Co-Axial Bicopter

By - Tarkshya

Problem Statement

Building and flying UAVs are slowly becoming a common norm for a new age society. In this huge wave of aerial vehicle manufacturing, where each and every project plays a significant role, a bicopter goes beyond the common norms of UAV manufacturing. A c0-axial bicopter, which is a bi - propeller (2 - Propellers) based UAV, providing thrust on the same axis, provides both durability and agility, which plays a greater role in observation and rescue operations.

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1. Understanding the Bicopter

What is a Co-Axial Bicopter?

A bicopter is a type of UAV or drone with two main rotors, often mounted on tilting arms, which allows controlled flight and high maneuverability while using fewer motors than traditional quadcopters.

This is an image of NASA's Ingenuity, which, in turn, turned out to be the inspiration for our Coaxial Bicopter.

Our Design

Our Bicopter has a prosperous, nowhere in the world design, which is novel, both in its features and its purpose. It achieves flight by generating aerodynamic lift from two main thrust points, with each point consisting of a propeller, both arranged coaxially (one above the other on the same axis). The entire craft is inherently stable and relies on a sophisticated thrust vector control to make constant, rapid adjustments to the motors, which are controlled by a transmitter.

Our design consists of the following parts:

The Upright Motor:

The upright motor is attached at the top of the whole structure, right above the avionics hub. The main purpose of the upright motor is to provide the main upright movement, the thrust, to the whole UAV. It consists of a single 1400 KV BLDC motor, which provides the main thrust, along with an 8-inch propeller.

The Avionics Hub:

The avionics hub is the “brain” of the whole system, consisting of:

1. ESP 32
2. MPU 6050
3. DHT 11
4. BMP 280
5. FlySky FS-i6Receiver Module
6. Jumper Wires
7. SG90 Servos X 2

The main function of the avionics hub was controlling the functions of all the elements, along with the synchronization of both the motors, using MPU 6050.

Battery Hub:

The battery hub stores the 4200 MAh battery along with the receiver module.

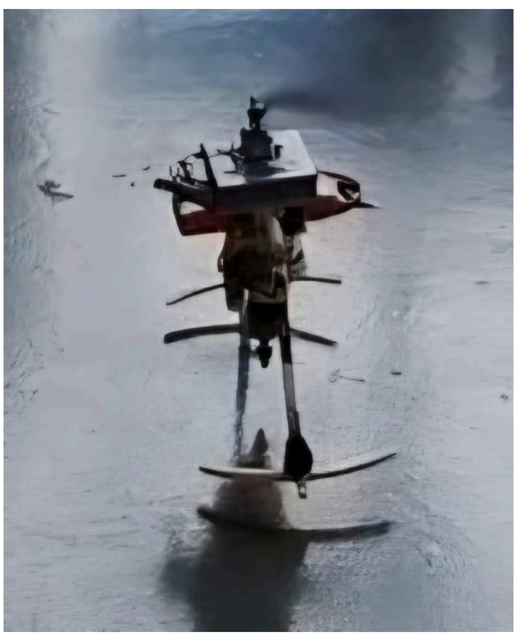
The Thrust Vector Control:

The thrust vector control is the main controlling component of the whole UAV, which controls the upside down motor. The upside down motor is controlled by the 2 SG90 Servos, in a bi-directional movement, with an allowance of 5 degrees. It is our very own innovation, in developing such a device for gimbal movement.

The Landing Gears

The landing gears are the parts that suffer the most weight, while taking off and landing. They are the shock absorbers and are designed in a circular art, to suffer the most shock, and have a stable landing.

The Flight



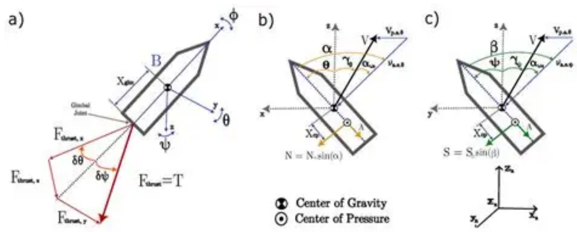
The lift for the bicopter is generated by the combined action of all the three components, including the upright motor, the upside down motor and the thrust vector control. Both the motors and the controls for the TVC are coded along with the PID and Filters, in the ESP32.

To control the whole framework, we have a transmitter that controls both the motors and the TVC. The rotation of both the motors, through the 8-inch propeller, which pushes the air downwards and allows for the upward movement. The movement of the upside down motor in the 2-directions, allows for a smooth control of the bicopter in all the directions. With just a few strokes on the transmitter, one can easily control the whole bicopter system.

The bicopter is comparatively easier to control and offers an automated control over the TVC as well.

The Thrust Vector Controlling

The Thrust Vector Controlling is a system of controlling any thrust mechanism of a rocket or a UAV. It is mainly used in rockets, to control the thrust of the propellant through the nozzle. It is very useful as it helps us to have a stable control over our aircraft.



This is a footprint of what a TVC mechanism looks like. A little shift in the angle of the thrust makes a drastic difference in the flow of an aircraft.

For our Bicopter, we have taken 5 degrees as our degree of freedom for the TVC.

This is our first design of the TVC that we have used in our Bicopter. This design is very simple in its structure, and allows the movement of the white pipe, which you all can see, in all the four directions. It is composed of two rings, one red and the other one, inside which this whole system moves.

The whole system is attached with the help of thin metal rods, which moves smoothly through the system.

This structure is 3D printed as is using PLA as the material, which in turn is flexible, and not brittle, like other materials.

This is our final design of how we integrated the TVC in our Coaxial Bicopter. The red ring is attached to one SG90 servo and the white pipe is attached to the other servo. The white pipe consists of the upside down BLDC motor, which mainly controls the thrust and the maneuvering of the aircraft.

This whole system is a simple, yet innovative approach to maneuverability in an aircraft which is never seen before. Innovating this TVC into a UAV is unique as well as efficient, as compared to other complex systems in aircrafts.

Design and Simulations

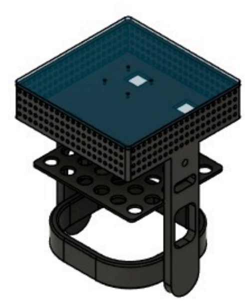
Design

This is the final CAD design that we made for our Coaxial Bicopter Prototype 1. Spent almost 3 months on the design, thinking about the stability and performance, in the end it gave us a beautiful and innovative design, with a muscular performance.

The design has girthy landing gears and the light upper body, to carry the whole weight downwards, stabilizing the centre of mass of the whole aircraft.

As you know, the landing gears are manufactured in PLA, which is more flexible. We expected it to handle loads and shocks at landing, which it did, making the design a success.

This is the avionics hub at the top, in the middle is the battery hub, and at the bottom is the outermost ring of the TVC.

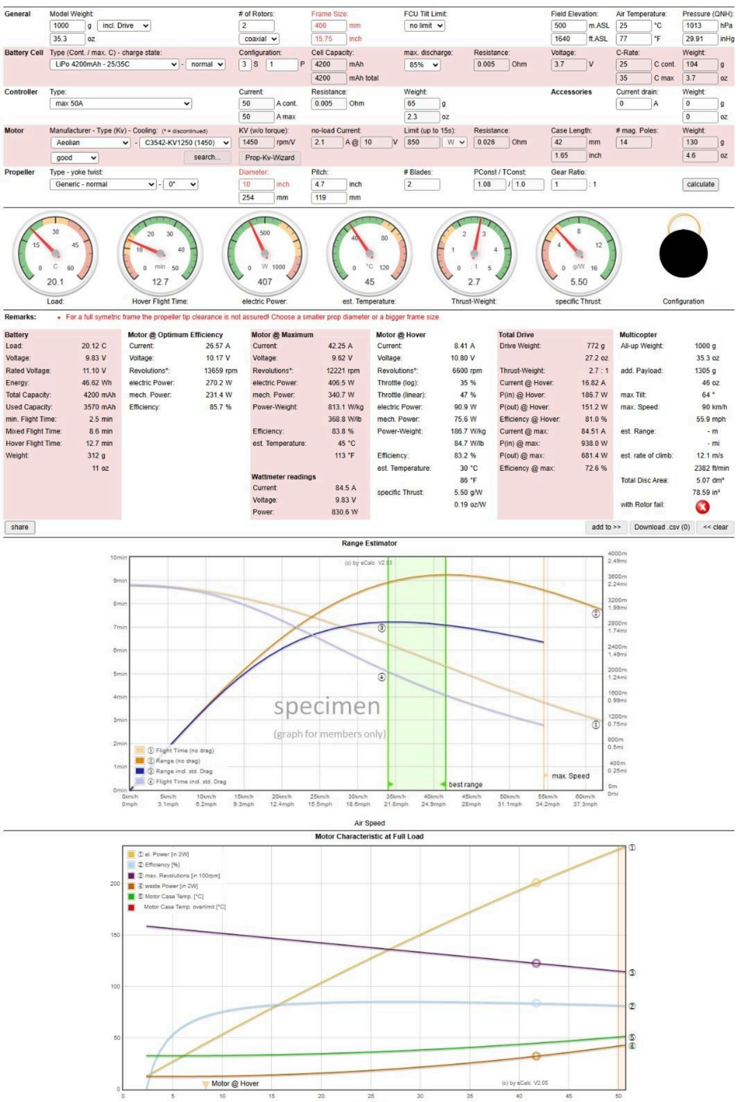


Keeping the weight of the battery in the middle, helped us in managing the cg a little. The avionics hub at the top, helped us keep it cool and airy, for the wires to be free.

The ring at the bottom, provided the final advancements of the TVC.

And this is the top view.

Simulations



This is the simulation report for our bicopter.

This whole calculation was done on ECalc, a popular tool for predicting the flight characteristics of multirotors. It analyzes how our specific combination of motors, propellers, batteries, and weight will behave in the real world.

It clearly shows the battery load, the hover flight time, the power consumption, temperature, thrust weight ratio and the specific thrust.

We attained the following:

1. Battery Load: 20.12 C
2. Hover Flight Time: 12.7 mins
3. Electric Power: 407 W
4. Estimated Temperature: 45 C
5. Thrust Weight Ratio: 2.7
6. Specific Thrust : 5.50 g/w

The graphs for Range and Motor Characteristics at Full Load is also present.

Range Estimator: The top graph shows that our "Best Range" (the green vertical band) occurs at an airspeed of roughly 35–45 km/h. If we fly at this speed, we will cover the maximum distance possible.

Motor Characteristics: The bottom graph shows the efficiency curve. Notice how the green line (Efficiency) peaks early and then stays relatively flat. This indicates that our motor and prop choice is well-matched for this weight.

Our setup is overpowered in a good way. With a 2.7 thrust-to-weight ratio, our bi-copter was very responsive.

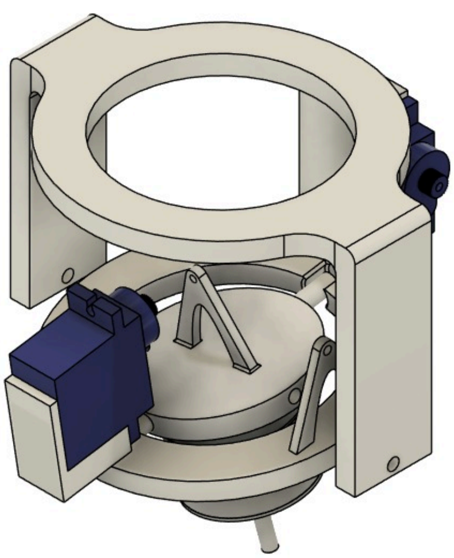
The New Design

After our first flight of our Prototype 1, we faced a lot of challenges, which we handled with the help of the trial and error method. Some of the problems were,

1. The centre of gravity of the whole system
2. The rotation of the system
3. The length of the white pipe in the TVC.
4. The Avionics Hub's size.
5. Battery Management

All these problems were handled in some or the other way. But while handling these problems, we came up with a new design of our very own bicopter. A new design, with a new approach, and a new way of handling things.

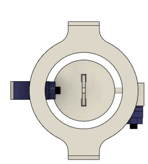
So let me introduce you to the new design.



This is our new design for the TVC. This is a new innovative design which subtracts the pipe and attaches a disc in place of it. The disc is controlled in the same manner as the pipe, with the help of two servos.

This new design helps us to decrease the size of the TVC as well as make it more stable. The motor is easily attached to the disc as compared to the pipe, and can maneuver more easily.

We hope that this new design helps us achieve the same success as we have achieved with the first prototype.



This is the top view

Some Moments to Success