body tube. From the 48" initial stock length, XX inches section was cut for the aft body tube. At the base, three X" by 0.125" fin slots were cut using a rotating saw. This process was pictured in Figures **??** and **??**.

The main shock cord was tied to the motor tube hook and the whole motor tube assembly was epoxied to the body with a 1" offset with the aft of the body tube and the motor tube. Next, the fins were epoxied in the fin slots, these were aligned to set such that the fins were parallel with the body tube axis and normal to the body tube at the root of the fin. This completes the assembly of the aft section of the rocket. The aft assembly can be seen in Figure 2.2 and 2.3

Figure 2.2: Caption

Figure 2.3: Caption

3 Avionics

The avionics of this project will utilize the hardware and software described in the Thrust Vector Control project [<**empty citation**>]. This is used to aquire flight data for that project. The output of the thrust vectoring will have no effect on the flight. A brief overview of the hardware and software is provided in this section.

3.1 Hardware

The following items are installed in the avionics bay:

- CPU: Teensi 4.1 from XXX used for real time data processing.
- Intertial Measurement Unit (IMU): The BNO055 IMU that can measure acceleration, quaternion orientation, angular velocity rocket
- Altimeter: Measures the altitude of the rocket.
- Apple Air Tag: Used to track the rocket after it has landed. One concern of the Air Tag is the limitation of accelerations at launch. No official acceleration limit is provided in the air tag specification. So it is unknown if the airtag will malfunciton during launch acclerations.
- Micro SD card: used for logging flight data
- Batteries: power the CPU

3.2 Software

The flight software is a state machine that controls the gimbal during ascent and ignites the ejection charges for the recovery system. Since there is no gimbal mount on the motor, this output will do nothing during flight but will be recorded on the Micro SD card for post flight data processing to help validate and improve the thrust vector control software. The ejection charges will be connected to the computer to deploy in the same manner as the thrust vector control project. This output will be both active and recorded on the Micro SD card. The software is programmed to deploy the drogue parachute at apogee and deploy the main parachute at 200 feet. For more details on the software in determining these states, please reference the thrust vector control report [<**empty citation**>].

4 Recovery

This project will utilize a dual deployment system, which deploys a drogue parachute at apogee and deploys the main parachute at an altitude of 800 ft. Tripoli requires the following for a recovery system:

Parachute recovery is required. Non-parachute recovery methods (e.g., tumble, helicopter, gliding, etc.) are not permitted for certification flights. If the rocket uses dual deployment, the first recovery event is not required to use a parachute. It may be either drogueless or streamer if the main event uses a parachute to decelerate the rocket to no more than the landing velocity allowed by the Tripoli Unified Safety Code.

4.1 Drogue Parachute

The drogue chute is placed in the section forward of the avionics bay. The sizing of the drogue parachute was determined from Apogee Rocket Newsletter 361, that suggests the following equation is used to determine the diameter of the drogue parachute,

$$D = \sqrt{\frac{4Ld}{\pi}} \tag{4.1}$$

where D is the diameter of the parachute, L is the length of the rocket, and d is the diameter of the rocket. For this design, that equates to a drogue parachute diameter of 18.5 inches. The off the shelf drogue parachute that was selected was the Explorer 18" Drogue Parachute from Valkyrie Recovery Systems.

The drogue parachute is tied to the middle of a 15 ft tubular Kevlar shock cord sourced from Madcow Rocketry. This shock cord is fixed at the ends to the forward bulk head of the avionics bay and a hook that is fixed in the nose cone.

The ejection charge is a capsule of black powder that is ignited by an electric match triggered by the avionics. This combustion of the black powder will separate the Forward Assembly from the Avionics Bay while pushing out the drogue chute at the same time. A 12" by 12" fire protective cloth is placed between the ejection charge and the parachute to ensure no holes are burnt through the drogue parachute on ejection.

4.2 Main Parachute

The main parachute is placed in the aft body tube. The 50" Nylon Chute from Madcow Rocketry was the diameter suggested on their website for a Descent weight of 5-9 lbs, so that is the main parachute that was chosen.

This parachute is tied to the middle of a 25 ft tubular Kevlar shock cord sourced from Madcow Rocketry. This shock cord is fixed at the ends to the aft bulkhead of the avionics bay and a hook fixed to the forward centering ring for the motor tube. The Main chute will utilize the same ejection method as the drogue parachute. A 12" by 12" fire protective cloth will also be connected to the shock cord to protect the main parachute from the ejection charge.

5 Cost

This section tracks the total cost of the project. In Table 5.1, each component is listed with its cost and procurement source. For avionics, the cost of the altimeter will be included as it is a necessary component for the Level 2 certification. However all avionic components that are included for the Thrust Vector Control will not be and the prices will be included in that report [**TVC_report**].

Table 5.1: Project Cost Breakdown

Component	**Cost (USD)**	**Procurement Source**
J192R (Motor)	$__	__
Nose Cone	$__	__
Altimeter	$__	__
Total	**$__**	

6 References