L.E.A.F

(LED Electronic Aerial Flare)

"Get Rich or Diode Trying"
UPDATE 3

Adam Berger, Genesis Mangunay, Jacob Milton, Jason Scroggins, Johnny Camarena

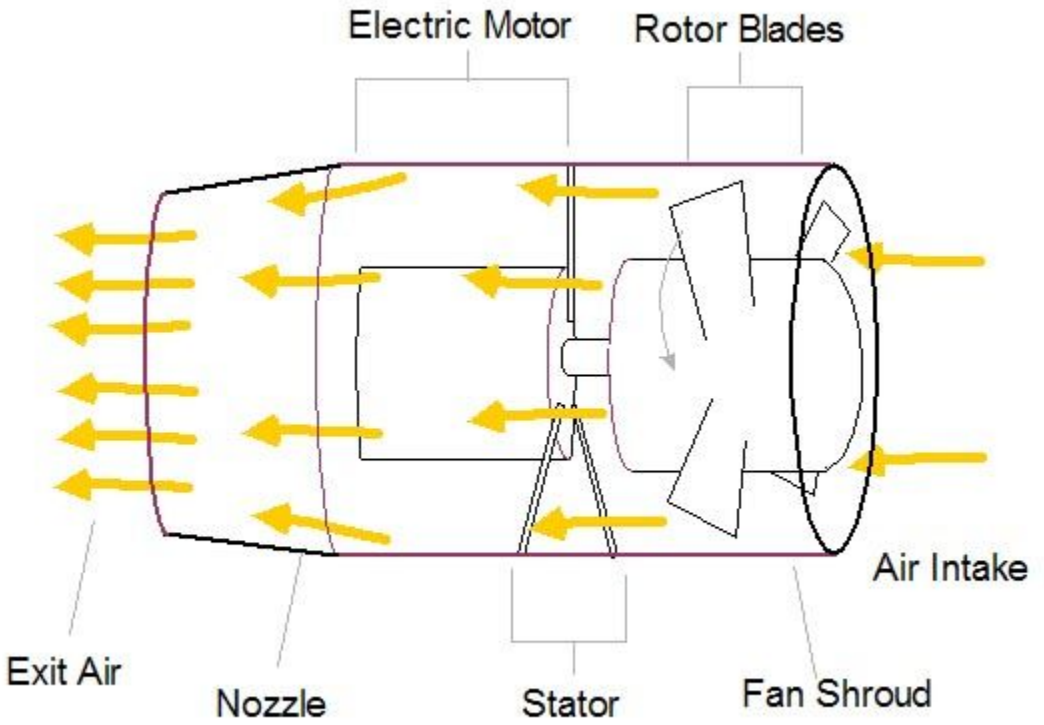
Introduction (Genesis)

What we're going to talk about:

- Our Proposal
- Device Constraints
- Components
- Current Progress
- Issues

Introduction

- **Frame Design** (Johnny)
  - .
- **Signal Lighting** (Jacob)
  - .
- **Design Constraints** (Jason)
  - Flight Components
  - Lighting
  - Systems control
- **Sensors** (Adam)
  - IMU, microcontroller
- **Introduction/ Conclusion** (Genesis)
  - LED indicators



Our Proposal

The design of the device, that we call **L.E.A.F** (LED Electronic Aerial Flare) is comprised of three major design components: the drone/flight system, the electronic flare system, and the device base and housing.

Current Devices

Flare Guns: Burn Time up to 7 seconds, Fire Hazard, Only One use, Can cause injury.

Flares: Stationary, One time use, burn at the melting point of steel and contain toxic chemicals.

Rocket Parachute Flare: Deliberately difficult to extinguish, hard to use, Burn time up to 40 seconds

Smoke Signal: Hard to see, Mainly used during the day

What's New

- We had to get new sensor, **Adafruit BNO55 Absolute 9-DOF**, because the old gyroscope wasn't producing accurate readings.
- We built a **testing stand**. Free standing testing was too difficult. In addition, the testing stand allows us to have a more safe work environment, not only for the drone, but us.
- Final components such as the mosfets came in. Waiting for assembly.
- Implementation of **LED indicators** for status/ battery level /calibration.

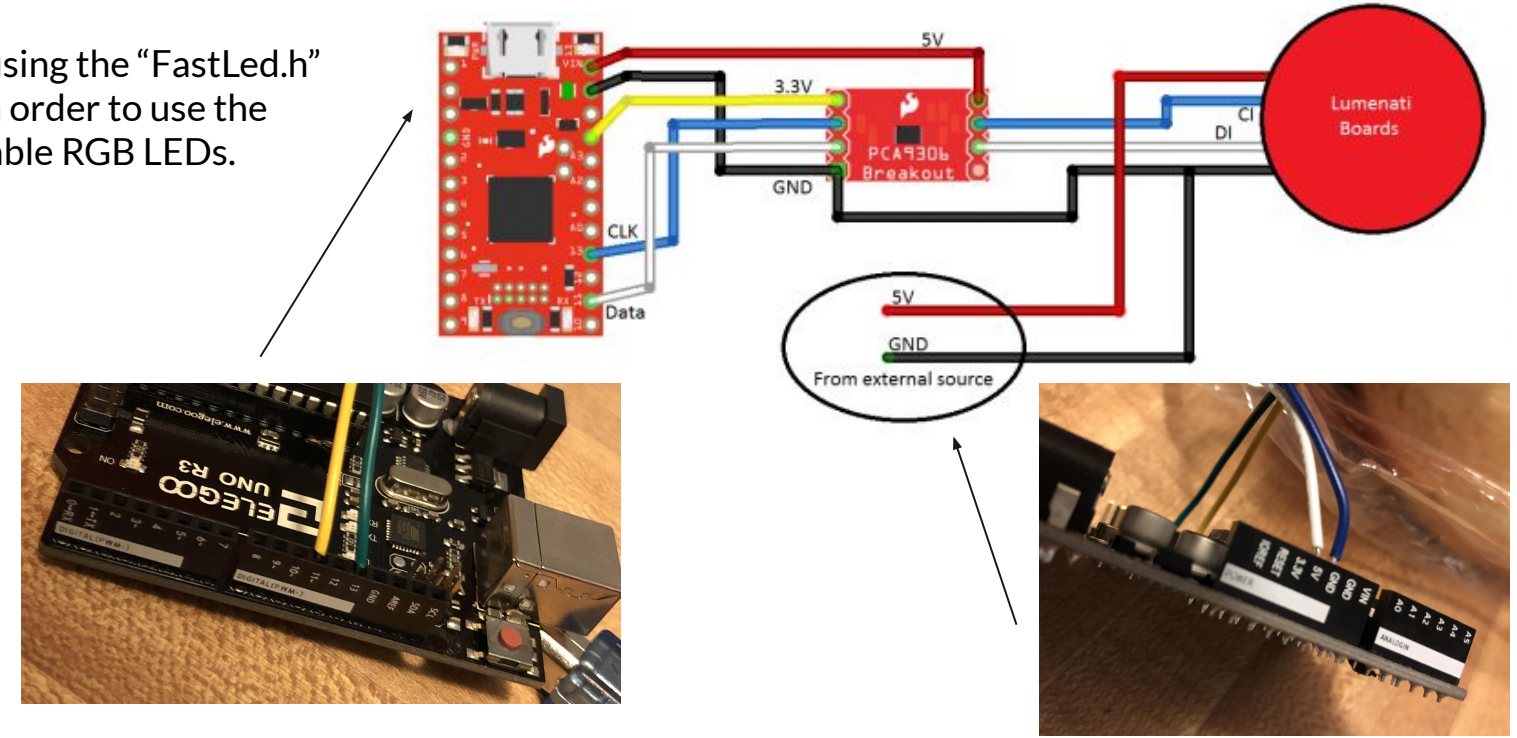
SparkFun Lumenati 4-pack (Apa102C addressable RGB LED's)

Location: attached on top lid, under the L.E.A.F. logo, also acts as the control button

LED status:

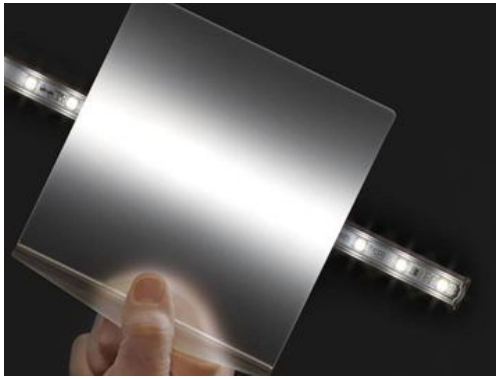
- Startup fault - 4 RED
- Calibration (IMU) - 2 BLUE flash → 4 BLUE steady
- Armed and ready - 4 GREEN
- Battery level - Testing and developing

- We are using the “FastLed.h” library in order to use the addressable RGB LEDs.



Light diffusion

Due to the Indicator lights being so bright, we had to 3D print a new top lid in order to make the lights shine evenly (to the best of our abilities).



Before

After

Design Constraints (JASON SCROGGINS)

To create a electronic flare with the capability of an autonomous drone
L.E.A.F is a tethered electronic autonomous aerial emergency flare

Proposed Constraints:

- 4 three inch propellers, 7” frame
- Enclosed Frame with ducted propellers
- Prolonged flight time (est 30 minutes)
- Emergency Lighting visible at 5+ miles

Current Spec changes:

- 8.25” frame
- Partially enclosed propeller, electronics are enclosed
- Est 12-15 minutes
- Not fully tested (Extremely Bright)

Quick note

The eventual goal of the the design would approach the idea show here, a single lightweight pcb frame with enclosed frame and propellers. Due to the shutdown, proceeding with a pcb fabrication was not a possibility.

This is the Ardubee -->
An educational stem drone.
http://luminousbe.es/ardubee/

Battery Management

To accomplish our goal we will be using 18650 Lithium Ion rather than lithium polymer because their energy density is higher for similar weight

Samsung 25R 18650 20A Flat Top 2500mAh Battery

In 3S1P = 12.6V (4.2V per cell)

at 80% discharge, => 10.8V (3.3V per call)

Battery protection provided by 20A BMS (battery management system) to prevent **over-current** condition and **over-discharge**. It also allows charging of the battery without removing the pack.

Weight reduction and using more efficient motors would also increase flight time and current draw.

Battery Monitoring (Arduino)

Voltage division to make safe voltage for arduino input

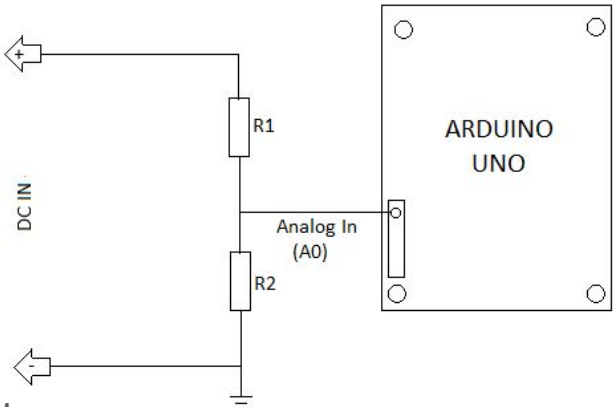
The max voltage the arduino i/o can use is 3.3V, our max voltage is 12.6V

Using a 4:1 Voltage ratio provides safe reading level.

100k and 33k resistors being used.

Arduino has 10 bits of resolution or for 3.3V/1024 = 3.2mV/div

With the voltage scaling, we can measure a change of ~13mV



The importance of monitoring voltage is to compensate for Voltage losses/drop to extend flight time and hovering capability

RS1306B-4000KV
Motor Weight：9.6g(No Included with silicone wire)
Silicone wire Weight：0.7g 26AWG：65mm length

Motor Type	Voltage (V)	Propeller	Current (A)	Thrust (G)	Speed (RPM)	Efficiency (G/W)	Power (W)	(%)
RS1306B -4000KV	12.6V	kingkong 3045	1.1	52	12940	3.75	13.9	30%
			1.9	82	16360	3.43	23.9	40%
			2.9	113	19940	3.09	36.5	50%
			4.1	150	21700	2.90	51.7	60%
			5.7	190	24440	2.65	71.8	70%
			7.9	232	26880	2.33	99.5	80%
			10.1	266	28760	2.09	127.3	90%
			14.6	389	Max	2.11	184.0	100%

Motors

EMAX 1306b 4000KV Race SPEC

1306 denotes the bell housing size

13mm wide, 6mm tall

4000 KV means the RPM/Volt unloaded

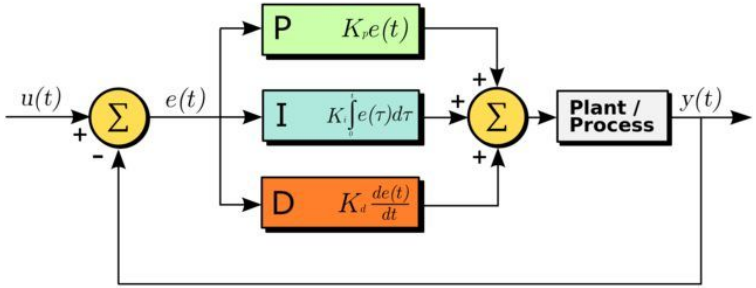
@12.6V x 4000KV = 50,400 Max RPM

At 350g, each motor needs ~100g of thrust, at 2.9A at 50%

Estimated flight time

2500mah @ 10A = 12 min flight time

Motor Control



Using PID control for each axis (pitch, roll, yaw)

The plant/process or each axis is the individual motor speeds. The total motor speed for each motor is the sum of each pid control.

-> Current loop time is 100Hz (a relatively low refresh rate, based on IMU sampling)

Code Sample:

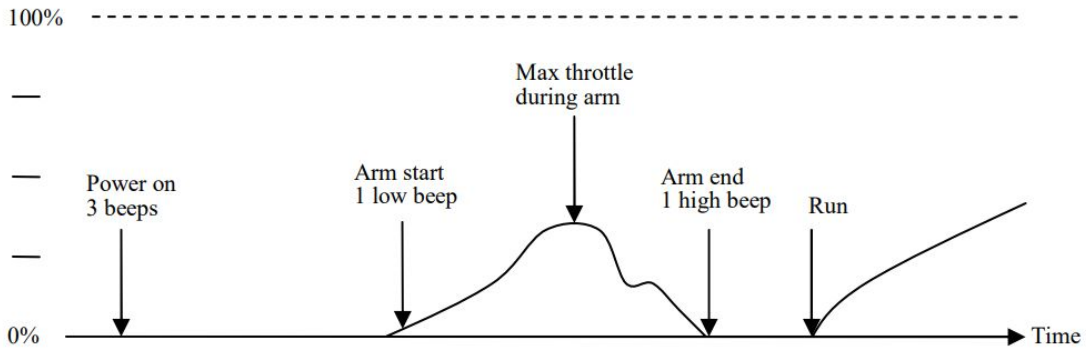
```
Motor2 = throttle + PID_Roll - PID_Yaw;
Motor3 = throttle - PID_Roll - PID_Yaw;

Motor1 = throttle + PID_Pitch + PID_Yaw;
Motor4 = throttle - PID_Pitch + PID_Yaw;
```

Since we are using a (+) frame arrangement, it simplifies the pid summation for each motor as each motor only affects a specific axis

Motor Control 2

The brushless motors are controlled by electronic speed controllers using BLHeli (a popular multirotor firmware), the motor speed is controlled using a pwm signal of 1000-2000ms (similar to a servo pwm).
The arming sequence must be performed every time the power is reconnected.

The arming sequence for BLHeli shown below. Implemented in arduino using for loops.

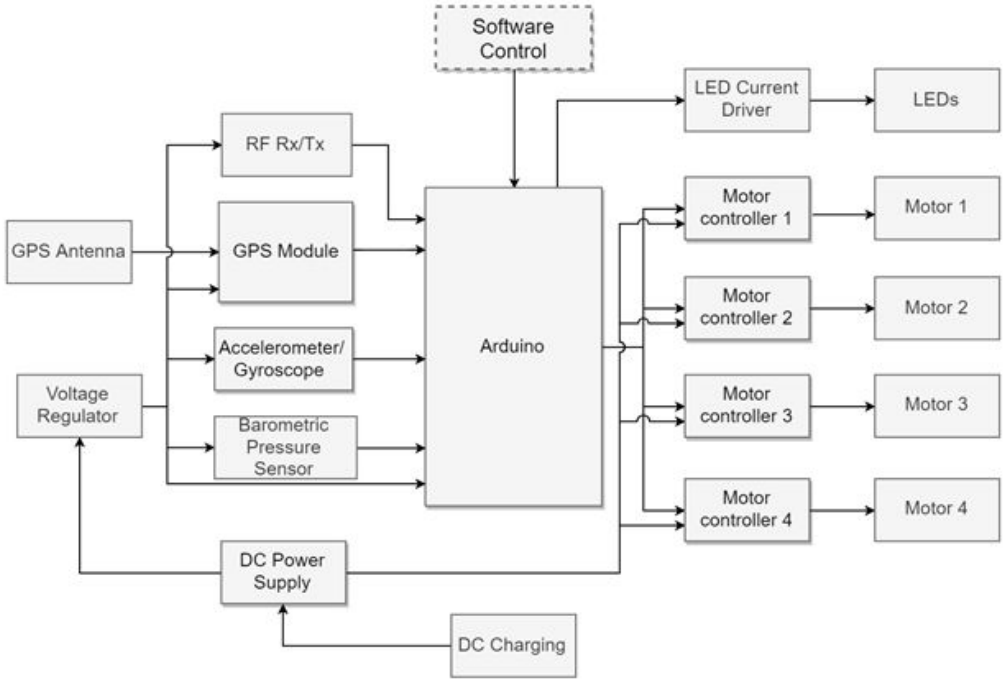


https://www.tme.eu/Document/565a6d126189bb1b31b17819c38dcc5c/Bullet%20firmware%20instruction.pdf

```
for (int i = 1000; i < 1050; i += 1)
{
  motor1.writeMicroseconds(i);
  motor2.writeMicroseconds(i);
  motor3.writeMicroseconds(i);
  motor4.writeMicroseconds(i);
  delay(100);
}
for (int i = 1050; i > 1000; i -= 1)
{
  motor1.writeMicroseconds(i);
  motor2.writeMicroseconds(i);
  motor3.writeMicroseconds(i);
  motor4.writeMicroseconds(i);
  delay(100);
}
```

Systems Control

Arduino microcontroller
BLE 33 Sense
- STM32 Cortex M4 processor
- Several on-board sensors



Signal Lighting (Jacob Milton)

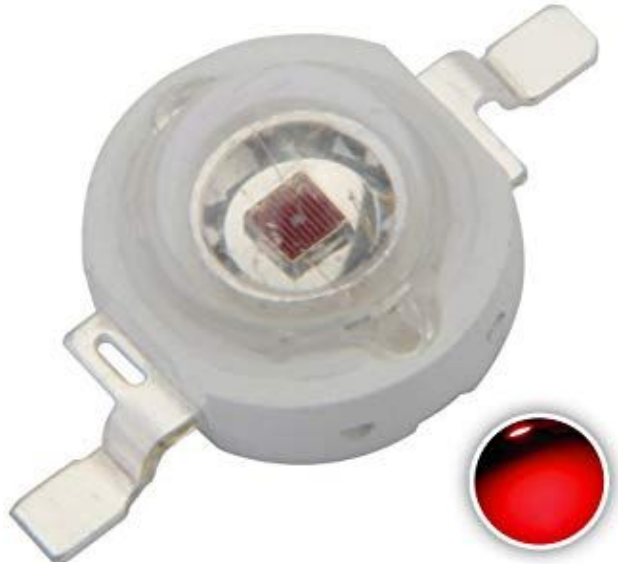
Using eight (2 per side) 3-Watt COB LEDs for high visibility.

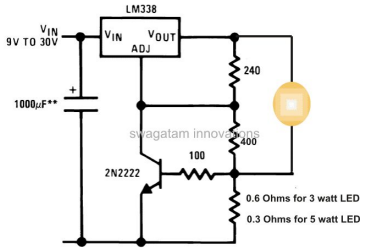
3 watt vs 5 watt - lower power consumption

The ability to blink the SOS signal will distinguish from other signal and reduce overall power consumption while using maximum current

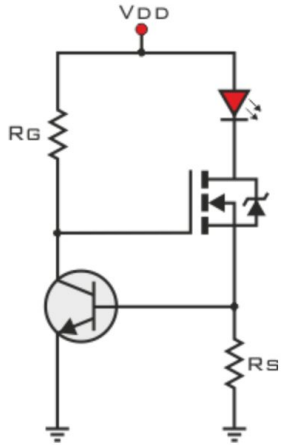
We will need to use DC LED Driver circuits for power control

Dedicated ATtiny85 controller

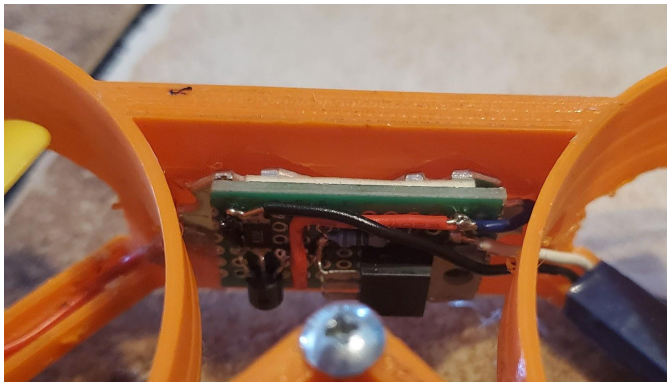




Light Emitting Diodes



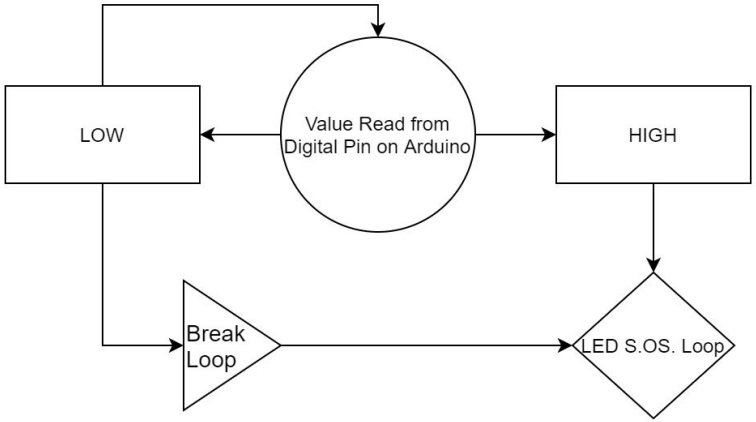
- Needed to create a LED driver circuit to maintain the current going through the LEDs
- While most LED drivers are big, we had to design one that would be lightweight and small
- We will be creating two seperate LED drivers with MOSFETS and resistors in parallel.
- There will be 4 LEDs in series per circuit

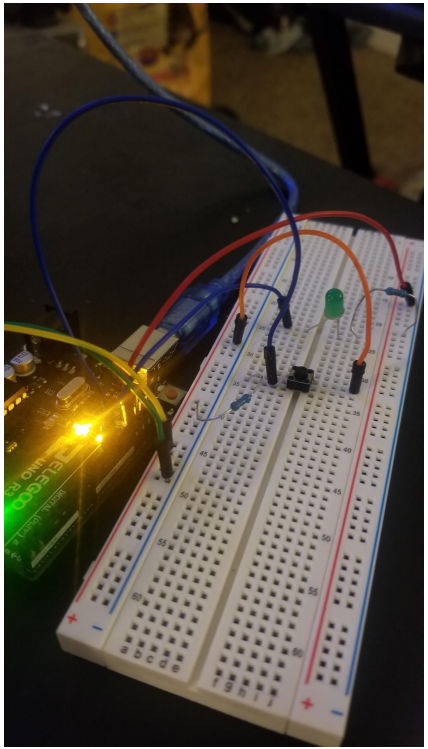


S.O.S. Morse Code

- Invented after Samuel Morse as a way to encode text through telecommunication
- Morse code letters are created by a series of dots (.) and dashes (-)
- Today Morse code is outdated and unused
- The term S.O.S. is universally acknowledged as a cry for help
- S (. . .) O (- - -) S(. . .)

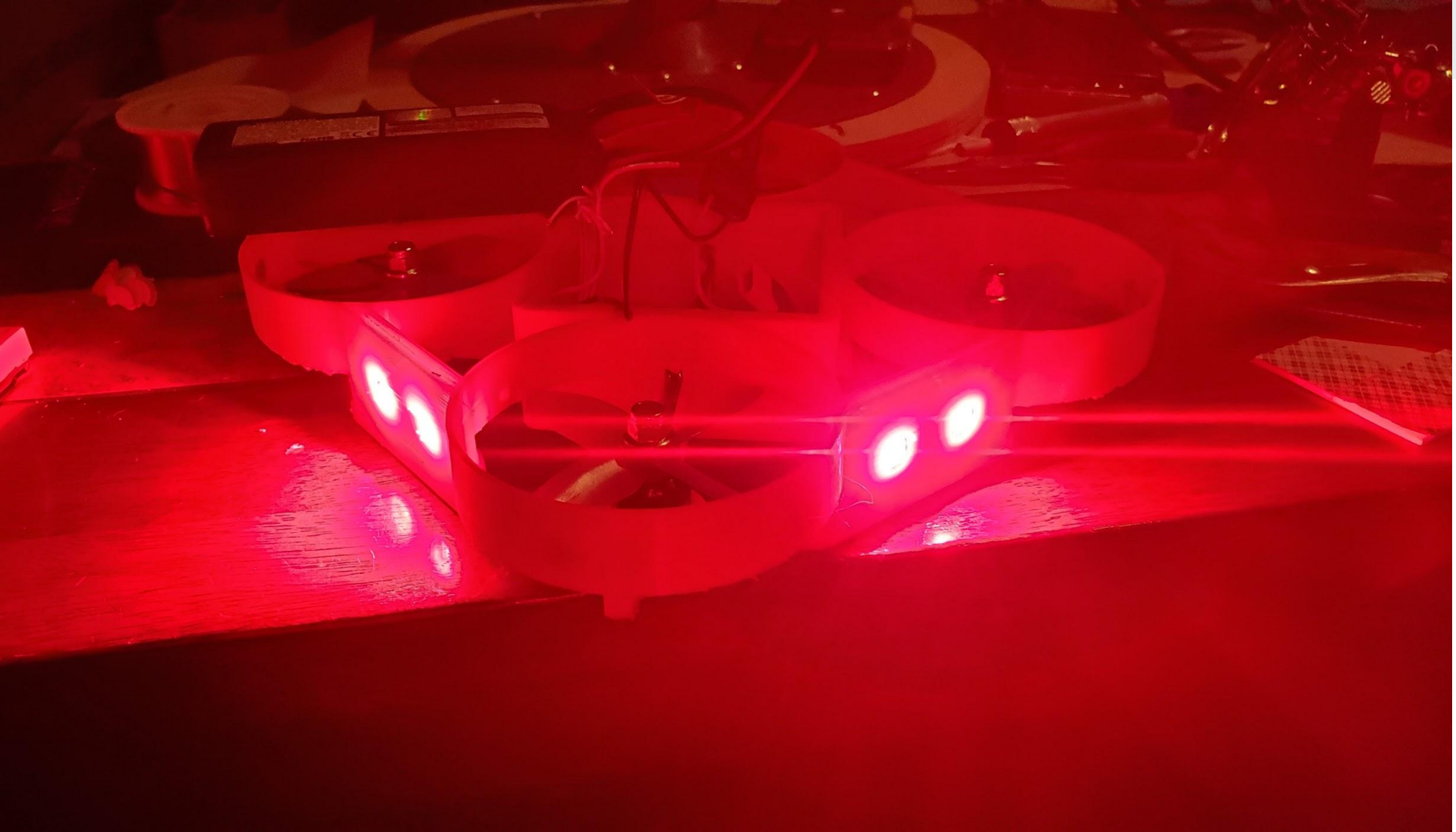
S.O.S. Implementation in Arduino





Prototype to test code

DO NOT PULL

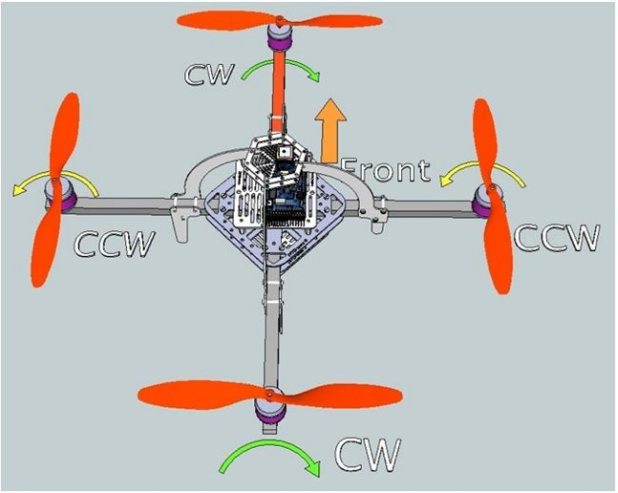


Cost Analysis (BOM - bill of materials)

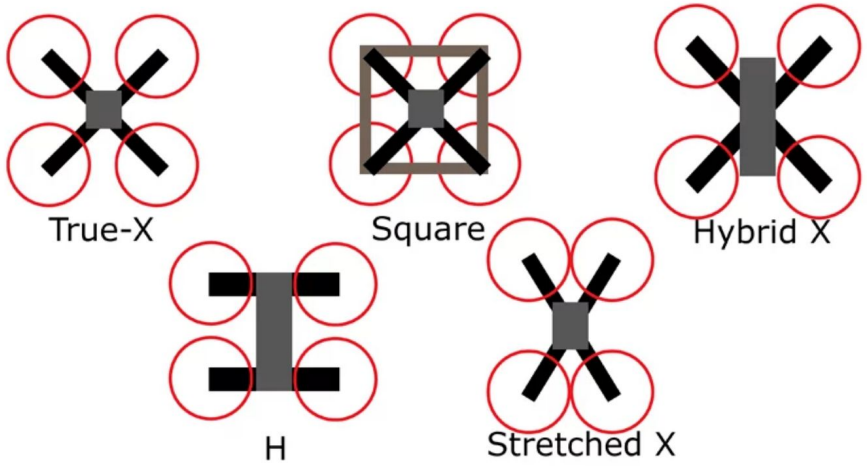
Qty	Item #	Description	Unit Price	Discount	Line Total
1	https://www.getfpv.com/azure-power-3060-3-blade-propeller-set-of-4-clear.htn	Azure Power 3060 - 3 Blade Propeller (Set of 4)	2.99	0	2.99
4	ESC (donated)	Favourite Little Bee 20A 2-4S ESC (No BEC)	0	0	0
1	https://store.arduino.cc/usa/nano-33-ble-sense-with-headers	Arduino BLE 33 Sense	31.5	0	31.5
4	https://www.getfpv.com/emax-rs1306b-v2-4000kv-brushless-motor-cw.html	EMAX RS1306B V2 4000KV Brushless Motor CW	10.99	43.96	0
	https://www.adafruit.com/product/2472	Adafruit 9-DOF Absolute Orientation IMU Fusion Breakout - BNO055	32.82	0	32.82
1	https://www.adafruit.com/product/746	Adafruit Ultimate GPS Breakout - 66 channel w/10 Hz updates - Version 3	39.95	39.95	0
1	https://www.amazon.com/OVERTURE-Filament-Consumables-Dimensional-A	3D Solutech Real Orange 3D Printer PLA Filament 1.75MM	23.99	0	23.99
1	https://www.amazon.com/Chanzon-400mA-500mA-Intensity-Components-Ligt	Chanzon 10 pcs High Power Led Chip on Board 3W Red (400mA-500mA/DC 2V-2.4V/3 Watt)	7.09	0	7.09
1	https://www.amazon.com/Chanzon-Aluminum-Circuit-Substrate-Heatsink/dp/B	Chanzon 25pcs 1W 3W 5W LED Heat Sink Beads 1/3/5 Watt	5.88	0	5.88
1	https://www.amazon.com/gp/product/B07HCDRL7W/ref=ox_sc_act_title_1?sr	Easycargo 10gram Thermal Conductive Glue	5.88	0	5.88
4	https://www.imrbatteries.com/lg-hg2-18650-3000mah-20a-battery/	LG HG2 18650 3000mAh 20A Battery	5.49	0	21.96
2	https://www.amazon.com/gp/product/B07S8QQYFR/ref=ppx_yo_dt_b_asin_tit	RuiLing 2-Pack N-CH Arduino Power Mosfets TO-220 ESD Rated 60V 30A RFP30N06LE	5.99	0	5.99
1	https://www.amazon.com/gp/product/B07KD2CN3F/ref=ppx_yo_dt_b_asin_tit	3S 20A Li-ion Lithium Battery Protection Board 18650	6.69	0	6.69
2	https://www.digikey.com/product-detail/en/vishay-dale/WSL2512R3500FEA/5	WSL2512R3500FEA 1W SMD Resistor	1.16	0	2.32
1	https://www.digikey.com/product-detail/en/sparkfun-electronics/BOB-12009/1	1568-1209-ND SparkFun Logic Level Converter	2.95	0	2.95
1	https://www.sparkfun.com/products/14353	SparkFun Lumenati 4-pack	4.95		4.95
			Total Discount	$ 83.91	
				Subtotal	$ 155.01
				Sales Tax	0.08
				Total	$ 167.80

Frame (Johnny Camarena)

We are using a True-X in a plus system configuration

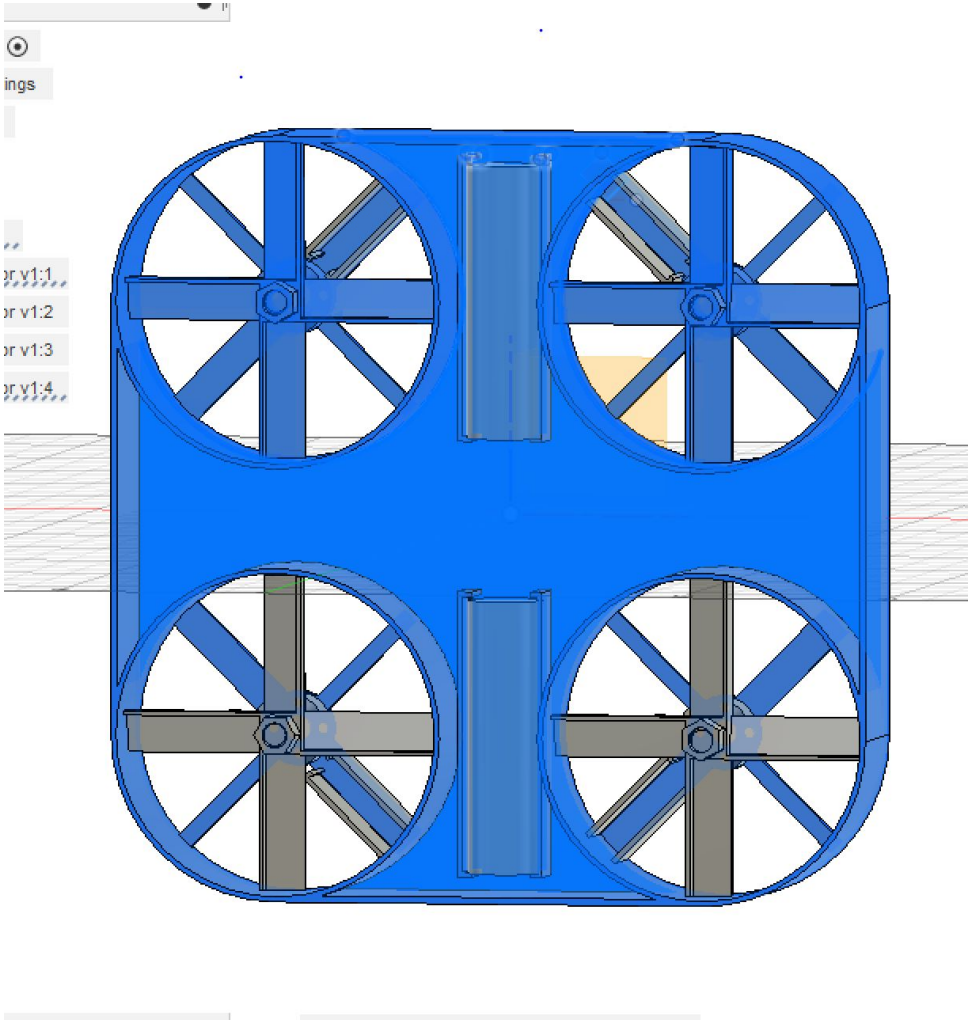


FPV Frames:
Common Frame Shapes



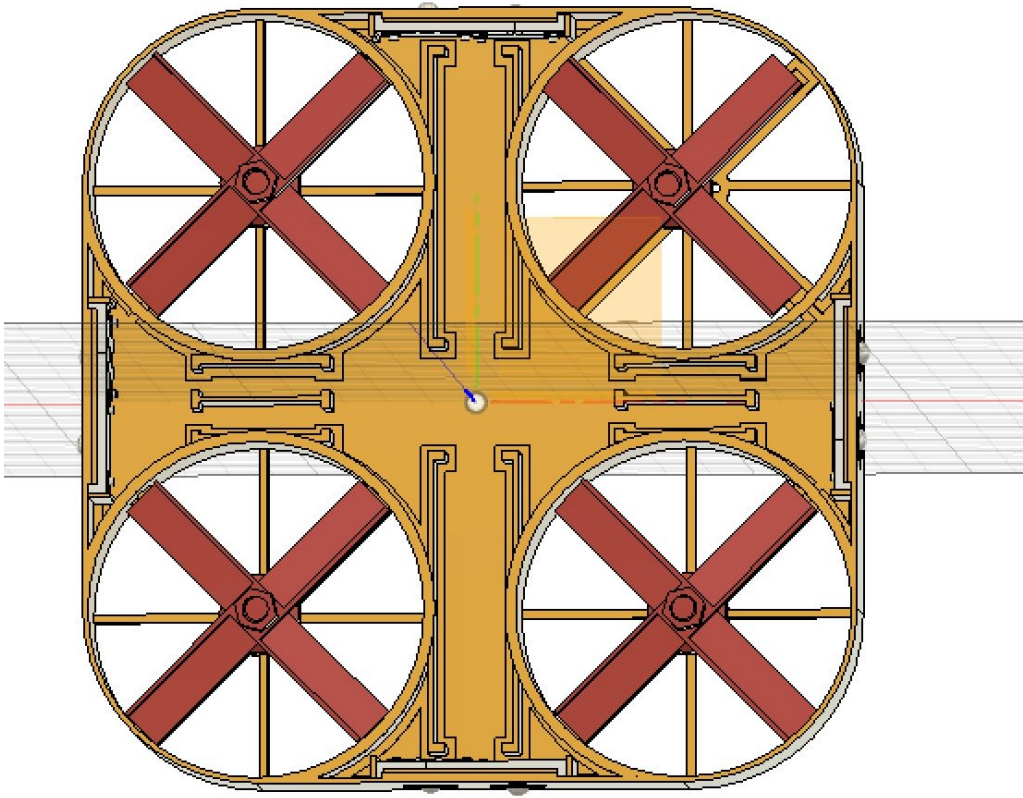
Version 1

- Too heavy ~200g +
- Not enough room to work with



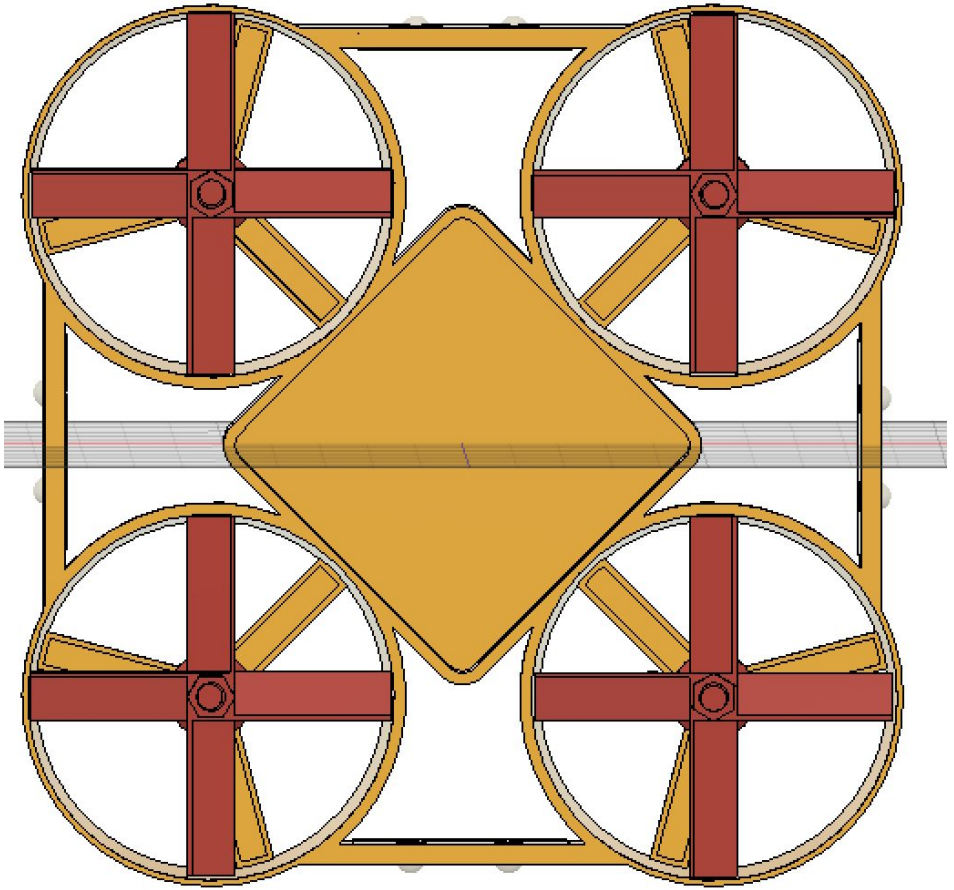
Version 3

- More room to work with
- Slightly bigger frame



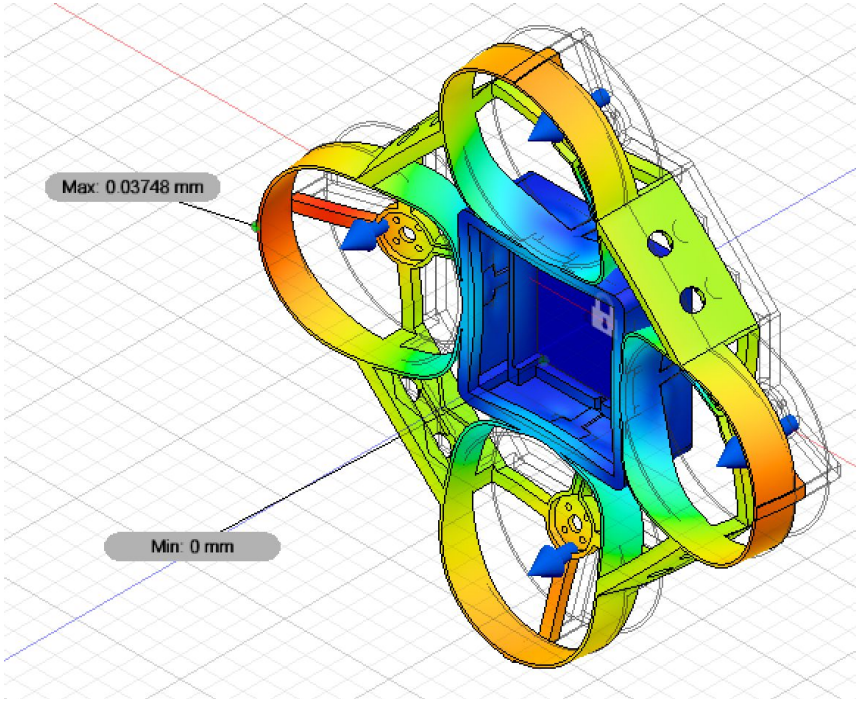
Version 6

- More Aerodynamic
- More space for components
- Lightest model so far
    - ~ 80g

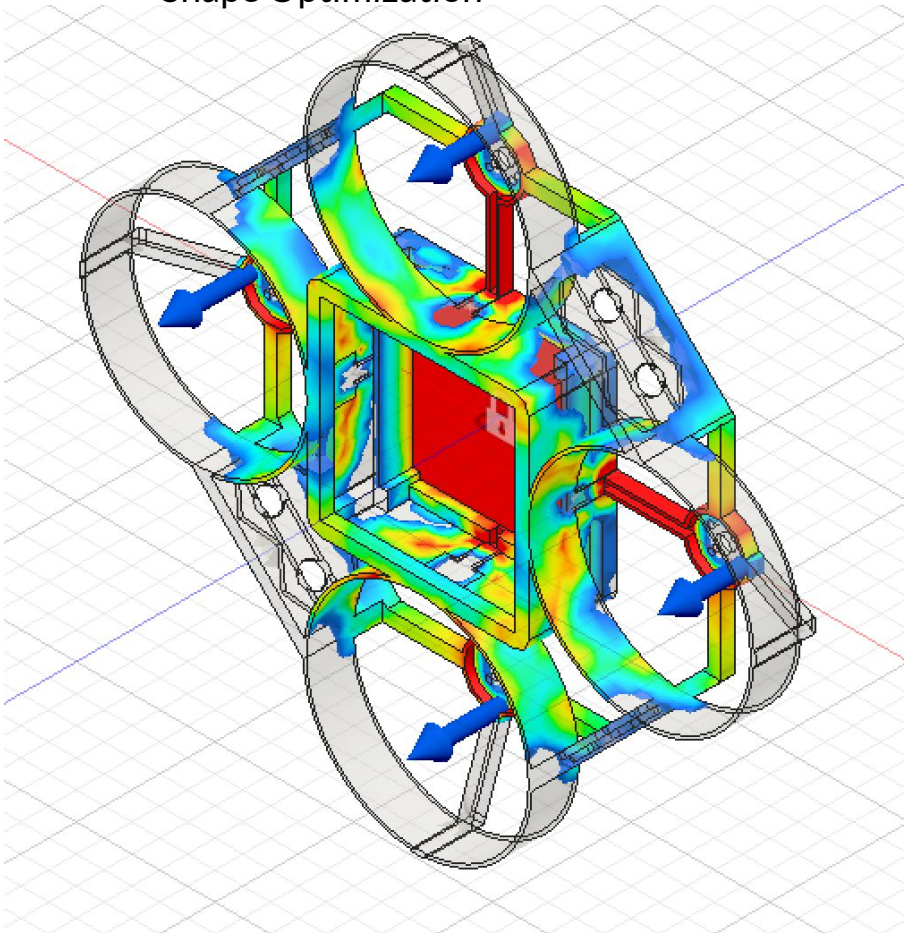


Version 8

Static Stress

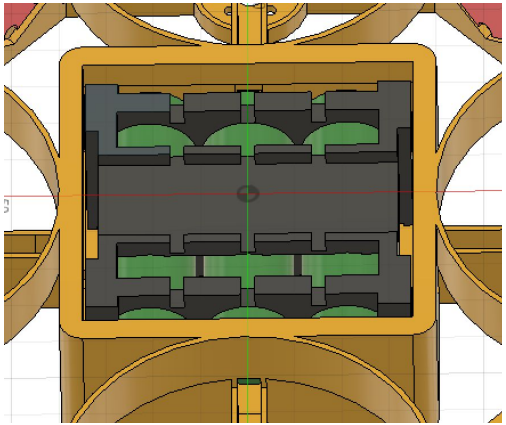


Shape Optimization



Cartridge

Designed to be able to remove electronics components and batteries as one piece by using a power distribution board for the motors and esc



3D Printing of Frame

Slicing Software

Cura -

Produces the G-code for the printer

Printer settings:

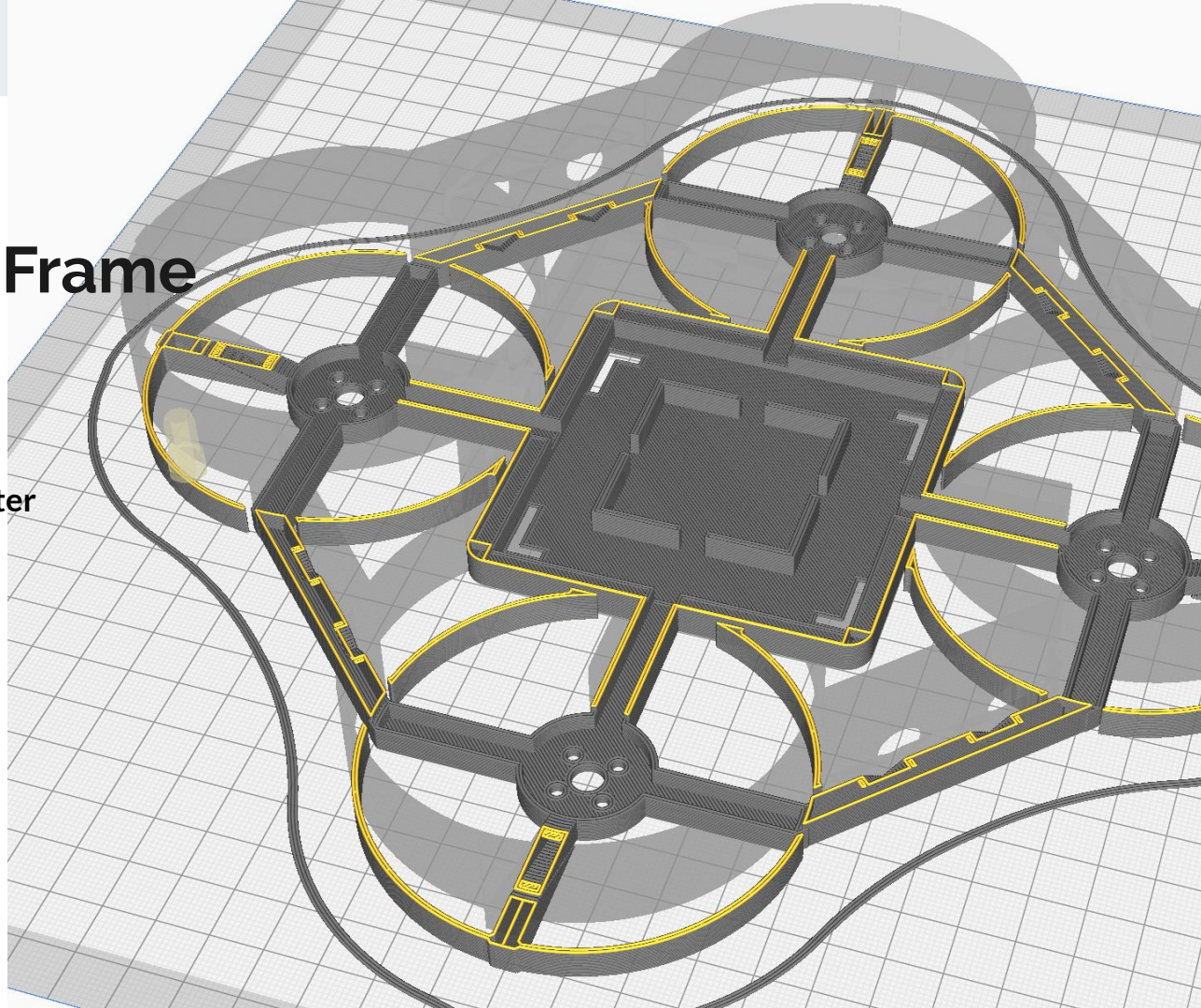
Sidewall thickness: 0.6mm

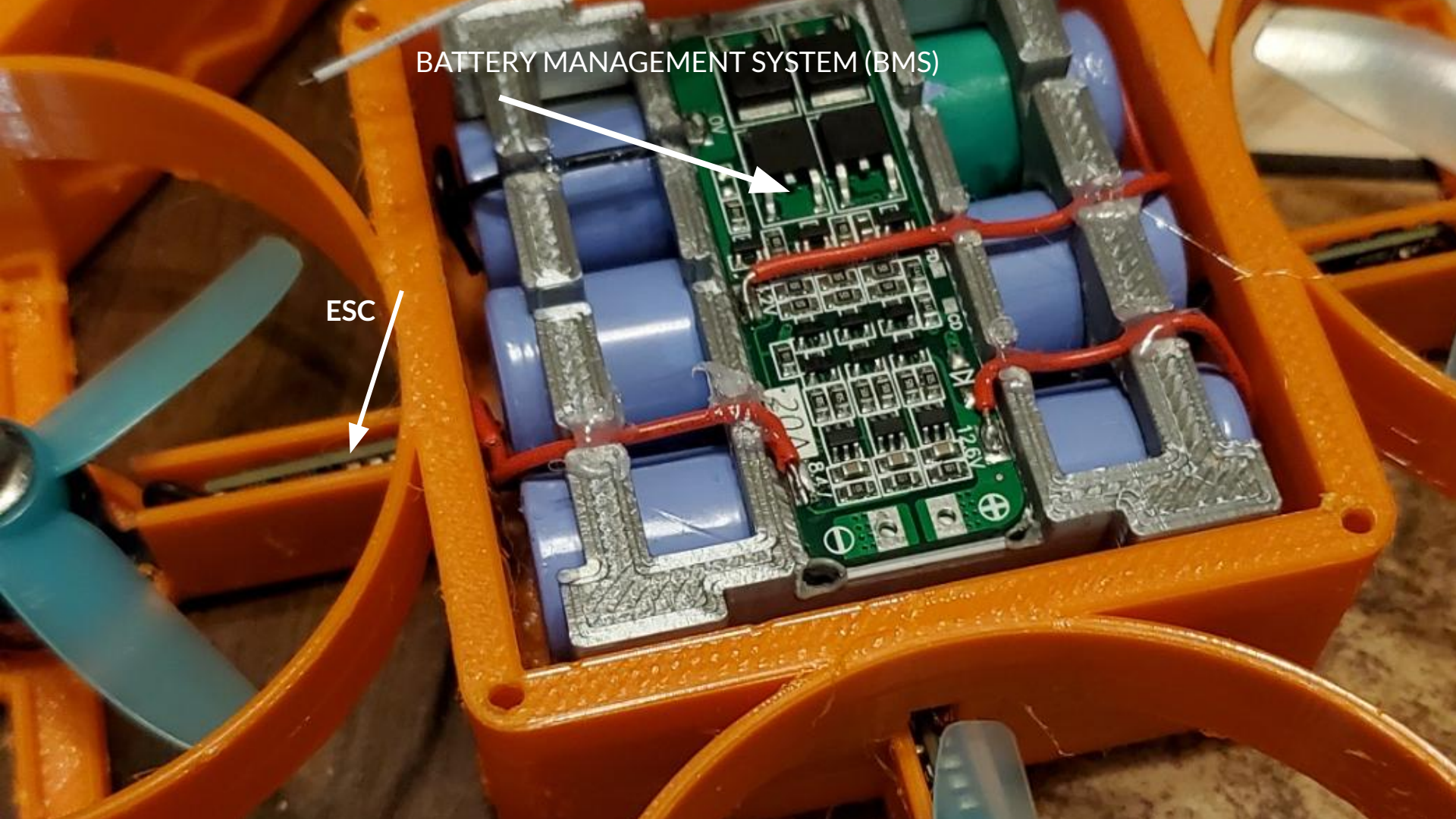
Upper/lower thickness: 0.64mm

Infill: 0% - To reduce weight, strength comes from the wall thickness

Layer height: 0.2mm

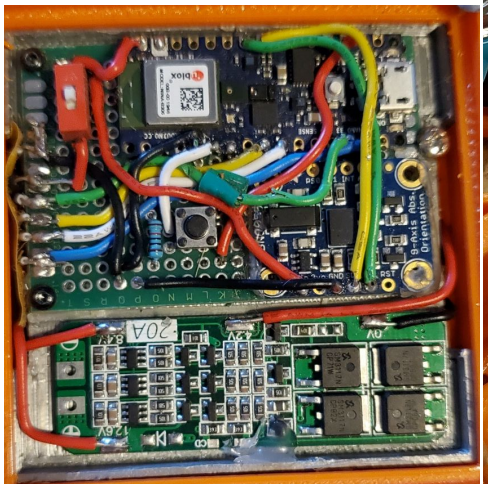
Printing Temperature: 240 C

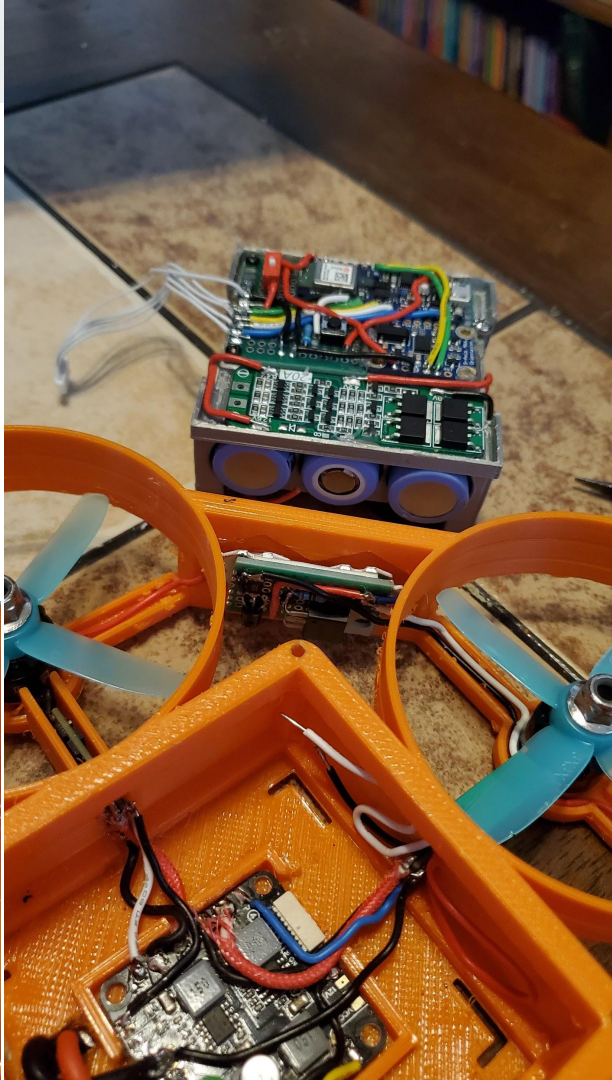



BATTERY MANAGEMENT SYSTEM (BMS)
ESC

Re-designed components

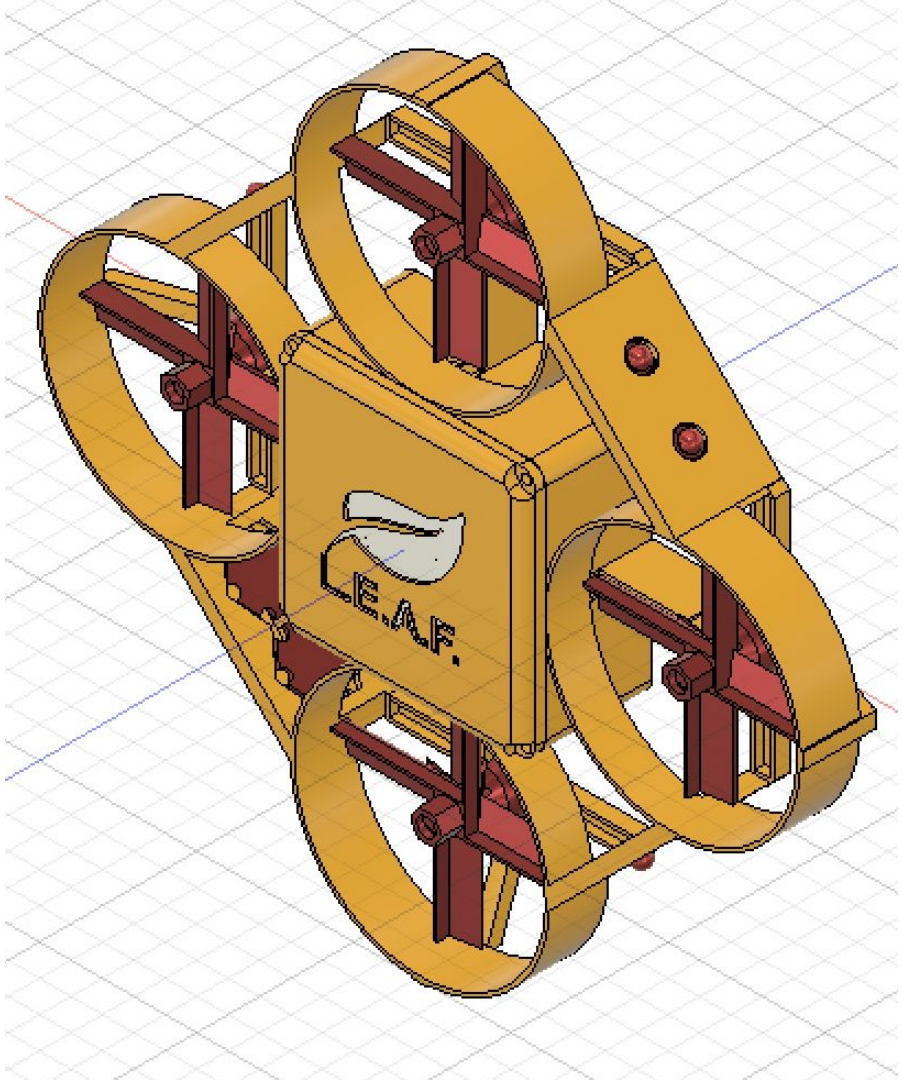
New design allows for components to be removed for programming, battery replacement, etc





Version 8

- More room to work with
- Slightly bigger frame
  - 215mm square
  - ~95g
  - Stronger than V6
- Made with PETG
  - Stiffer than PLA
- Approx ~12 hours per print
  - For best quality

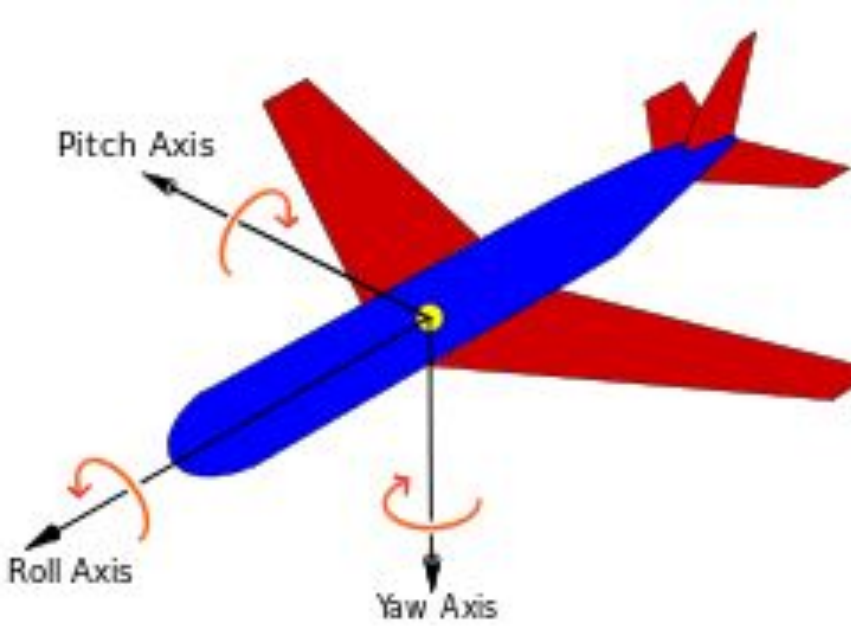


Sensors (Adam)

Since there is no controller inputs, the motor speeds must correspond to sensor readings from a GPS, altitude, accelerometer, magnetometer, and gyroscope.

The BNO055 sensor will calculate roll, pitch, and yaw

The GY-NE06MV2 GPS sensor will calculate the latitude, longitude, and altitude.

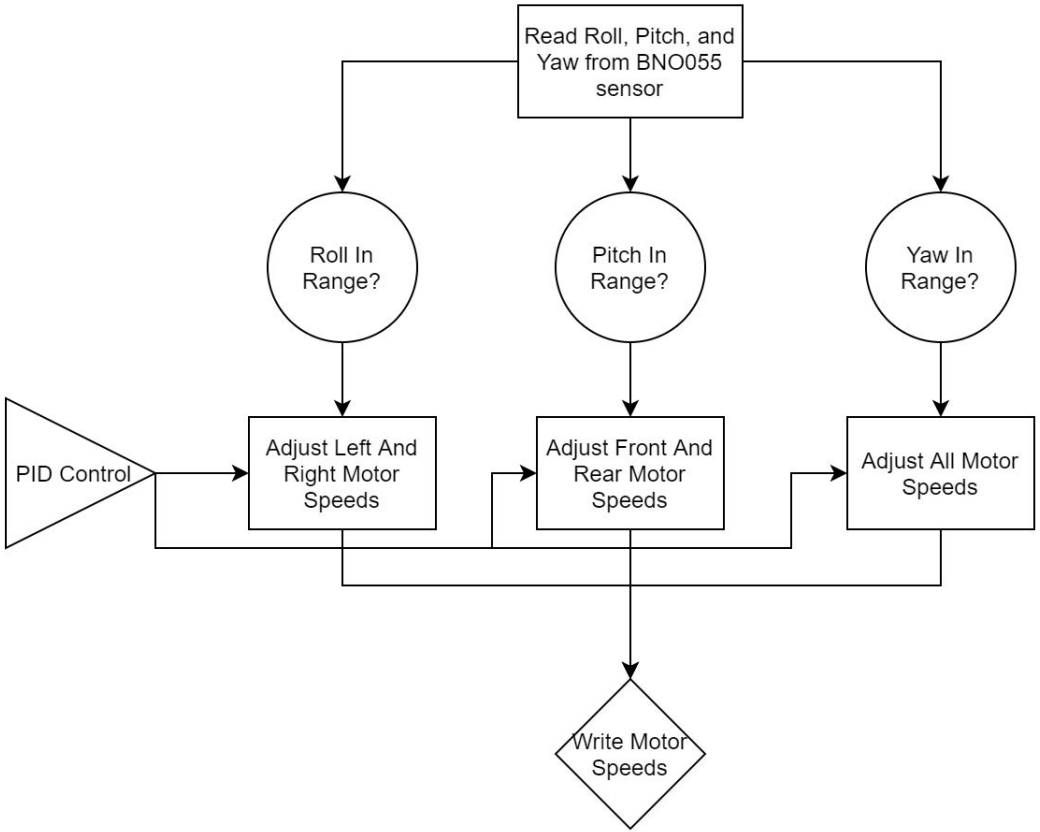


Sensor Data Flowchart

-Data is read from the BNO055 sensor

-Motors are adjusted based on roll, pitch, and yaw.

-PID control is used to fine tune the balancing function



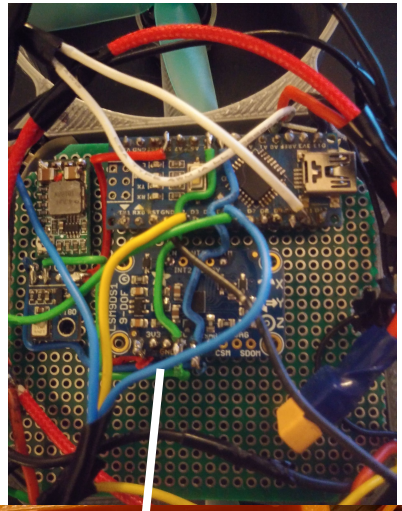
Choosing The Right Microcontroller & Sensors

Originally we were using a seperate Arduino nano (16 MHz) and LSM9DS1 sensor.

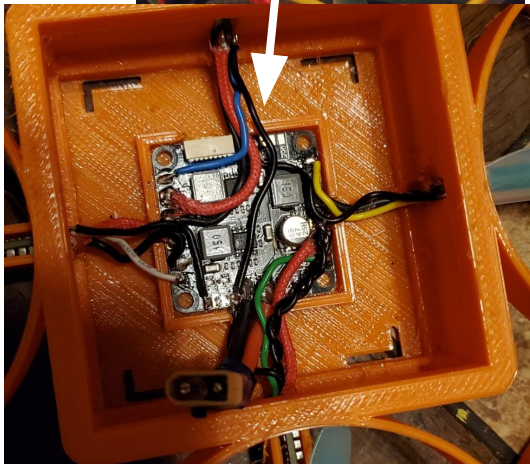
Then we came across the Arduino nano 33 sense (64MHz) with an onboard LSM9DS1.

This provides 4x the clock rate and occupies about half the area.

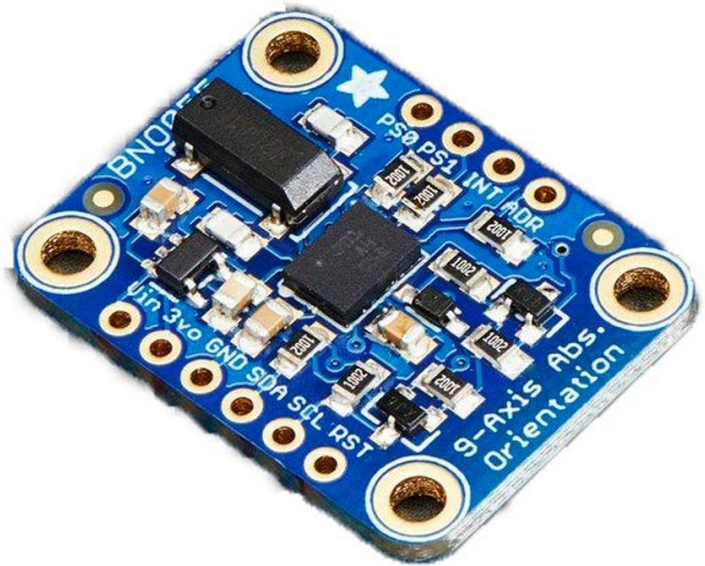
Prototype ESC Wiring



Finalized wiring using PDB



Adafruit 9-DOF Absolute Orientation IMU Fusion Breakout - BNO055



Calculations of roll, pitch, and yaw based on raw gyroscope, accelerometer, and magnetometer can be difficult as they require a great deal of math.

Adafruit's BNO055 breakout board includes all required sensors as well as library functions to directly calculate yaw.

Although this board will make the built in LSM9DS1 sensors unused in our project, however the increased clock rate of the Arduino Nano Sense 33 BLE will provide the necessary performance.

Conclusion (GENESIS MANGUNAY)

Updates:

- Frame updated to meet design constraints
- All components acquired
- Still fine tuning the code
- Further testing base components

Things to finish

		Not finished	FInished	
Frame	• Assembly of all components.	✗	✓	• Frame is complete
Components	•	✗	✓	• Motors • Arduino unit • LED/ Mosfets x8 / current sense resistors • Batteries • Battery management system • Addressable RGB light indicator.
Coding	• Coding for GPS sensor	✗	✓	• LED coding completed • IMU (inertial measurement unit) almost completed • Altitude completed • Gyroscope completed / Yaw code completed.

Timeline

January	Initial test of sensor readings, flight controller settings
January	Initial test of autonomous flight
February	First design of body printed
February	LED testing
February	Maximum LED visibility test
March	Test of base components
March	Completion of base components
April	Completion of system testing

Due to the COVID-19, the project has come to a halt. We are unable to meet up which has impacted the project timeline and completion.