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Design and Development of a Modular Reconfigurable Aerial Vehicle

Relatório Intermédio

Keywords

Design, Development, Reconfiguration, Reconfigurable, Aerial Vehicle, Vehicle, MAV, MRAV, Modular, Module, WBS, Swashplate, Swashplateless,counter rotating, Drone.

Abstract

This study proposes the development of a modular reconfigurable aerial vehicle for enhanced efficiency and logistical management in construction sites. The modular design enables seamless connections and detachments, facilitating versatile payload transportation and improved resource utilization. The proposed vehicle employs co-axial motors with counter-rotating blades for stable and controlled flight, extended flight time, and enhanced maneuverability. The project's scope encompasses performance, reliability, and design requirements, ensuring the drone meets the demands of complex construction tasks. The MRAV's potential extends beyond construction, with applications in search and rescue, disaster relief, and specialized missions in remote or hazardous areas. The development of MRAVs represents a significant advancement in aerial technology, offering transformative capabilities for various industries.

Contents

Chapter 1

Introduction

1.1 Background

In construction sites, efficiency and logistical management are crucial elements for project success. In this context, the introduction of a small aerial vehicle specialized in transporting equipment and materials represents a revolution in how companies address the challenge of cargo movement in construction environments. This drone, designed to meet the demands of the industry, will enhance safety, optimize available resources, transportation and offer cost reductions. But if one is great, multiple will be best. This drone will be able to attach and detach to other drones forming a connected fleet that works synergistically to accomplish complex tasks, such to transport larger payloads, and this versatility allows the drones to be dynamically configured to meet the specifications of each mission.

It is important to mention that this project will not be for profit, it is to be used as a tool for research and education along the journey.

1.2 Problem Statement

Modular Reconfigurable Aerial Vehicles are comprehended as individual and fully functioning aerial vehicles capable of performing tasks on their own whilst at the same time being able to assemble with other vehicles such as them in order to better perform some of its tasks. Such vehicles have built-in mechanisms that facilitate this assembly.

It is also worth noting that such study might help comprehend how future in-space assemblies might take place, and help accelerate that reality in terms of the technology used.

1.3 Objectives

Every project must have clear objectives set to be fulfilled, and this one is no exception, therefore, some have been set some for this project to go on by. On this study, the objectives have been divided into two categories, being primary and secondary.

The primary objectives are:

- Development of two independent aerial vehicles capable of reconfiguring in flight.
- Study, comparison and selections of assembly methods for the vehicles.

The secondary Objectives are:

- Demonstrating the scientific principle and applicability.
- Utilize of co-axial motors with counter rotating blades for propulsion.
- Optimization of the structure of the aerial vehicles.

And one extra goal is to attach a payload to the modules if all the above are successful.

1.4 Significance of study

The development of a modular reconfigurable aerial vehicle (MRAV) holds significant potential to revolutionize the construction industry and beyond. This innovative technology offers several key advantages:

- Adaptability and Versatility.
- Extended Flight Time and Maneuverability.
- Cost-Effectiveness and Scalability.
- Educational and Research Potential.

Potential Applications Beyond Construction: MRAVs hold the potential to transform various industries, including:

Search and Rescue: MRAVs can quickly access remote or hazardous areas, providing search teams with enhanced situational awareness and the ability to transport injured personnel or critical supplies.

Disaster Relief: MRAVs can deliver emergency supplies, assess damage, and support rescue operations in the aftermath of natural disasters or other emergencies.

Specialized Missions: MRAVs can be customized for specific tasks, such as carrying out scientific research, monitoring environmental conditions, or performing surveillance in remote locations.

In conclusion, the development of modular reconfigurable aerial vehicles represents a creative step forward in the field of aerial technology. With its potential to enhance efficiency, adaptability, and versatility, MRAV technology has the power to revolutionize construction operations, streamline logistics, and enable new applications across various industries.

1.5 Scope

In this study there were also requirements set to be fulfilled and to guide the path to the solution, requirements which are also divided into three categories, Performance, Reliability and Design.

Therefore, the requirements set, in order of priority are:

1. Performance:
    - Stable and controlled flight.
    - In-flight reconfiguration.
    - 6 Degrees of freedom.
    - Use of the swashplateless system.
2. Reliability:
    - 10 minutes of flight.
    - Resistant structure.
    - Protected avionics.
    - Reusable.
3. Design:
    - Simple design.
    - Easy to assemble.
    - Easy to maintain.

1.6 Work Breakdown Structure

Figure 1.1: WBS

The project is divided into 6 sections:

1. State-of-the-Art Review and Trade-off Analysis:
    - Where it is intended to understand the study, the problem and objectives, propulsion, swashplateless system and define all the literature review.
2. Module Design:
    - Define the connection between the modules, as well as the architecture and components, it's structural design and make some test guides for the next section for the critical components.
3. Initial Tests:
    - Realize the tests prepared beforehand and analyze their results.
4. Module Development:
    - Acquisition of the rest of the components and build the vehicle, assure its flight and solve any issues that might be encountered.
5. Validation and Testing:
    - Continuation of the tests and maybe a demonstration of it working to recognize its potential and limitations.
6. Documentation:

- Should be done during all stages of the project and it propose should be reporting all the results gotten and all steps made to the project.

For this projects there were some risks identified. Bellow there's a list from the most impactful to least and the respective mitigation strategy to it:

1. Swashplateless failure:
    - Deep research and of different configurations and testing. Possibly contacting The creator of the system to gather information in order to re-model until correct.
2. Structure's mass:
    - Realize the tests on the motors to ensure lift is possible.
3. Technical difficulties:
    - Study well the connections between components, the components and it's compatibility.
4. Reconfiguration:
    - Testing of the different mechanisms and since this step may not happen, it might be possible to substitute magnets with electromagnets.
5. Project dates:
    - Following the WBS and working on some tasks beforehand.

Chapter 2

Literature review

2.1 Swashplateless

The swashplateless[1] is a usually lighter version of the swashplate. The swashplate is a device, notably used in helicopters, that allows for the control of cyclic and collective pitch of the aircraft's rotor blades. This cyclic pitch control can alter the pitch and roll of the helicopter. However, mechanical control of blade pitch is complex, as these controls are transmitted from the pilot or actuators on the non-rotating frame to the blades on the rotating frame through the swashplate, typically causing significant drag and high maintenance load.

Swashplateless replaces this mechanical difficulty with an electronic challenge. In other words, swashplateless involves fewer components in the system and between control and response. However, controlling it is challenging on the electronic side. In swashplateless, a cyclic system is used to induce high pitch in the blades as they pass through one part of the rotor and then low pitch as they pass in the opposite position. To achieve this, a sinusoidal component is applied to the motor in phase with it's rotation, exciting a variation in lag angle and, consequently, in pitch with each revolution. Essentially, sinusoidal variations in motor speed and acceleration enable the MAV (Micro Air Vehicle) to move in the indicated direction.

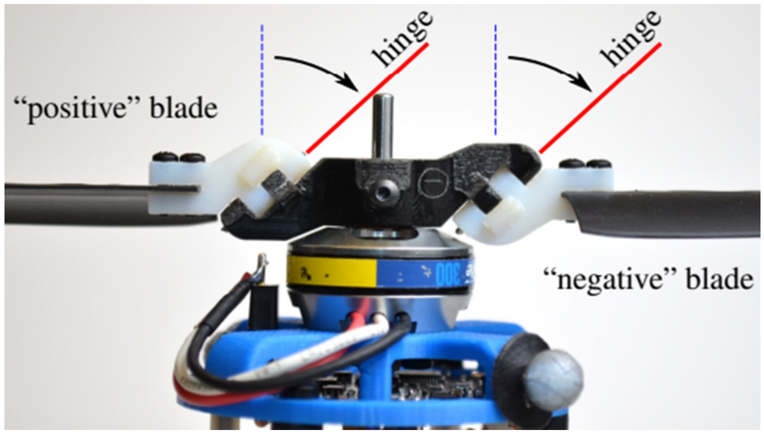


Figure 2.1: Swashplateless

The design of this component is very simple. It consists of one piece connected to the rotor and two additional pieces, each attached to the blades. These two pieces are connected to the first one through hinges. As can be seen in the figure, these hinges are not vertical, and this is what allows the lead-lag movement of the MAV. According to Tom Stanton [2], adding washers and brass inserts to the hinges decreases friction between the material of the system and reduces the amount of wear, because they are swinging back and forth so often during the rotation, the 3d prints would wear out. He also concluded, in terms of the hinge angle, it can be changed and the lower the angle is, the harder it is to tune, because it is more mechanically sensitive therefore the slightest electronic input generates a massive mechanic output, the higher angles are easier to control, however for the motor to speed up and down at those frequencies would heat the motor, nonetheless it was not conclusive on what is the best angle for the hinges.

2.2 Coaxial counter rotating blades

Counter-rotating blades are a type of propeller configuration where two or more propellers spin in opposite directions along a common axis. This configuration is commonly used in coaxial motors, which are rotary airscrews or turbines mounted one above the other on concentric shafts. The top motor rotates in one direction and the rear one rotates in the other. The torque created by one of the propellers will be canceled by the one created by the other.[3]

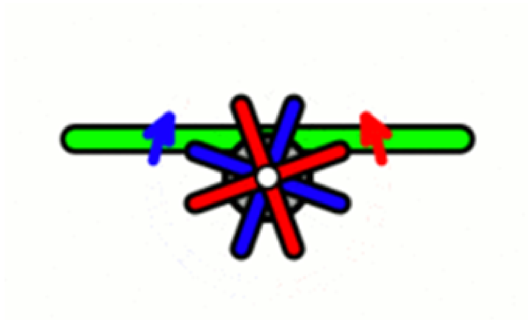


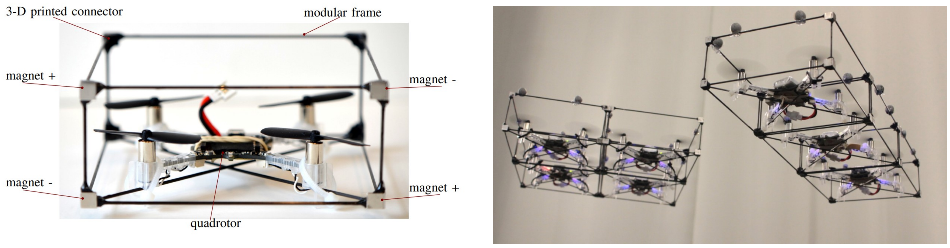
Figure 2.2: Coaxial Counter Rotating blades

There are some advantages and disadvantages to this system. It improves the efficiency due to cancelling the torque, allowing for better power transfer, it also increases stability of the aircraft, especially in hover mode. However, it is more complex, leading to higher cost and can be very noisy.[4] One other test, with the aim of finding the best coaxial layout for drones, and it was concluded that at higher speeds (>1750 RPM), the separation distance between propellers has little to no observable impact on rear propeller efficiency and increasing rear propeller size (diameter) may exacerbate the relative decrease in rear propeller thrust generation as front propeller speed is increased and increasing front propeller speed may cause lower thrust and torque generation in the rear propeller. So these are things that we need to take in consideration when choosing the blades and position of the rotors.[5]

2.3 Reconfiguration

One of the main objectives of this project is to demonstrate the concept of having two drones assemble and "join forces" in flight. For this purpose, a thorough study of this application was needed, where it was possible to learn about all the approaches used in the past to achieve the same objective. One of the main difficulties this presents include the mechanism used to assemble the modules, given the fact that our goal is to do so in flight.

A study has been made where this goal has been achieved using quadcopters, and their assembly is done in flight, the same as we pretend, where in that study, autonomous drones are used and to them are enclosed and attached a frame made with carbon fibre rods that contains magnets on the vertices to achieve the reconfiguration, where the modules connect to each other by the magnets [6].



(a) A Flying Modular Robot.

(b) Flying modular structures.

Figure 2.3: Flying Modular Robots.

Studies have also been made using single rotor drones with fixed-pitched propellers which by itself cannot fly, and each module can move on the ground until it docks with another and only afterwards, they could achieve flight [7].

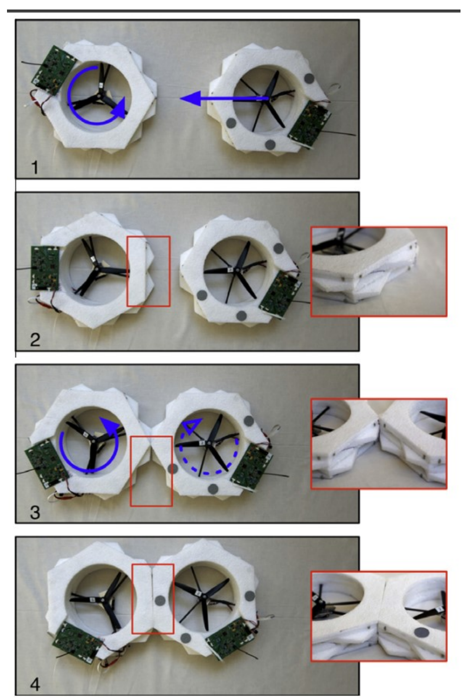


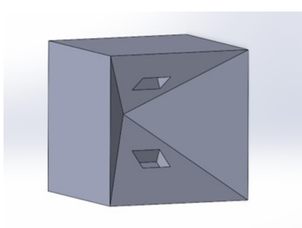
Figure 2.4: DFA concept.

Chapter 3

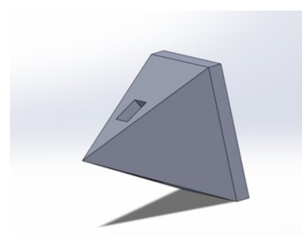
Design and Development

3.1 Reconfiguration

For this project, the goal is to use a concept with similarities to both studies presented, which would include a mechanical and magnetic assembly mechanism. For that reason, three concepts were prepared, each of them using the same principle, which consists of two components (one male and one female) where the *male* part connects to the *female* part.



(a) Female



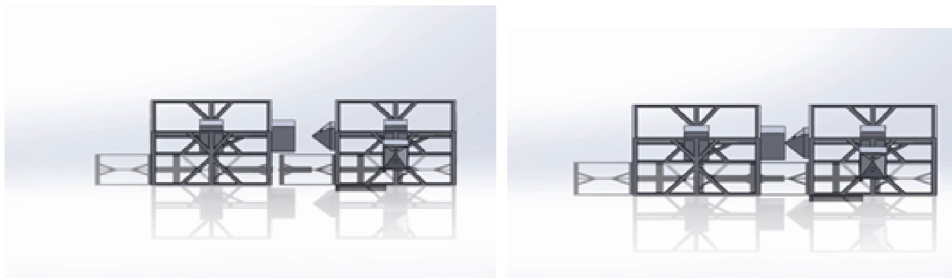
(b) Male

Figure 3.1: Connection parts.

In this concept, it is expected that the male part can more easily connect to the female given its proposed shape, where it would allow more freedom and the modules would not need to be 100% aligned for them to join, the pyramid shape would allow for the vertices of the male to always tend towards the female. This proposal also includes a slot for magnets to be placed inside, which would help assure the modules have a stronger connection in flight and would transit the forces from one to another.

The three proposals, as mentioned before, use this same concept, being:

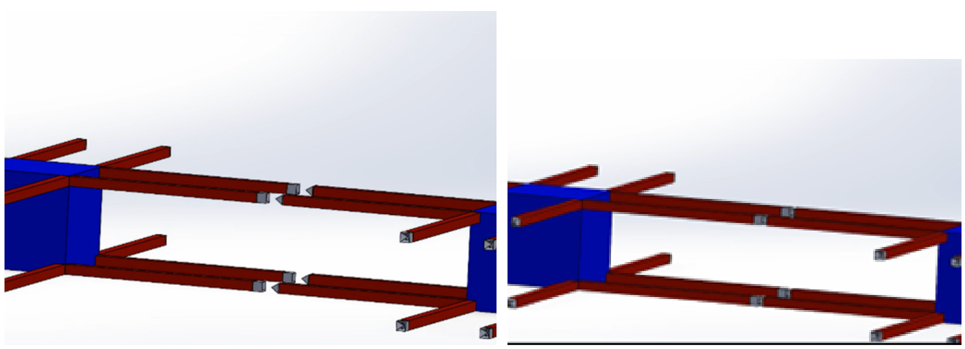
1. **Concept 1:** The connection between modules is on a single and point. This proposal would allow an easier connection, although in counterpart it would make the module heavier and more unstable.



(a) 1 (b) 2

Figure 3.2: Illustration of the first concept.

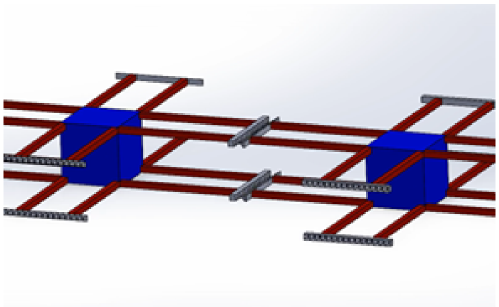
2. **Concept 2:** In this proposal, the connection is made in four, smaller points. This indicates that the stability in flight would be greater, and the weight of the aircraft would decrease significantly, but they would need to be more aligned for the connection to happen.



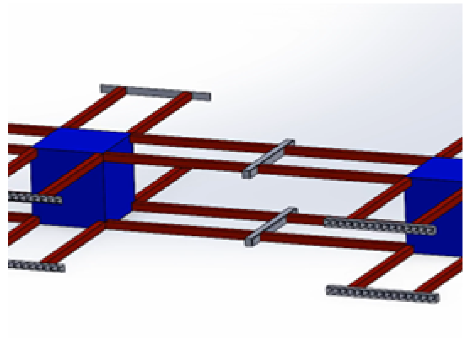
(a) 1 (b) 2

Figure 3.3: Illustration of the second concept.

3. **Concept 3:**On this last proposal, the connection is intended to be made in two arrays of points (number to be determined), where it is thought to offer more stability than the other two proposals, while having less weight than the first proposal and being easier to connect than the second.



(a) 1



(b) 2

Figure 3.4: Illustration of the third concept.

All three proposals are intended to be tested, in order to better determine which of them is better suited to fulfil our objectives.

3.2 Structure

The vehicle's structure is in the early stages of development, but the team is considering using foam or 3D printing materials due to them having lightweight and protective qualities.

However, some of the early thoughts of structure involve using similar structures to [6], involving using lightweight rods, in our case with FDA printing, with the filament yet to be chosen. The other structural principal would be an adaptation of [7], possibly using polypropylene foam as well. This means that the structure would need to be adapted in order for the air to flow in the center of it, therefore allowing the vehicle to be able to lift off the ground. Lastly, the structure would need to include a built-in landing gear, considering that the vehicles will be using coaxial blades, in order to protect the propellers and motor in the bottom of the module.

3.3 Components

For this project, it is expected to use the least amount of components possible in order to complete the requirement of having a simple design. Bellow there is a list of the main components of a singular module for the project, noting that there may be additional components in the future.

LiPo Battery:

Figure 3.5: Battery

A 5200mAh 50C LiPo battery with an XT60 connector is a popular choice for radio-controlled (RC) vehicles due to it's combination of high capacity, high discharge rate, and compact size.

- Capacity: The 5200mAh capacity means that the battery can store a significant amount of energy, providing extended runtimes for RC vehicles. For example, a 1/10 scale RC car with a 5200mAh LiPo battery can run for approximately 30 minutes on a single charge.
- Discharge Rate: The 50C discharge rate indicates that the battery can deliver a high amount of current, crucial for powering high-performance RC vehicles. A 50C discharge rate is sufficient to meet the power demands of even the most demanding RC vehicles, such as brushless motors and high-speed cars.
- Connector: The XT60 connector is a popular type of connector for LiPo batteries due to its ease of use and reliability. It is a locking connector that prevents the battery from accidentally disconnecting.

Brushless motor Racerstar BA2216 1250KV 2-4S

Figure 3.6: Rotor

The Racerstar BA2216 1250KV 2-4S brushless motor is a popular choice for fixed-wing RC planes and FPV racing drones. It is a high-power and high-efficiency motor that can deliver excellent performance in a variety of applications.[8]

Here are some of the main features of the Racerstar BA2216 1250KV 2-4S brushless motor:

- High Thrust Force: The motor can generate up to 1330g of thrust with a 10x4.7 propeller.
- Low Weight: Weighing only 25g, the motor is a suitable choice for lightweight aircraft.
- Compact Size: With a diameter of just 27.7mm and a length of 31mm, the motor is suitable for a wide variety of aircraft.
- Durable Construction: The motor is constructed with high-quality materials and designed to withstand the challenges of RC flight.

Eletronic Speed Controller(ESC): Flycolor 50A ESC 2-4S Electric Speed Controller 5v 3A BEC with XT60 & 3.5mm Bullet Plugs.

Figure 3.7: ESC

The Flycolor 50A 2-4S Electric Speed Controller (ESC) is a popular choice for RC vehicles due to its combination of high current output (50A), efficiency, and compact size.[9][10]

- Current Output:With a current output of 50A, the ESC can control a motor with a traction current of up to 50A. This is sufficient for powering a variety of RC vehicles, including drones, quadcopters, racing cars, and helicopters.

- Efficiency:The Flycolor 50A ESC is a high-efficiency ESC, meaning it can convert a high percentage of battery energy into usable power for the motor. This can help improve flight times and reduce the risk of overheating.
- Compact Size:Measuring just 40mm x 25mm x 23mm, the Flycolor 50A ESC is compact, making it a good choice for small and lightweight RC vehicles. Its size allows it to fit into a variety of applications.
- Battery Elimination Circuit (BEC):The Flycolor 50A ESC features a 5V, 3A Battery Elimination Circuit (BEC), which can be used to power servos, flight controllers, and other electronic components. This is a convenient feature as it eliminates the need for a separate BEC.
- XT60 and 3.5mm Plugs:For power and signal connections, the Flycolor 50A ESC uses XT60 and 3.5mm plugs. These are common connectors that are easy to work with in the RC community.

Computer and flight controller: Teensy 4.1

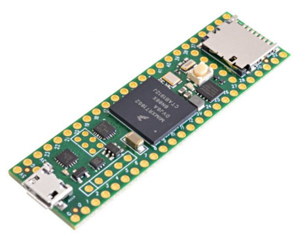


Figure 3.8: Teensy 4.1

The Teensy 4.1 microcontroller is a powerful and versatile device that can be used as a computer and flight controller for a variety of applications. It features several characteristics that make it well-suited for these roles[11], including:

- High Performance:The Teensy 4.1 is equipped with a 32-bit ARM Cortex-M7 processor that can operate at up to 600 MHz. This level of performance makes it capable of handling complex flight control algorithms and other demanding tasks.
- Large Memory:With 512 KB of RAM and 1 MB of flash memory, the Teensy 4.1 provides ample storage for a variety of data and code. This includes flight control software, sensor data, and video data.

- Multiple Analog and Digital I/O:The Teensy 4.1 boasts 54 analog input pins and 64 digital input/output pins, enabling it to connect to a wide range of sensors and actuators.
- Real-Time Operating System (RTOS) Support:The Teensy 4.1 supports various real-time operating systems (RTOS), such as FreeRTOS and NuttX. This allows it to efficiently execute multiple tasks and avoid blocking the main execution thread.
- Compact Size and Low Power Consumption:Being a small device with low power consumption, the Teensy 4.1 is suitable for use in small applications and battery-powered scenarios.
- Open-Source:The Teensy 4.1 is an open-source device, meaning there is a large community of developers actively working on projects that utilize it. This open nature makes it easier to find help and support when needed.

Propellers: helicopter 19 cm blades

Figure 3.9: Helicopter Blades

Propellers are a good choice for many applications because they are:

- Lightweight:They are light enough to be used in a variety of RC vehicles, even smaller ones.
- Powerful:They can generate a significant amount of thrust for their size, making them suitable for high-performance applications.

- Durable:Made from durable materials, they can withstand the demands of RC flight.

- Efficient:Propellers are efficient in converting motor power into thrust.

Transmitter: FS-I6X

Figure 3.10: Transmitter

The FrSky FS-i6X is a popular 2.4GHz transmitter that is known for its ease of use, durability, and compatibility with a wide range of RC vehicles. It is a great choice for both beginner and experienced pilots. [12] [13]

Here are some of the key features of the FS-i6X:

- 2.4GHz technology: The FS-i6X uses 2.4GHz technology, which provides interference-free communication for a range of up to 1.5 km (0.93 miles).

- Six flight channels: The FS-i6X has six flight channels, which allows you to control a variety of features on your RC vehicle, such as throttle, ailerons, elevators, rudders, and collective pitch.

- Bind-and-fly operation: The FS-i6X is bind-and-fly, which means that you can connect it to your RC vehicle without the need for soldering or programming. Simply turn on the transmitter and receiver, and they will be paired automatically.

- Ergonomic design: The FS-i6X has an ergonomic design that is comfortable to hold and use. It also features a built-in buzzer and support for telemetry.

Receiver : FS-IA6B Receiver

Figure 3.11: Receiver

The FrSky FS-IA6B is a popular 2.4GHz receiver that is known for its reliability, compatibility, and affordability. It is a great choice for both beginner and experienced pilots.[14][15]

Here are some of the key features of the FS-IA6B:

- 2.4GHz technology: The FS-IA6B uses 2.4GHz technology, which provides interference-free communication for a range of up to 1,500 meters (0.93 miles).
- Six flight channels: The FS-IA6B has six flight channels, which allows you to control a variety of features on your RC vehicle, such as throttle, ailerons, elevators, rudders, and collective pitch.
- Support for SBUS and PPM: The FS-IA6B supports the SBUS and PPM protocols, making it compatible with a wide range of flight controllers.
- Failsafe: The FS-IA6B has a failsafe feature that will automatically cut power to the motors if the signal from the transmitter is lost.

Sensor: AS5048

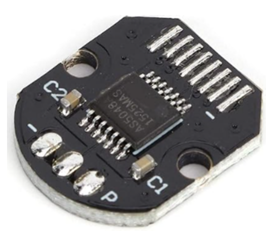


Figure 3.12: As5048

The AS5048A is a high-precision absolute encoder with a built-in 14-bit magnetic sensor. It is capable of measuring rotation angles with a resolution of 0.05 degrees, making it ideal for applications where precise angular position is required.[16][17]

Here are some of the key features of the AS5048A:

- High precision: The AS5048A can measure rotation angles with a resolution of 0.05 degrees, making it one of the most precise magnetic position absolute encoders available.
- Integrated magnetic sensor: The AS5048A has a built-in 14-bit magnetic sensor, which eliminates the need for external Hall sensors. This simplifies the design and reduces the overall cost of the encoder.
- Wide operating range: The AS5048A can operate in a temperature range of -40°C to 140°C. This makes it suitable for a variety of harsh environments.
- Compact size: The AS5048A is a compact encoder with a small form factor. This makes it ideal for applications where space is limited.

For the project, the sensor will give the motor shaft angle, and with that the cmputer will run PID control so the vehicle goes to where the user wants using the transmitter.

Additionally, the components masses as shown in the figure bellow, will add up to 876g.

1 Módulo			
Componente	Qtn.	Mass(g) p/unit	Potencia(W)
Rotor	2	68	400
ESC	2	82	15
Teensy 4.1	1	12	0,5
Bateria	1	475	
Recetor	1	15	0,125
Sensor	1	5	0,25
Cables	n	15	
Helices	4	11	
Swashplateless	1	10	
Total		876	415,875

Figure 3.13: Enter Caption

The chosen motor, when equipped with 8060 propellers, can produce thrust equivalent to 1170g at maximum power (14.8V and 27.2A). On this

project, other propellers, way bigger, will also be used, therefore it won't be necessary to use so much power and there will still be available of mass for the structure. At the estimated power of this module(P=415,875W), the battery would last about 11.1 minutes, which would be enough to ensure that the reliability requirement is fulfilled.
It is presented bellow what would the architecture could be for this project

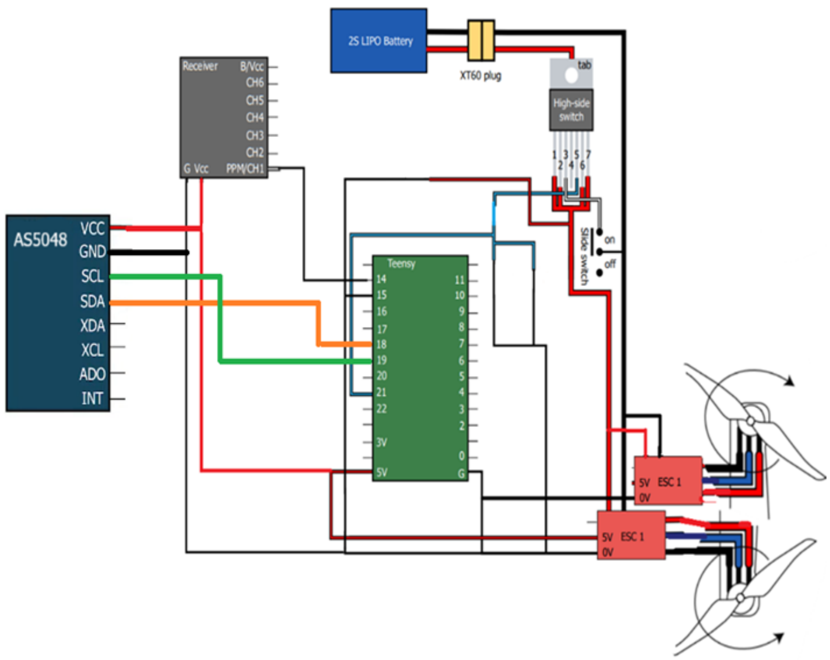


Figure 3.14: Possible Architecture

It is not the final architecture but it gives an idea of what it could be.

3.4 Swashplateless

There were a few models of the swashplateless made accordingly to the literature review and the components. One of them is this system, in the figure bellow. It is a 65º angle hinge with the horizontal and matches all of the criteria of the components, the motor shaft and the blades fitting.

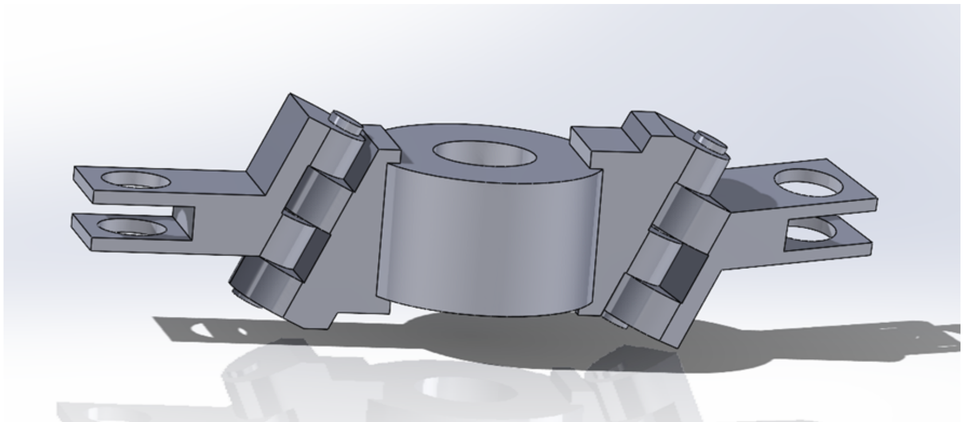


Figure 3.15: Swashplateless Model - CAD

However this model still needs testing to determine if it is capable of creating the high and low pitch to the blades.

If this model it is not sophisticated enough, it might be a good thought to ask the model to the author of this amazing piece - James Paulos.

Chapter 4

Discussion

The development of a modular reconfigurable aerial vehicle (MRAV) presents a compelling solution for enhancing efficiency and logistical management in construction sites. By enabling multiple drones to seamlessly connect and detach, MRAVs offer a versatile platform for transporting equipment, materials, and even specialized payloads. This adaptability translates into improved efficiency, reduced costs, and optimized resource utilization.

The project aims to design and implement two independent modules capable of reconfiguring in flight. This capability, along with the utilization of co-axial motors with counter-rotating blades, promises stable and controlled flight, extended flight time, and enhanced maneuverability. The modular design, with its emphasis on simplicity, ease of assembly, and maintainability, further enhances the practicality and scalability of the system.

For this to be possible, through careful benchmarking of other projects of similar kind and involving aspects worth consideration, much was learned in order to properly implement the desired outcome, therefore, a new WBS was proposed and components have been carefully chosen.

In this process, an adequate architecture has been selected, which is divided into three parts, being User Input, Flight control and Power-train, each of them involving the listed components. It's worth mentioning that this architecture of the vehicles was taken from [18].

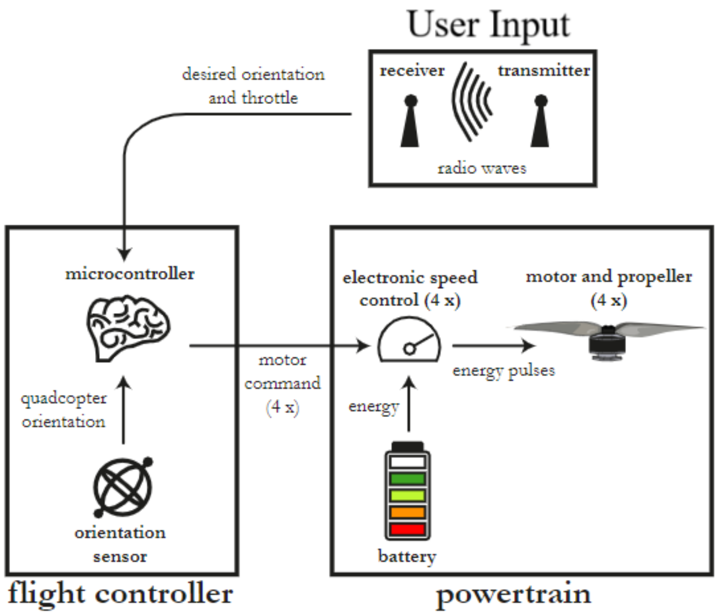


Figure 4.1: Architecture from [18]

Following this architecture would allow there to be guidance in regards to the basics of the project and therefore it would give more room to work on the swashplateless system, the reconfiguration of the vehicles, structure and tests of critical components.

In addition to the architecture, much time was given to focus to the mechanism for the reconfiguration of the vehicles. This was done after reviewing past concepts in [7] and [6]. The proposed mechanism consists on a electromechanical interconnection between the modules, and it is expected to be enough to ensure that the modules stay connected in normal flight conditions. Furthermore, tests are due to be made in order to properly validate and choose one of the three proposed concepts(Chapter 5).

Moreover, the structure design of these vehicles is in it's early stages of development, nonetheless, there are two concepts considered in this stage. The first one includes the use of rods as seen in [6], using FDM manufacturing, with the filament yet to be decided. The second concept is similar to the modules in [7] having a more robust structure and the material being a polypropylene foam as well.

For this project it is understood that for the validation of these concepts, testing will be extremely necessary and pivotal in order to achieve success, which is why it will be aproached in the next chapter.

The project holds immense potential to revolutionize the way construction sites operate. By leveraging the advantages of modularity and reconfigurability, MRAVs can improve logistics, enhance productivity, and reduce costs. As the project progresses, it will be crucial to carefully evaluate the performance, reliability, and design of the MRAV system, ensuring it meets the demands of real-world applications. The project's educational and research components will also contribute to the advancement of MRAV technology, paving the way for broader adoption across various industries.

The potential benefits of MRAVs extend beyond construction applications. Their ability to adapt to various payload configurations and environments makes them well-suited for a wide range of tasks, including search and rescue, disaster relief, and specialized missions in remote or hazardous areas.

Chapter 5

Future Tests

5.1 Propulsion

It is proposed to make a simple thrust stand in L shape. The principle of this test is that the thrust produced by the motors and the blades is the same felt by the scale. Both should be positioned at the same distance to the fix point. In that way the torque produce by the rotor will be the same in the point of the scale, as they are away from the same distance the force will be the same.[19]

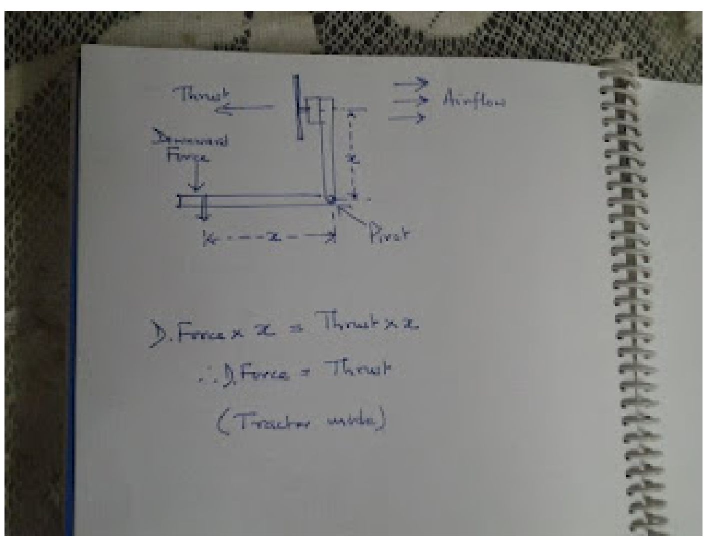


Figure 5.1: Principle

What we need for this test is a scale, two pieces of wood(similar size), some type of mount to fix them, a watt-meter with a built in PWM generator which means that a transmitter+receiver are not required to run the tests, an ESC, a RPM-meter , a led light for the RPM-meter, the battery, a scale and the motor.[20]

Finally it will look like this:

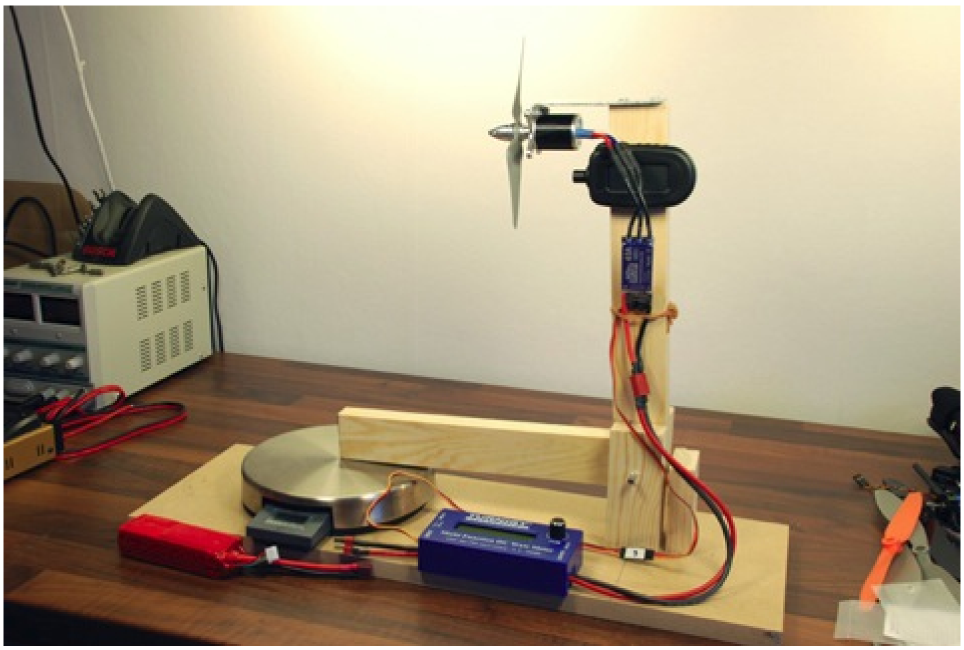


Figure 5.2: Mounted Thrust Stand

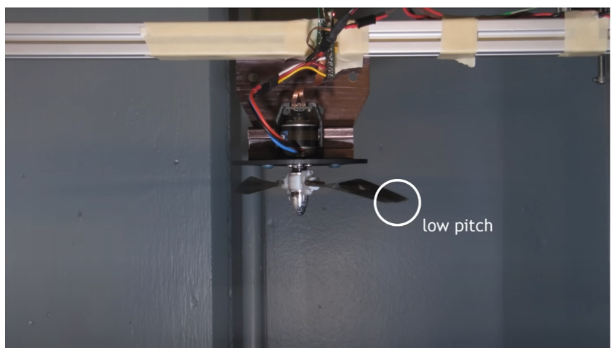
As the PWM is moved, different values of current, voltage, RPM and thrust will be obtained. Then it is possible to determine the maximum value of thrust and the best efficiency in terms of thrust/power of the system. This test will be made for the swashplateless motor and non-swashplateless motor.

5.2 Reconfiguration

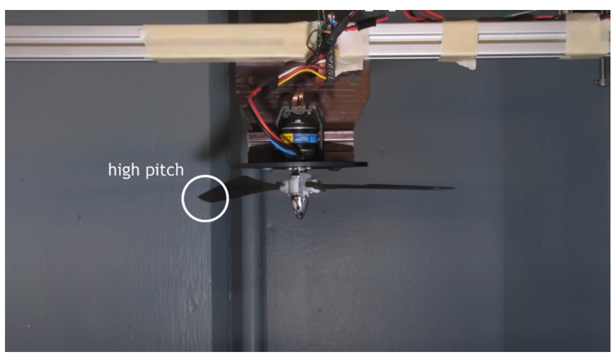
As it is a primary objective in the project, there will be tests on the connection between modules, in order to choose the best association. This test will involve calculating the stability and the endurance of the connection. These tests are intended to determine how the stress in one module propagates to the other, it will also help to determine how efficient this mechanism is compared to others previously attempted by others. However there is still uncertainty regarding what type of tests will be made.

5.3 Swashpleteless system

It will be very important to realize this test, however this test will depend from the coding of the flight controller. This test will reveal if our blades can perform high and low pitch so the drone moves.



(a) 1



(b) 2

Figure 5.3: Low and High pitch of the blades

Chapter 6

Conclusion

The culmination of this drone development project marks a significant milestone in our journey to explore the boundless potential of unmanned aerial vehicles. This endeavor has been an intricate tapestry of challenges and triumphs, each thread woven into the fabric of our collective learning and growth.

Throughout the process, we have delved into the intricacies of drone technology, demystifying the intricate interplay of mechanics, electronics, software, materials and forms of attachments between vehicles. We gained insights into the principles of propulsion, working together and unusual ways to create a drone.

We came to the conclusion that this project is very difficult, due to the atypical system we need to use, the lack of information there is and the absence of knowledge we have in this industry. There is things we could have done better, such anticipating our reunions to conclude the chores earlier and give time to conclude others.

For the future, accomplishing the tests previously mentioned, before the module development phase will be the most important to achieve the objectives of this project and to work along the WBS will be the way to the finish line.

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