Spaceport America Cup

Authors: Kevin Bustamante, Austin Erickson, Sean Kimbrough, Caitlin Matthews, Joseph Phillips, Cameron Vail
in affiliation with the U of U Aerospace Club
Advisors: Dr. Jacob Hochhalter, Bill Hooper, and Kian Ben-Jacobs

THE UNIVERSITY OF UTAH
Department of Mechanical Engineering

Problem Statement

The goal for the Spaceport America Cup competition is to develop, manufacture, and launch a Level 3 rocket using a commercial off-the-shelf motor. The rocket must deliver an 8.8 pound payload, apogee at an altitude of 10,000 feet, successfully deploy the recovery system, and be easily retrieved using GPS.

Engineering Analysis

Nose Cone Analysis: An Ansys simulation calculated the coefficient of drag of different nose cone shapes. This rocket design is expected to reach a maximum speed of Mach 0.8. This requires a shape that performs just below sonic conditions. From the simulation, we determined that the Von Karman nose cone performs best at the flight conditions.

Fin Flutter Analysis: Fin flutter analysis determines the maximum velocity the rocket may travel at before the fins shear from the rocket body. The flight conditions were compared to different fin geometries to determine which fin shape resulted in a factor of safety of 1.5. We determined that a clipped delta fin design with 0.25 inch thickness will safely sustain the flight.

Ejection Analysis: Shear pins are used to hold the fore and aft sections of the rocket together during flight. A black powder charge is ignited at the apogee of flight to break the pins and launch the recovery system. Our analysis determined that we need 0.141 ounces (4 grams) for our primary ejection charge and 0.247 ounces (7 grams) for our secondary charge.

Recovery Analysis: The rocket must land at 16 feet per second or slower in order to avoid damaging any components. The main chute also cannot be deployed to early or the rocket could drift outside of the landing area. We determined that the main chute must be deployed at approximately 1,500 feet to meet both of these requirements.

Specifications Table and Materials

Metric	Value
Airframe Length	107 in
Airframe Diameter	6 in
Fin Span	6 in
Vehicle Weight	30.0 lbs
Motor Weight	16.8 lbs
Payload Weight	8.8 lbs
Total Weight	55.6 lbs
Black Powder Charge	0.141 oz

G12 Fiberglass Fuselage Body
Polycarbonate Payload Section
Carbon Fiber Fin Structure
Aluminum Alloy ASTM A666 304 Screws and Fasteners
AeroTech M1845 Motor
Steel Alloy Payload Structure

Aerostructure Systems

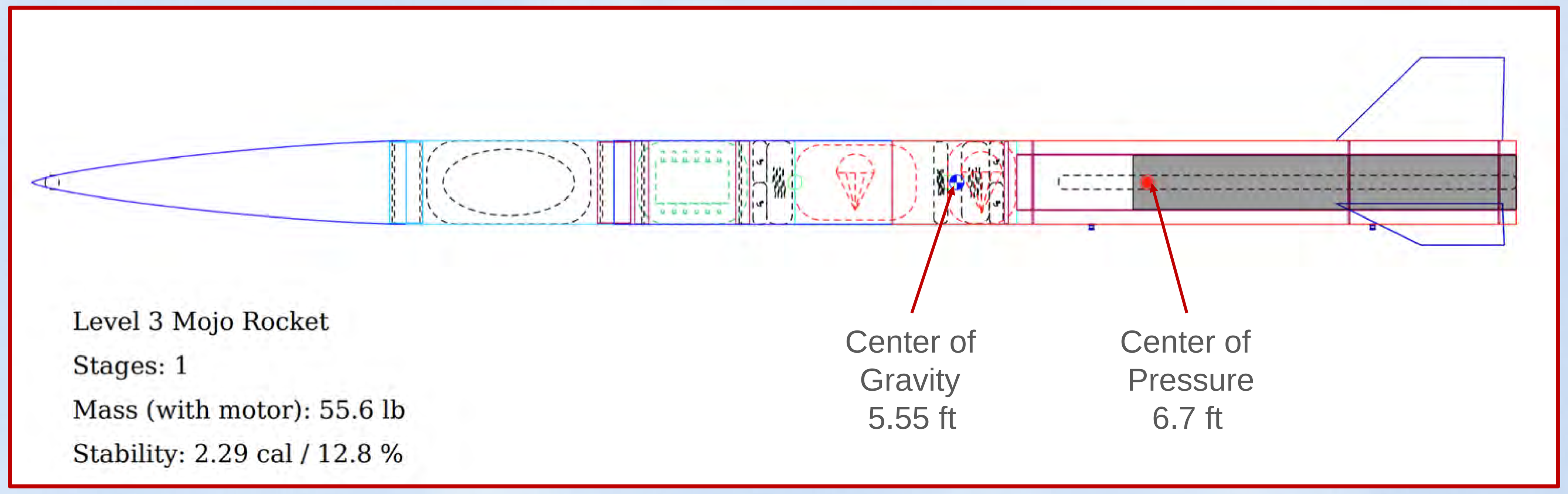
Payload System: 360° GoPro Max Camera with structural support.

Avionics System: Battery powered altimeter with GPS and parachute deployment device.

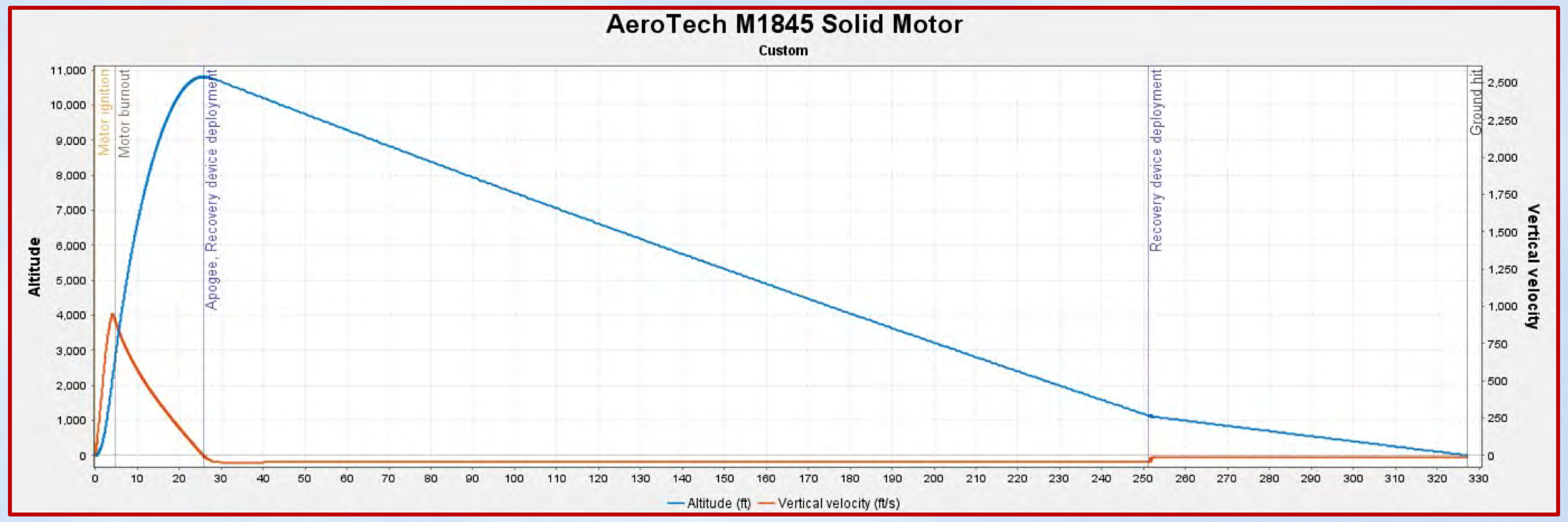
Recovery System: Single stage fishbone recovery method. Drogue chute is 48 inches. Main chute is 120 inches, deployed with secondary black powder charge.

Simulation Overview

Thrust to Weight Ratio: 7.6
Off Rod Velocity: 97 ft/s
Max Velocity: 958 ft/s
Max Acceleration: 315 ft/s²
Projected Apogee: 10812 ft
Main Chute Deployment: 1500 ft
Landing Speed: 14.5 ft/s



Schematic design of the level 3 rocket from OpenRocket. Center of pressure is denoted by ● and center of gravity is denoted by ◐. These metrics are used to determine the stability of the rocket during flight. A stability of 1-4 is ideal for the rocket to maintain its trajectory.



Flight simulations were conducted using OpenRocket software with the AeroTech M1845 motor, which has a burn time of 4.44 seconds. Two data plots were generated: Altitude (ft) and Vertical Velocity (ft/s).

Conclusion

Based on our analysis, we know that we can accomplish the Spaceport America Cup objectives. The rocket is predicted to exceed the target apogee which can be adjusted by adding additional weight to the rocket. The maiden launch will be on April 20th to verify the accuracy of the OpenRocket simulation. Using data from the launch, the final design can be modified to better fit the goals of the Spaceport America Cup.