of disturbances just as well. This way if one blade falters or is affected substantially by a disturbance the other rotors can still rectify the error. Some multi-rotor designs can still fly with substantial control even after losing power to one or more of the rotors [17].

IV. DISCUSSION

This discussion looks at the different rotor configurations and attempts to address each parameter mentioned above. ~~It starts~~ with the traditional helicopter which is always seen as a main rotor with a smaller rotor at the tail, even when there are many different types of anti-torque tail set ups. The ducted fan approach increases the efficiency of the tail rotor by channelling the air flow of the rotor. The NOTAR design [15] manipulates the airflow generated by the main rotor and directs it to counter act the induced torque. A tip-jet design eliminates the torque applied to the airframe and therefore no tail rotor is required [5]. There have been many attempts at improving the standard helicopter design. These improvements have taken the form of adding rotors, designing hybrid aircrafts and complex mechanical designs to harvest advantages of both the fixed wing and VTOL crafts. Some have even tried to combine multiple features as Flanigan [10] did in his design of a tip-jet, compound, tilt rotor aircraft.

Let's begin (too informal!) We will begin

explain? stands for?

In an attempt at simplification, not all configurations were investigated. The following standard groups of designs were covered:

1) Traditional helicopter
2) Coaxial rotors
3) Tandem rotors
4) Multirotor designs
5) Tilt rotors

A. Traditional Helicopter

When most people think of a rotorcraft they will think of a conventional helicopter, which is still the most widely used configuration for large rotorcrafts [5]. It consists of a single main rotor, coupled with a smaller counter rotating rotor located in the tail to counteract the developed counter torque.

The main rotor of a standard helicopter has a very low disk loading ratio which gives it excellent hover efficiency. To achieve yaw stability this configuration makes use of a small tail rotor to counter act the induced moments of the main rotor. The extended tail rotor requires energy which it will draw from the motor while also adding a significant amount of length to the craft. Since the single rotor only gives the pilot thrust control and the tail rotor gives measurable yaw control, there is need for more control surfaces to do more manoeuvring. To implement this most helicopters use a variable pitched rotor system. Cyclic control of this pitch allows the pilot to adjust the angle of attack of the rotor blades while they rotate, thus more force can be applied on the left by increasing the pitch and the craft will tilt to the swash plate for cyclic control will be a mammoth sized task on it~~'~~s own.

Once the mechanics are set up the control algorithms are still slightly limited and intensive. However with only ~~Only having~~ a single main rotor, ~~makes~~ the traditional helicopter is extremely susceptible to disturbances and hard limited ~~the~~ payload capability with the low disk loading factor.

B. Coaxial Rotors

A coaxial configuration consists of two counter rotating blades located about the same centre of rotation that both use the same drive system. This eliminates the need for a tail rotor as the torque applied by both rotors cancel each other out. Functionally the coaxial is very similar to the traditional helicopter [8]. With no modifications and only using fixed pitched rotors, this platform will only give yaw and over all thrust control. Bohorquez et al [2] attempted a number of lateral control methods, eventually settling on aerodynamic flaps to control the flow of the downwash. That, and other methods, are shown in figure 5. Briod et all also used the same set up in his team's design of the Gimball [4].

The control flaps are the most common used form of lateral control for small coaxial MAVs. They introduce little mechanical complexity and do not require excessive power to use. The flaps do however decrease efficiency of the system, but if designed correctly should only influence the system while being used. For hover and vertical flight the impact will be negligible. As a control surface the flap is quite rudimentary and will require some more advanced control methods as well as in-depth testing to obtain smooth flight transitions. Due to it's compactness the design can have considerable manoeuvrability if the control algorithms are designed effectively. Each flap will require an actuator, ~~this~~ which will increase total weight, power consumption and required mechanics.

Since half of the bottom blade is working in the top blades slip stream it will have a higher v_0 and therefore a larger v_i, which according to equation 3 will induce a larger thrust. This relates to high values of efficiency and lower values of disk loading, decreasing the payload capability. Coleman in [8] did an extensive survey of coaxial rotors and also found that they produce more drag than the conventional rotor set up, which becomes more pertinent at higher speeds.

Localising the blades around a single point also helps with the geometry of the craft as it is a more compact design. Briod et al [4], [13], [3] used this to their advantage when they were designing a collision resistant robot, the compact design allowed them to surround the entire craft in a rolling

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