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A5_10 Red Bull Gives You Wings?

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Abstract

Assuming that there is a mechanism to transfer Red Bull's nutritional energy into kinetic energy to propel a person in a wingsuit, we found that at maximum lift a standard can of Red Bull would propel someone for 808 m. Although, this is not a maximum possible distance.

Introduction

The energy drink, Red Bull, has the slogan 'Red Bull gives you wings'. In this paper we investigate the distance the energy from a standard 250 ml can of Red Bull could power us, given that we are mid-flight. We are aiming to calculate the distance of flight where we do not vary velocity or altitude. In this scenario we are wearing the wingsuit detailed in the 3D model of [1].

Theory

In order to guarantee that we continue flying, we have to ensure that we have enough lift force, F_L, given by the equation,

$$F_L = \frac{1}{2} C_L \rho v^2 A_{wp}, \tag{1}$$

where C_L is the lift coefficient, ρ is air density, v is velocity and A_{wp} is the area of the wingsuit projected in the direction of travel [2].

We can find the velocity for equation (1) by evaluating the energy needed for flight. In this case we want to keep flying at a constant velocity, therefore only needing enough energy, E, to overcome the drag force, F_D,

$$E = F_D x = \frac{1}{2} \rho v^2 C_D \sigma x, \tag{2}$$

where C_D is the coefficient of drag, σ is the cross-sectional area of the surface causing drag and x is the horizontal distance travelled.

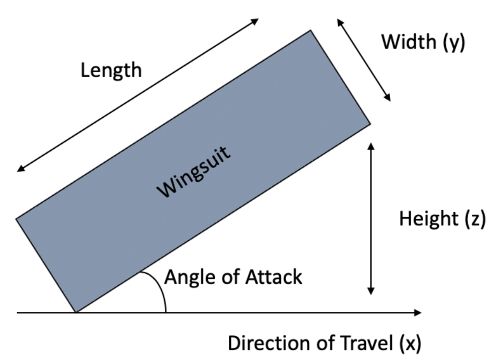

Figure 1: A diagram attempting to display the 3D geometry of the wingsuit during flight with axis labels. Axis labels show directions for the width, height and flight (all perpendicular).

If we rearrange equation (2) for v^2 and substitute it into equation (1) we get a lift force of

$$F_L = \frac{C_L}{C_D}\frac{EA_{wp}}{\sigma x}. \tag{3}$$

Since we want to continue flying at the same altitude, the force of lift is set to the weight caused by the mass of the suit and person, m, and gravitational acceleration, g. Once this is rearranged for x we get

$$x = \frac{C_L}{C_D}\frac{EA_{wp}}{\sigma mg}. \tag{4}$$

If the geometry of the suit is approximated as a rectangular sheet at an attack angle, θ, to the direction of flight (Figure 1) we can calculate the cross-sectional area as the height multiplied by width, which is equivalent to

$$\sigma = wl \sin\theta. \tag{5}$$

Where w is the width of the suit and l is the length. A similar method is used for A_{wp} to find

$$A_{wp} = wl \cos\theta. \tag{6}$$

We then substitute equations (5) and (6) into equation (4) to get

$$x = \frac{C_L}{C_D}\frac{E}{mg\tan\theta}. \tag{7}$$

Results and Discussion

To find the distance travelled per can of Red Bull we plug values into equation (7), where E would be the nutritional energy of the can of drink, 486 kJ [3]. Ferguson finds maximum lift coefficient of a wingsuit to be 2.73 with an attack angle of 47 degrees and a drag coefficient of 1.95 [1]. We estimate the mass of a wingsuit and person to be 80 kg. These values correspond to a distance per can of 808 m.

808 m is not the maximum possible distance flown with the energy of a can of Red Bull, it is just the distance travelled at maximum lift. To find the maximum possible distance we would have to find the attack angle that results in the greatest C_L to C_D ratio. The values used in this paper are unlikely be the highest ratio, as it is usually the case where a higher attack angle produces high C_L but also increases C_D and σ [2]. These relationships are not linear and are usually found experimentally or through numerical simulations, consequently we would need Ferguson's data to find the maximum distance possible.

The most obvious issue with the scenario is the release of energy. The nutritional energy stated on the canned beverage refers to the chemical energy in the drink that a human body assimilates and transfers into kinetic and heat energy through respiration and ATP hydrolysis. However, here there is no mechanism to transfer the chemical energy of Red Bull into kinetic energy to propel the person in a wingsuit. Hence, this paper is more of a comparison between the energy Red Bull provides for a person and the energy needed for flying, much like the comparison their slogan makes.

Conclusion

By using the details of a numerical simulation for the lift of a wingsuit [1] with equations for lift (1) and drag (2), we found that the distance flown at maximum lift for one can of energy was 779 m. However, this is not the maximum distance as calculating it would require values of C_L and C_D at varying angles of attack. The situation is also unrealistic as there is no mechanism to transfer the chemical energy of Red Bull into kinetic energy. Nevertheless, we compared the energy of the soft drink to the energy for flight, which is what the slogan suggests.

References

[1] Ferguson, M. (ND). Design and Computational Fluid Dynamics Analysis of an Idealized Modern Wingsuit.

[2] Anderson, John D. (2004), Introduction to Flight (5th ed.), McGraw-Hill, p. 257.

[3] https://groceries.asda.com/product/energy-drinks/red-bull-energy-drink/910001160731