FlyMi assignment report

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1 Introduction

The following information is given:

- Maximum total weight of 10kg
- Structural mass is 35%-50% of total weight
- Minimum payload weight of 1.25kg
- Takeoff is to be completed in a 10x10 m area
- Flight of at least 15 minutes
- After landing battery capacity should be 20%
- Maximum speed is 50kts

I then made the following assumptions:

- Structural mass weighs 50% of maximum allowed, with the UAV weighing the maximum allowed [1]
- Budget for parts is unlimited [2]
- The UAV takes only the minimum cargo possible
- The UAV is flown in cruise at maximum $E = 25.5$, takeoff is performed at $C_{Lmax} = 1.46$ with corresponding drag coefficient $C_{D,CLmax} = 0.061$ [3]
- There are no space constraints for batteries and motor dimensions
- Wing shape is rectangular with $b = 3.7m$ and $c = 0.15m$ [4]

[1] I am assuming the worst case scenario, more assumptions about saving weight will be made after motor selection is further perfected

[2] Again, more assumptions will be made later

[3] I took this value from last year's FlyMi assignment where the polar curve for a similar UAV was given

[4] Based off my estimations taken by observing FlyMi's Nyx UAV in person

2 Initial calculations

First of all I calculated the peak thrust required to perform the takeoff in the given distance. First I calculated the takeoff speed: $V_S = \frac{Q}{\frac{1}{2}\rho S C_{Lmax}}$ and found $V_S = 14\frac{m}{s}$

I then calculated both the air resistance at that speed for that configuration and the force required for a short enough acceleration: $D = \frac{1}{2}\rho v_S^2 C_{D,CLmax}$ and $F = \frac{1}{2}v_{TO}^2 \frac{m}{d_{max}}$

The greater force between the two is the one required for initial acceleration at $F = 70.1N$

I also calculated the air resistance for cruise flight, assuming that most of the flight is conducted at maximum efficiency conditions $D = \frac{Q}{E}$
With that, calculating energy required for cruise flight is: $E_R = D_{cruise}V_{max}t_{flight}$
Energy required for the takeoff roll is: $E_{TO} = F_{TO}d_{max}$

To that sum I then added an additional 40% divided as follows:

- 20% to comply to the rules regarding after landing battery capacity
- An additional 20% to account for internal parts friction and dissipation, manoeuvered flight and wind during the competition (not accounted in my calculations), as well as a safety margin for any calculation errors

The total energy calculated is $E_{Tot} = 1.23 * 10^5 J$

Having calculated these values, I was ready to start choosing batteries and motors.

3 Battery

I prioritized the choice of batteries so that later I would have the exact value of the maximum possible weight for the motors.

First of all I converted the total energy value found above from Joules to Watt-hours: $1.23 * 10^5 J = 34Wh$

With that number in mind, I started searching the internet for a battery that would fit the energy requirement [5]

I then found the "Tattu R-Line 22.2V 2200mAh 6S 95C Lipo Battery" [6] as the best compromise between energy and weight

The battery has the following characteristics:

- 22.2V voltage
- 2200mAh capacity
- 321g weight

I was now ready to start selecting the motors.

[5] I did not check for voltage compatibility between the battery and the motor because I assumed that there would eventually be an electrical circuit/controller to take care of that

[6] https://gensace.de/collections/tattu-r-line/products/tattu-r-line-22-2v-2200mah-6s-95c-lipo-battery-with-xt60-plug

4 Motor

First of all I calculated the maximum allowed weight for the motor/motors (the choice between single and multiple motors will be made later)
Considering:

- 5kg structural weight
- 1.25kg payload weight
- 0.321kg battery weight

The maximum possible weight is 3.429kg

First I converted the peak force required from Newtons into kilogram-force (the force unit used on the website): $70.1N = 7kgf$ I then manually filled a .dat table with the most important characteristics of the motors found on the website provided, leaving out the motors with too high or too low maximum thrust and/or weight.

Having imported the table into Matlab, I calculated which motor solutions were single-engine and which were double-engine, I then created a thrust vector and a weight vector to plot all of the motors into a graph.

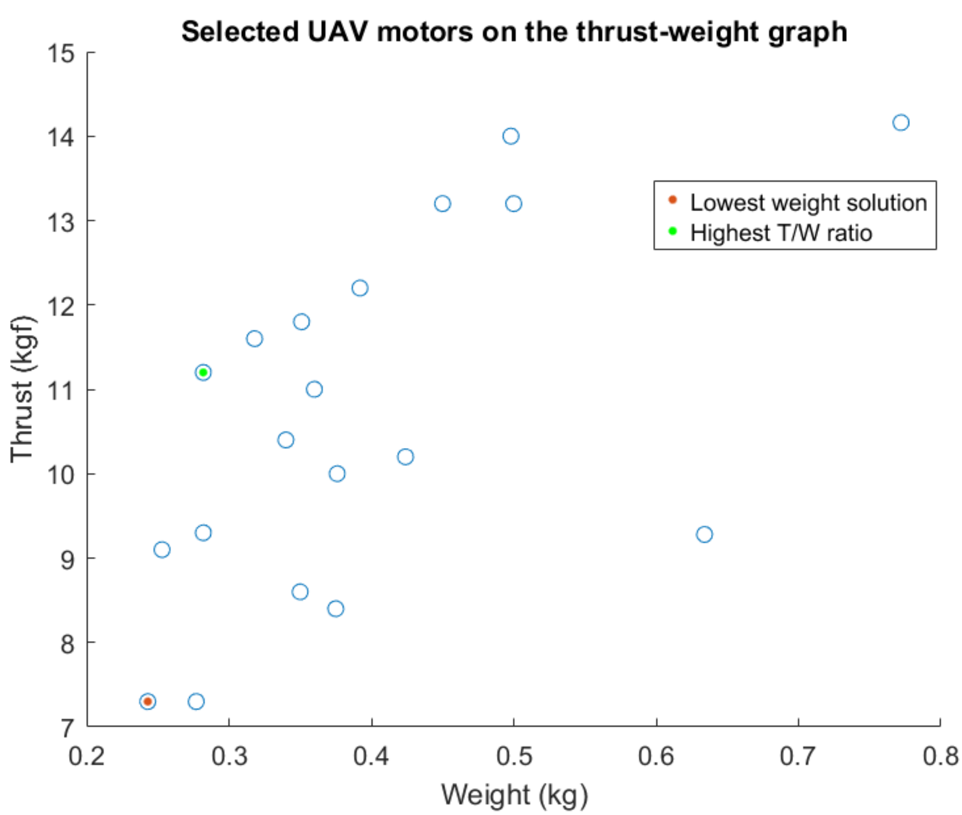

Figure 1: All motor solutions plotted onto the T/W graph

By plotting this graph I found two possible candidates for the final motor selection:

1. The lowest weight motor: "U8 Lite Efficiency Type UAV Motor KV100", which weighs 243 grams and produces 7.3kgf of peak thrust[7]
2. The motor with the highest T/W ratio: "U8 Lite L Efficiency Type UAV Motor KV110", which weighs 282 grams and produces 11.2kgf of peak thrust[8]

The first motor is better if the full UAV is very close to the weight limit, or if carrying 39 more grams of cargo could mean the difference between first place or a lower positioning. Otherwise I think the second option is better because, while adding a little more weight, it has a much higher peak thrust, which really helps for the short takeoff requirements.
Both motor candidates are intended to be used in a single-engine configuration.
Both motors also have a similar price.

NOTE: If, for some reason, both motors couldn't fit onto the UAV, any other motor close to those two highlited points in the graph would still be a good enough choice.

5 Final considerations

The calculations above are made from rudimentary data and spur-of-the-moment observations. More accurate results could have been achieved, had there been more precise data available. Despite this, the achieved results are a good starting point for the UAV initial dimensioning.

As for the motor data, instead of getting the numbers by hand from the website, I could have built a bot that would have done it for me, but I don't have enough knowledge in that field. I don't think I would have gotten much better results anyway, nor would I have saved much more time.

[7]https://store.tmotor.com/product/u8-lite-kv100-u-efficiency.html
[8]https://store.tmotor.com/product/u8lite-l-kv100-u-efficiency.html