that of a multi-rotor craft of a similar size [1]. Figure 3 shows some examples of disk loading values for a variety of rotor configurations, as shown disk loading is also a measure of hover efficiency. A higher disk loading value results in larger values for induced velocities as well as the required power to hover. This means that the larger the blades, the better the efficiency. More force will be generated by pushing large quantities of air slowly, than forcing small amounts of air through at high speeds [20]. Of course with bigger blades, comes larger rotational inertia and geometry. ~~as well as~~ T the craft ~~being~~ is also less immune to gusts and interferences. A larger blade ~~also~~ creates faster tip velocities, which ~~will~~ limit the speed of the craft severely [14]. t(?)

Power is given by the product of both Thrust and the induced velocity at the blade. It can be written as shown in (9). What this ratio shows is that the ideal power is in cubic proportion to the induced velocity at the rotor. Therefore to reduce required power the rotor's induced velocity must be small, which can be accomplished by a significant increase in disk area [14].

$$P = 2\rho A v_i^3 \tag{9}$$

Another important ratio is between thrust and power, it is called power loading (PL) and is shown in (10). Power loading can be seen as a measure of craft efficiency.

$$PL\left(\frac{N}{kW}\right) = \frac{T}{P} \tag{10}$$

From (8) and (10) it can be shown that power loading is inversely proportional to disk loading. Therefore a craft with a lower disk loading ratio will be a more efficient platform.

D. Electrical Power to Thrust

Equation (9) gives a quantitative approach to solving for aerodynamic power (P_i). If electrical power is taken as $P_e = VI$, where V is the applied voltage and I is the sourced current, with an efficiency of η then $P_i = \eta VI$. Noting that $P_i = Tv_i$ and using (9), a relationship between thrust and P_e can be formed and is represented in (11).

$$T = (2\rho A)^{\frac{1}{3}} (\eta P_e)^{\frac{2}{3}} \tag{11}$$

Equation (11) brings to light a very important relationship which states that thrust grows at a slower rate than the electrical input power to the system.

$$T \propto P_e^{\frac{2}{3}}$$

III. SELECTION PARAMETERS

Some of the fundamental theories described above relate to the basics behind various rotor configurations and even varying flight techniques. Each different arrangement of blades introduces certain advantages and disadvantages to

is critical for the intended application. An analysis of varying rotor configurations is done below and follows a similar trend to that seen in [5], [2] and [21]. The main weighted criterion for the discussion were listed in no particular order as:

1) Flight time, payload capability and efficiency
2) Geometry, ~~and~~ size and mechanical complexity
3) Drone manoeuvrability and control algorithms
4) Stability and Disturbance Rejection d r

A. Efficiency, Payload Capability and Flight Time

Flight time is a by-product of efficiency and payload, as a more efficient craft will drain the power source slower, thus producing a longer flight. Where a heavier craft, with a larger payload, will have a shorter flight duration. Most miniature drones these days have a flight time somewhere between 6-12 spaces. minutes before they need recharging. This is not conducive for a variety of applications where longer mission durations are pertinent. Of course a larger power source could always be added, but this increases the weight, limiting the payload capability and once again flight time. The relation between hover efficiency and disk loading was mentioned above, but what was not discussed was how a potential payload a effects these decisions. A single rotor will have a lower disk loading ratio at hover and will not be able to carry as heavy loads as a multi-rotor craft that has a higher disk loading at hover [14], [12], [1].

B. Geometry, Size and Mechanical Complexity

In any aerial vehicle mass is always an important design criterion. Every aspect of the platform must be designed to be the lightest it possibly can. Having a light-weight craft is one part of the design criterion, another would be ensuring that the weight is geometrically spread out correctly, as well as functionally distributed appropriately. The table below was adapted from [21] and demonstrates the latter point better. Depending on the different criteria for the craft, different functional blocks will be allocated a certain percentage of weight. For example if the user would like a longer flight time, a higher percentage would be given to the power source and possibly less to the external payload. Generating a good mass model before designing helps better understand the requirements for the craft and could be a deciding factor in the construction.

not sure what this is.

Component	0.3kg	1.8kg	3.7kg
Rotor System	11.0	11.2	13.9
Tailboom Assembly	8.0	9.1	7.8
Main Rotor Motor	15.4	10.5	8.1
Fuselage/Structure	7.0	15.1	12.0
Main Transmission	2.0	3.4	3.4
Landing Gear	2.3	3.4	2.9
Control System	5.7	18.3	9.3
Avionics	29.4	2.4	1.6
Power Source	19.2	26.6	41.0

TABLE I

MAV WEIGHT DATA (ADAPTED FROM [21])

The rest are not all caps