L1 Write Up Example

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Part I
Introduction to the Project

1 Introduction

L1 rockets are a great way to learn about rocketry. This is why Maxx and I have decided to make this an introduction project. We realize that the upcoming information may seem somewhat intense and over your head. Please don't get discouraged from that, but rather immerse yourself in the experience. Aside from all the in-person help that we are planning to offer, we have put together this example to show you exactly what we expect in terms of understanding and depth.

This document will give you a full example of the expectation as well as some commentary explaining the reason for including something. The commentary will take place in blue. The actual report (similar to what is expected of you) will be done in black.

Part II
Write-Up

1 Macros

The macros of the rocket can be considered a summary of the rocket. Similar to the dieting analogy, it tells you the most important information about a rocket–its form, flight characteristics, and cost. Be sure to specify a reasonable reference point and stay consistent in using that reference. The following are all the expected macros which should be listed in your write-up.

The locations of Center of Gravity and Center of Pressure are referenced from the *bottom* of the rocket which is defined as the end of the aft tube. Apogee is measured relative to sea level.

- Length: 35.5 in.
- Diameter: 54 mm. Use *imperial* units when possible. Here we have used mm due to constraints on available sizing.
- Center of Gravity: 11.15 in.
- Center of Pressure: 8.51 in.
- Stability: 1.17 cal.
- Total Dry Mass: 0.803 lbs.
- Total Wet Mass: 1.25 lbs.
- Velocity off the rail: 88.2 mph.
- Maximum Velocity: 0.72 Mach
- Maximum Acceleration: 33.3 G.
- Apogee: 2545 ft.
- Total Cost: $215.00

2 Design

Here it is important to go deeper into your design and list all allocations as well as explain your design. One of Airframe's key responsibilities is to ensure that the needs of all the other subteams are met. For example, if the Payload subteam requires a space allocation of 24 $in.^3$ and 3 lbs., it is Airframe's job to see what is feasible and make decisions accordingly. Because we have this role, it is important that we support all of our decisions with hard data. For this reason, documenting everything is of the utmost importance.

In general, this section should consist of both a physical description of each component of your rocket as well as the reasoning behind any design choices you made. Aside from restrictions imposed by the criteria of the project, some things to consider may be cost, component availability, drag and aerodynamic considerations, weight, ease of manufacture, etc.

2.1 Electrical Components / Payload

For the sake of simplicity, no full payload will be flown. A PerfectFlite Pnut Altimeter from Apogee Rockets will be installed on a plywood mount ahead of the bulkhead in the forward tube. The device is roughly 2.4 in. long and 0.6 in. in diameter, weighing 0.016 lb. The altimeter will provide altitude and speed measurements of the flight.

The payload and electronics that go into your L1 rocket are entirely up to you. Items such as altimeters, cameras, GPS systems, accelerometers, and other devices can be included. However as stated before, the design of the rocket is often restricted by what it is carrying.

2.2 Nosecone

The nosecone is 9.5 in. long, has a base diameter of 2.26 in. and has a nearly 4:1 tangent ogive shape. It is made of a polypropylene plastic and was selected as it is a lightweight, low drag and low cost nosecone that fits in the forward tubing.

2.3 Forward Tube

The forward tube is 15 in. long and has an outer diameter of 2.26 in. with a thickness of 0.06 in. These dimensions were chosen to accommodate the parachute, shock cord, and altimeter. It is made of wound Kraft cardboard which is lightweight and inexpensive, though it does not have particularly high strength. This was a reasonable material choice given the small and lightweight nature of the rocket, where large accelerations will not result in very high internal forces.

2.4 Aft Tube

The aft tube is 10.5 in. in length and is made of the same tubing as the forward tube. This length was chosen primarily to house the motor as well as the rear shock cord. Three 3.125 in. by 3/16 in. slots will be cut into the aft tube to allow the fins to be properly seated.

2.5 Coupler

The only coupler in the design connect the forward and aft tubing, and is made of wound Kraft cardboard as well. It has an outer diameter of 2.138 in. and a thickness of 0.061 in. which allows it to snugly fit in both the forward and aft tubes. By convention, it has a length of 4.52 in. allowing at least the length of one body diameter to slide into both of the coupled tubes. This allows for sufficient strength and minimizes binding when the tubes separate.

2.6 Motor Tube

The motor tube is made of wound Kraft phenolic tubing for its heat resistant and load bearing properties. It has an outer diameter of 1.269 in. with a thickness of 0.062 in. and a length of 8.5 in. The dimensions are such that the motor assembly slides perfectly in and has a little over an inch of clearance at the top. The bottom of the motor tube is extended past the bottom of the rocket by 0.5 in. to allow for the motor retainer to be secured.

2.7 Bulkhead

The only bulkhead in the design is made from 1/8 in. plywood for its lightness, relative strength, and ease of manufacture. It is located 5 inches above the bottom of the forward tube or 15.5 in. from the bottom of the rocket. This allows space for the parachute and forward shock cord below the bulkhead, and creates a pressure seal for the separation charge. The altimeter will be mounted above the bulkhead.

2.8 Centering Rings

Three 1/8 in. plywood centering rings are used to attach and align the motor tube to the aft tubing. They are located 0 in., 4 in., and 8 in. above the base of the rocket.

2.9 Fins

Three fins are also cut from 1/8 in. plywood, and due to the overall light nature of the rocket, should be sufficiently strong. They were designed to be inexpensive and easy to manufacture while keeping the stability between 1.0 cal. and 1.5 cal. The leading and trailing edges will be left square for simplicity. Fin dimensions are as follows:

Root Chord: 3 in. - Tip Chord: 2 in. - Sweep Length: 1 in. - Height: 2.25 in. - Fin Tab Height: 0.495 in.

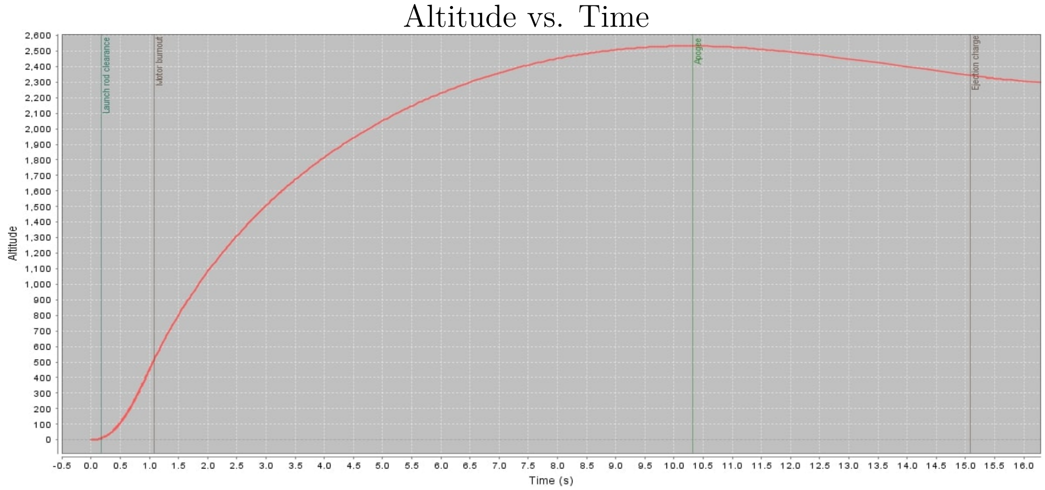
2.10 Motor

The current design uses an Aerotech H165R motor with a 14 second ejection charge delay. This was chosen because it has sufficient thrust to meet the requirements of this project, and is available for purchase by Apogee Rockets.

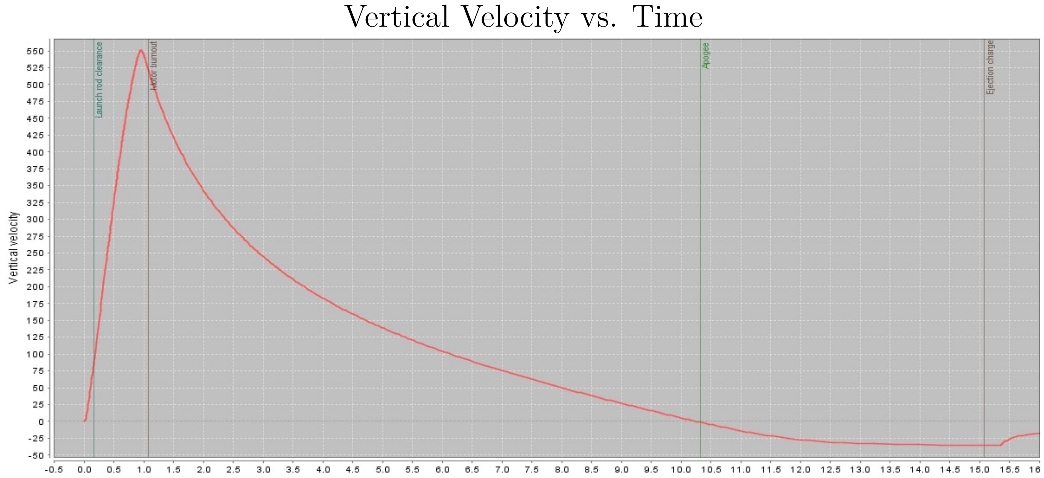
3 Simulation Data & Plots

This section should include any relevant plots describing the flight performance of your rocket. Shown below are several plots taken straight from OpenRocket which give the general characteristics of the flight. Many more plots are available in OpenRocket, and the data can also be exported and plotted using other software. Please explore the plotting options that OpenRocket has available, and ask if you need help creating any plot.

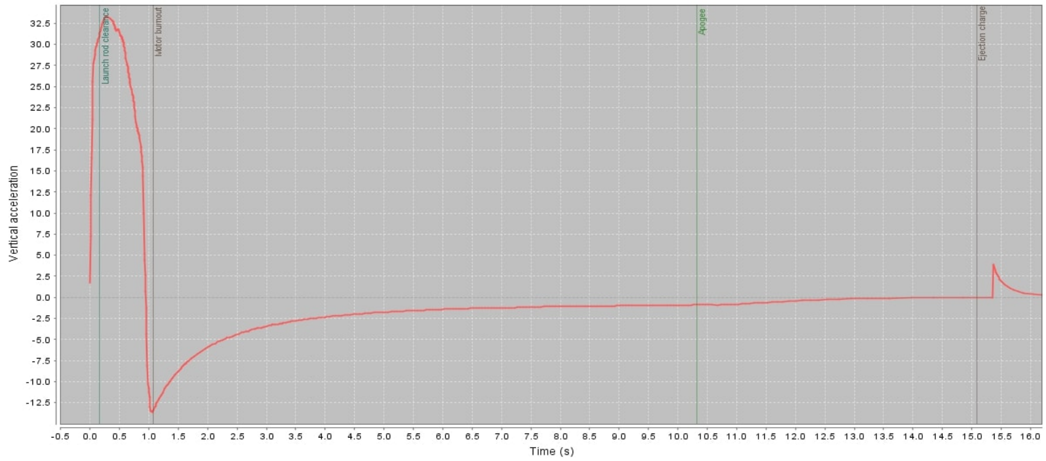
Altitude vs. Time



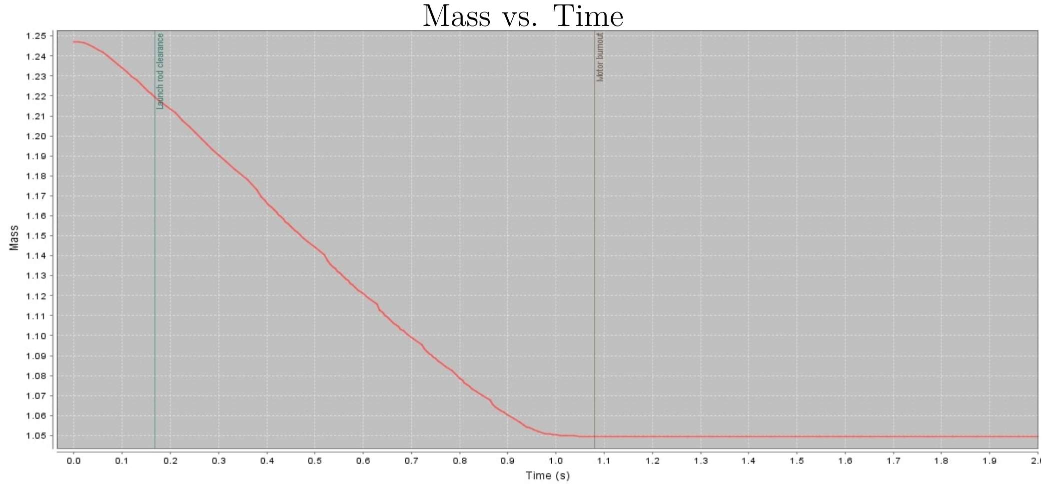
Vertical Velocity vs. Time



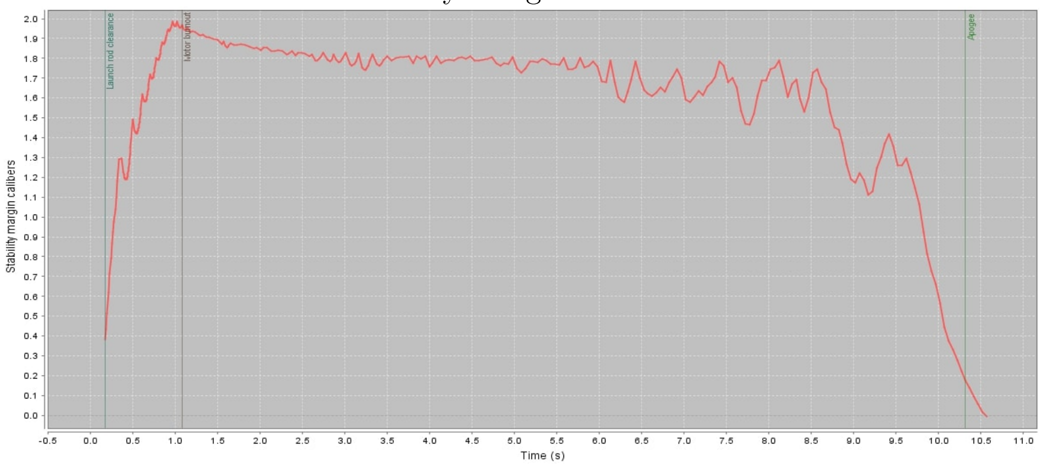
Acceleration vs. Time



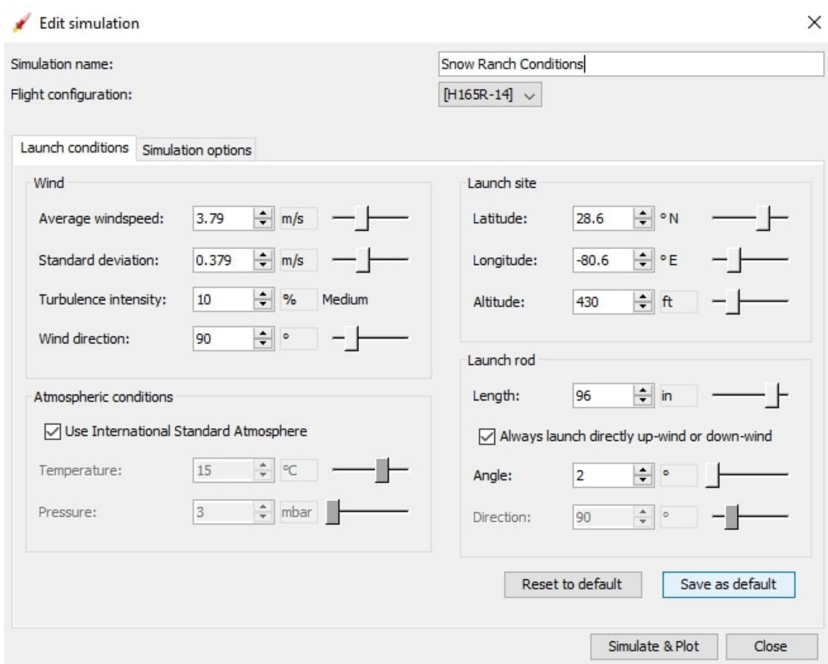
Mass vs. Time



Stability Margin vs. Time

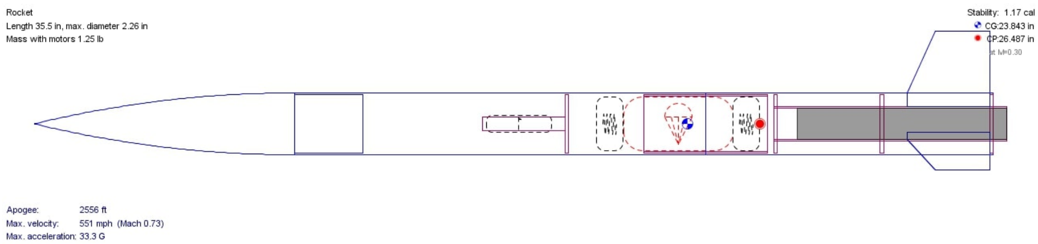


Simulations should be done under conditions similar to what will be available at the Snow Ranch launch site. The picture below shows the conditions you should be using for your simulations. Take note of the angle of the launch rail and the elevation of the launch site.



4 Rocket Visualizations

Please include at least one figure depicting your OpenRocket component design and one three-dimensional visualization, preferably from your Solidworks model.



5 Summary

The summary is a simple recap of the highlights of your design. It should serve as a way to quickly understand your overall design and provide some insight into the thought process behind your design choices.

This L1 certification rocket is designed to be sturdy, lightweight, and cheap. It is flying with an Aerotech H165R-14 motor and carrying a PerfectFlite Pnut Altimeter. The vehicle is simulated to reach an apogee of 2545 ft., hit 0.72 Mach, and pull 33.3 G's during flight. The rocket is 2.26 in. in diameter, 35.5 in. long, and is primarily constructed of wound Kraft cardboard tubes with 1/8 in. plywood used for the bulkhead, centering rings, and fins. These components and materials will be purchased from apogeerockets.com, publicmissiles.com, and amazon.com, along with a 9.5 in. polypropylene nosecone and an aluminum motor retainer. The total estimated cost of manufacture is $215.00. This vehicle should be able to achieve a safe and successful L1 certification flight at a relatively low cost.