Individual Analytical Analysis

Descent Rate and Drift Analysis

By:

AislinnJoy Gacayan

Active Rocket Controls

Team Number: F25toSp26_01

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1.0 Introduction

The Active Rocket Controls Capstone focuses on the design and development of a rocket with a control system that dynamically adjusts the orientation and stability. The control system will adjust the fins of the rocket in order to induce a roll about the z-axis. While attempting to achieve controlled flight, other factors such as safety and maintainability are important to the overall success. This is to include a safe landing and retrieval of all equipment.

In a previous report, the ejection charge and parachute sizing were calculated. This report will serve to calculate the descent rate and horizontal drift in order to further evaluate whether the parachute size will result in a safe recovery.

2.0 Assumptions and Variables

For this analysis, the following assumptions will be made:

- The parachute will be fully open upon being activated
- Wind speeds will remain constant
- The drag will remain constant
- Atmospheric density will remain constant

Additionally, the following variables will be used:

- Mass, m
- Acceleration due to gravity, g
- Density, ρ
- Height, h
- Drag Coefficient, C_d
- Area (parachute), A
- Descent Velocity, V_y
- Wind Speed, Vx
- Horizontal Drift, X
- Descent Time, t

3.0 Calculations

In order to solve for the descent velocity, the mass is multiplied by the acceleration due to gravity and 2. It is then divided by the density of air multiplied by the drag coefficient and area, and finally the square root is taken of the result. The descent velocity can be seen modeled by equation 1 below.

$$V_y = \sqrt{\frac{2mg}{\rho C_d A}} \tag{1}$$

Next, the total time for the descent can be found by dividing the vertical distance the rocket will travel by the descent velocity.

$$t = \frac{h}{V_y} \tag{2}$$

The horizontal drift distance due to the wind can be found by dividing the altitude by the descent rate and then multiplying it by the wind speed. The altitude divided by the descent rate is also equal to the total time, so the drift distance equation can be simplified to equation 3 below.

$$X = V_x * t \quad (3)$$

4.0 Results and Discussion

Descent Velocity

The following values will be used for the calculation of descent velocity:

- m = 1,254.85 g
- C_d = 0.75
- $g = 9.81\ m/s^2$
- ρ = 1051 g/m^3

Additionally, it will be calculated for both an area associated with a 0.37 m diameter and 1.9 m diameter to account for both cases of the previous report. The associated areas are 0.11 and 2.84 m^2 respectively.

Substituting these values into equation 1 results in a descent velocity of 16.85 m/s (55.1 ft/s) and 3.32 m/s (10.9 ft/s).

Descent Time

To calculate for the descent time, an altitude of h = 1219.2 m (4,000 ft) above ground level will be utilized. Using equation 2, the resulting total descent time for a descent velocity of 16.85 m/s is 72.36 s. For a descent velocity of 3.32 m/s, the total descent time is 367.23 s.

Horizontal Wind Drift

The Horizontal Drift will depend on the wind speed the day of the launch. The table below summarizes the results for different wind speeds.

Descent Time (s)	Wind Speed	Drift Distance
72.36	3 mph = 4.4 fps	318.384
72.36	5 mph = 7.33 fps	530.4
72.36	7 mph = 10.27 fps	743.14
72.36	9 mph = 13.2 fps	955.15
72.36	11 mph = 16.13 fps	1,167.17

Table 1: Drift Distance when $V_y = 16.85$ m/s

Descent Time (s)	Wind Speed	Drift Distance
367.23	3 mph = 4.4 fps	1,615.81
367.23	5 mph = 7.33 fps	2,691.80
367.23	7 mph = 10.27 fps	3,771.5
367.23	9 mph = 13.2 fps	4,847.45
367.23	11 mph = 16.13 fps	5,923.42

Table 2: Drift Distance when $V_y = 3.32\ m/s$

Discussion

The first area used resulted in a descent velocity that far exceeded the maximum as specified by Tripoli's safety regulations. In order to ensure that we comply with safety regulations, we will need to select a parachute sizing greater than the minimum calculated in the previous report. However, the other size selected drastically slowed the descent speed and time. If we want to still remain more conservative on sizing we can continue to calculate for different sizes that fall in between 0.37 and 1.9 m diameters to fit all the parameters required.

The results of the wind drift analysis showed that depending on the wind speeds on the day of the launch, the recovery distance increases significantly as wind speeds increase a few mph. These factors will need to be taken into account much closer to the actual launch date.

5.0 Conclusion

The results of this analysis will impact the project by giving more factors to consider for the parachute sizing required for our rocket. The previous minimum size found did not comply with safety standards when checking it with the analysis in this report, and therefore a larger size will be needed to ensure a safe descent speed that will comply with regulations while also ensuring that our equipment is maintained. Additionally, this analysis gave insight into how the weather conditions could possibly affect our flight. This can also be looked into further to ensure that any other weather conditions not considered will not affect the actual test portion of our launch.

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