General comment:

I like the article, and it could be very useful. However, some work is required. Please take the feedback seriously, and don’t be discouraged.

Terminology:

The term MAV is questionable. Although the military uses the term UAV, no civilian refers to aircraft as a “vehicle”. ICAO consistently uses “Unmanned Aircraft” (UA), and the whole system is referred to as a UA System (UAS). I would strongly recommend using a derivative of standard terminology, rather than using obsolete military terms that are not meaningful in a civilian context. If you need confirmation of this recommendation, look for “UAV” or “Vehicle” in the Civil Aviation Regulations, Part 101, governing unmanned aircraft of this ilk. You won’t find it there.

Technical and terminology issues:

There are conventions that are applicable to the analysis of aircraft motion and dynamics. “Thrust” acts in the direction of motion. “Lift” acts to counteract weight. I would strongly suggest that you change all references to rotor “thrust” to “lift” instead. In a helicopter, thrust is produced by tilting the rotor lift vector, so that a (generally) horizontal component is produced that acts as thrust. Calling the total rotor reaction “thrust” is confusing and will complicate further analysis.

Tandem-rotor helicopters are invariably built with variable-pitch (feathering) rotors. There is no other way to compensate for torque, as the RPM must be kept constant to avoid inter-rotor conflict. Because of flapback, helicopter rotors are dynamically unstable with lateral displacement. Your assumption of fixed-pitch rotors would provide no roll control, which means that every lateral upset would result in uncontrollable roll and a crash. The use of a feathering rotor provides complete attitude control, just like in a conventional helicopter. Differential use of the two rotors can then provide yaw, roll and pitch control.

There is a short section describing electrical power by defining its relationship to voltage and current. The relationship is never used again. I would suggest removing it, as it is completely irrelevant to the discussion. Also, most systems under discussion have essentially constant voltage, so power is simply proportional to current (another piece of irrelevant info).

NOTAR does use an airfoil in the tail to counteract yaw, but its main mechanism is an air nozzle that blows air to produce lateral thrust (just like a tail rotor). Your explanation mentions the airfoil but not the blown air.

Your description in IV.A. of how a feathering rotor works is flawed. If lift is increased on the left, the rotor will precess and either cause a forward acceleration (American helicopter) or a deceleration (French helicopter). To make the helicopter roll right, the pitch would have to be increased ahead of the helicopter in an American helicopter, or near the tail in a French helicopter. Pitch angle controls flap rate, not blade position.

There is some confusion between angle of attack and pitch angle. A fixed rotor has a fixed pitch angle (albeit different as a function of radius from the hub), but it has a variable angle of attack as a function of inflow and RPM. Descent, climb and power setting all have an influence on the actual angle of attack. This distinction is very important in the analysis of coaxial rotors, as the downflow from the top rotor actually decreases the angle of attack of the bottom rotor, requiring an increased pitch angle to achieve the same torque and lift (although it is not awfully important to produce equal lift on the two rotors).

The choice of axes in III.C. needs to be looked at. A quadrotor is essentially isotropic in the azimuth plane, so the reference axes are very loosely coupled to airframe geometry. However, the z axis should remain orthogonal to the plane of the rotors. There is no such thing as “up” and “down” to define the direction of the z axis, as the craft can tilt. I would suggest “top” and “bottom” to label the axis, rather than the “up” and “down” used in Fig. 4. It still contains an element of wishful thinking, but at least it is not blatantly untrue, as the craft does have an invariant top and bottom section.

Language:

Please refrain from formal, flowery prose. This paper is aimed at a technical audience. Excessively long sentences, haughty vocabulary and marketing hype do not belong here. Words like “therefore” and “thus” and “so” and “seriously” are generally redundant, and just make the prose sound clumsy. The first paragraph of the Introduction is a prime example.

The plural of “craft” is “craft”. The same goes for “aircraft”, “rotorcraft” etc. Please fix all occurrences of “crafts”. “Crafts” are things that are home-made for decorative purposes.

The word “this” should never be used as the subject or object of a sentence, as it is always ambiguous. Talk about “This mass” or “this improvement” or “this technique”.

“it’s” means “it is”. If you want to say “its” as in “its compactness”, don’t use the apostrophe.

“Criterion” is singular, and “criteria” is plural. There are several mishaps with inappropriate use of the terms and with verb agreement. It should be “criterion is” and “criteria are”.

“Fixed wing aircraft” includes aeroplanes and gliders. I don’t see any reference to gliders in this paper, so please replace the use of “fixed wing” with “aeroplanes”.

You often refer to “blade” when it should be “rotor”. Please check all occurrences of “blade” and see whether they should be changed to “rotor”. In almost every case, they should.

When you start a new thought, start a new sentence. You should very seldom have a sentence that occupies more than one line in a word processor (e.g. about 80 characters), and you should be able to justify it if you do.

You often refer to “disk loading ratio”. Disk loading is a ratio, so “disk loading ratio” is a comparison between two different aircraft. Just use “disk loading”.

What do you mean by “control law”? Control law is a term that applies to internal workings of a control system, and is well outside the scope of this article. In all but one case, I think the term is used inappropriately. Please review and get rid of it.

I would suggest making “et al” italic. It’s a borrowed phrase, not native to English.

Blow by blow:

Original text is quoted, followed by comments or corrections in [square brackets].

rotorcrafts.

[rotorcraft.]

making controlling rotorcraft possible

[making rotorcraft control possible]

With the… full drome kits.

[Rewrite this paragraph. Tone it down, so it doesn’t sound like the introduction to a horror movie.]

since it has recently gained

[What is “it”?]

This ends in the majority of people not using a drone type that is the right fit for their application.

[This what?]

[Many users end up using a drone type that is not the optimal choice for the application.]

By the end of this paper the reader should be able to identify the appropriate rotor configuration for their application.

[The reader…their. Either singular or plural, not both.]

It is important to note that any rotating blade will cause a rotation of the craft in the opposite direction to that motion.

[What does “it is important to note” mean? I would suggest deleting it and starting a new paragraph with “Any rotating rotor will cause…]

[Blade or rotor? For the purposes of this discussion, it should be “rotor”. A single unbalanced blade will cause translation too.]

[The rotating rotor will cause torque to the craft. It may or may not result in a rotation, depending on other factors. “Torque”, not “rotation”.]

mechanism, this function

[Start a new sentence.]

the blade’s angle relative to air stream in shifts as shown in 1

[“in” seems superfluous. Delete?]

[What is “1”? Figure 1? Equation 1? How is it shown? I couldn’t figure it out, so perhaps other readers will need some help too.]

down stream

[downstream]

Angular velocity equations state that the speed of any part of the rotor varies along the length of the rotor

[How about: “The speed of any part…”?]

the maximum velocity sitting at the rotor tip

[Delete “sitting”.]

Figure 1

[Unreadable on paper. Blow up?]

Figure 1 demonstrates the functions as well as the naming scheme.

[I could not find the functions. Do they need to be stated in the text?]

This complicates the rotor dynamics

[This what? Relationship? Flight? Velocity? Ground? Rotor? Speed?]

approaching Mach conditions

[What are Mach conditions? Do you mean “transonic conditions”?]

Wr <= V¥

[Use the standard mathematical symbol for “less than or equal”. You’ve used programming syntax.]

This is known as a stall condition

[This what?]

[Look for a standard text on “lift asymmetry”. The FAA has good training material. However, the discussion is mostly irrelevant for small rotors and low horizontal speeds.]

With a fixed wing aircraft the analysis of the blades is simplified because the only air flow produced is from the translational velocity of the entire craft.

[Aeroplane]

[Blades? Or rotors?]

[airflow]

(weight = thrust)

[weight = lift]

Tangible and effective

[Huh?]

Negligible and obsolete

[Huh?]

[Please avoid platitudes and try to say exactly what you mean. Both these phrases are complex but completely unintelligible. At least to your reviewer…]

is common to Leishman et al

[Huh?]

There is no velocity jump across the rotor, the energy being fed into the system by the rotor is represented by a pressure change between P1 and P2.

[I’m not sure what this “velocity jump” means. Did you mean a discontinuity?]

[Split into two sentences.]

[Use subscripts to distinguish the pressures.]

lift is generated

[I agree fully, but this terminology is inconsistent with the original use of “thrust”.]

Since v0 is zero during hover and acceleration is the difference in v¥ and v0, (5) can be obtained.

[Acceleration is not a spacial derivative, it is temporal. Please rewrite the sentence to reflect exactly what you mean.]

rotor crafts

[rotorcraft]

the area a rotating disk makes

[covers, traverses, spans.]

Since the pressure drop across each rotor is considered uniform,

[Is this assumption reasonable? With translation, there is considerable asymmetry across a rotor.]

Equation 8

[Don’t include the units in the equation. If you want, you can include a note about the units. The unit you’ve quoted is equivalent to Pa.]

multi-rotor crafts

[craft]

of a single rotor craft

[single-rotor craft]

configurations, as shown disk loading is also a measure of

[Start a new sentence.]

[As shown, disk loading… (insert comma).]

This means that

[This what?]

More force will be generated by pushing large quantities of air slowly than forcing small amounts of air through at high speeds [21].

[Not true. There is an advantage in efficiency, as impulse varies linearly with speed and energy varies quadratically, but there is no inherent reason why more force will be generated that way.]

A larger blade creates faster tip velocities which will limit the speed of the craft severely [15].

[What about turning the larger blade at lower RPM?]

Power is given by the product of both thrust and the induced velocity at the blade.

[Delete “both”.]

Therefore to reduce required power the rotors induced velocity must be small, which can be accomplished by a significant increase in disk area [15].

[Comma after “power”.]

[rotors’…]

[Delete “a significant” and replace with “an”.]

Another important ratio is between thrust and power, it is called power loading

[Start a new sentence.]

Equation 10:

[Remove the units. Add a note in the text if required. N/W is the base unit.]

a lower disk loading ratio will be a more efficient platform.

[Delete “ratio”.]

If electrical power…Pi = nVI.

[The discussion is irrelevant and is never used again. Delete?]

Fig 3

[Unreadable on paper. Enlarge.]

what criteria is critical for the intended application

[criteria are]

The main weighted criterion for the discussion were listed

[criteria]

Where a heavier craft,

[Delete “where”. If you want to continue the previous sentence (not a good idea), use “whereas”.]

This is not conducive for a variety

[This what?]

[conducive to, not for. But “conducive” is not the best word, is it? Appropriate? Suitable?]

mission durations are pertinent.

[“pertinent”? How about “required” or “needed”?]

but this increases the weight

[this what?]

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

[Huh? Isn’t the disk loading one of the limiting factors? I would expect a lower disk loading to provide better lifting capacity, as disk loading constrains lift production for a particular lift coefficient.]

one part of the design criterion, another would be ensuring

[criteria]

[Start a new sentence.]

geometrically spread out correctly, as well as functionally distributed appropriately.

[Word order, times two.]

demonstrates the latter point better.

[Delete “better”.]

Table 1

[Add descriptions of the labels and values (e.g. “Gross mass [kg]”, “Percentage of mass”.]

If this is done correctly the principle axes of inertia will

[This what?]

[principal, not principle]

This is obviously crucial since the application is to move a body through 3D space!

[Indeed. So please delete the sentence.]

The three axes change as the aircraft changes

[Huh? Did you mean that the aircraft’s orientation changes?]

forward, sideways and vertical

[“vertical” is a bad choice, as it seldom is. How about “normal”, as is the convention in aerodynamics?]

Fig 4.

[Relabel the z asix with “Top” and “Bottom” rather than “Up” and “Down”.]

allows only for control in the amount the craft flies up or down.

[Force balance does not determine up or down displacement. It determines acceleration. Perhaps “upwards or downwards acceleration” would work better?]

This of course means that since the angle of attack is fixed for the blade, an increase in speed will be required for a change in lift.

[Of course. So those two words serve no purpose—delete them.]

[Do you mean “blade” or “rotor”?]

[The AoA is not fixed. The pitch angle is.]

[An increase of RPM, not speed.]

This then requires more motor

[This what? Pitch? Increase? Blade? Drag?]

Both of these facts become pertinent in the final decision making of the platform design.

[Delete “decision making of the”.]

To do this the craft will need more control surfaces to apply forces in those planes.

[This what?]

[Insert a comma to separate the clauses.]

[Why are control surfaces required? We are looking at differential application of rotors, not control surfaces.]

full six degrees of flight freedom

[the full six degrees of freedom in flight]

the anti-torque generated by each motor.

[the torque reaction generated by each motor.]

amount the craft flies up or down,

[The force balance controls acceleration, not displacement.]

authority, the trade off becomes between number of rotors

[Start a new sentence.]

[tradeoff of trade-off]

a good control law should be able to help the user find stability

[Huh? A good control system can make the aircraft stable.]

They have been isolated

[Who are “they”?]

Multiple blades helps reduce

[maybe “Multiple rotors help”?]

If one blade falters

[Blade or rotor? If a blade “falters”, the rotor is unbalanced and will destroy the craft.]

by a disturbance the other rotors

[Insert a comma.]

The ducted fan approach increases the efficiency of the tail rotor by channelling the air flow of the rotor.

[Fenestrons are no more efficient than tail rotors (possibly less). They are quiet and less prone to damage.]

NOTAR

[Modify the description to include the nozzle, which is actually the main component of the NOTAR.]

Hybrid aircrafts

[Aircraft. Really.]

(VTOL) crafts

[Craft. Really.]

Large rotorcrafts

[Craft. Really.]

smaller counter rotating rotor

[Delete “counter rotating”.]

disk loading ratio

[Delete “ratio”.]

To achieve yaw stability this configuration

[Insert comma.]

counter act

[counteract]

To implement this most helicopters

[Delete “To implement this” and start a new sentence.]

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 right.

[Not true. Rewrite after learning about precession and flap rate.]

This set up is mechanically very complex but luckily has become a standard production set up, with many companies providing solutions to this problem. Custom designing the swash plate for cyclic control will be a mammoth sized task on its own.

[This explanation does not sit right in a technical paper. Take it out or rewrite it to reflect the intention better.]

two counter rotating blades

[two counter-rotating rotors]

This eliminates the need

[This what?]

cancel each other out.

[“cancel out”, or maybe even just “cancel”?]

Briod et all

[et al]

same set up

[setup]

most common used form

[Delete “used”.]

The flaps do however decrease efficiency of the system, but if designed correctly should only influence the system while being used.

[Huh? I don’t get the intention at all. Please rewrite.]

in depth testing

[in-depth testing]

it’s compactness the design

[its]

[Insert comma.]

half of the bottom blade is working in the top blades slip stream

[blade or rotor?]

[Why half?]

[slipstream]

[insert comma after “slipstream”.]

This relates to high values of efficiency

[This what?]

used this to their advantage

[This what?]

collision resistant robot, the compact

[Start a new sentence.]

[There are another 40 marks on the last two pages, but the weekend beckons. It is 20:00 on a Saturday night. Please have the language seen to!]