RACING DRONE DESIGN
FUNDAMENTALS

By Eli DElia
UAV Designer

Eli DElia

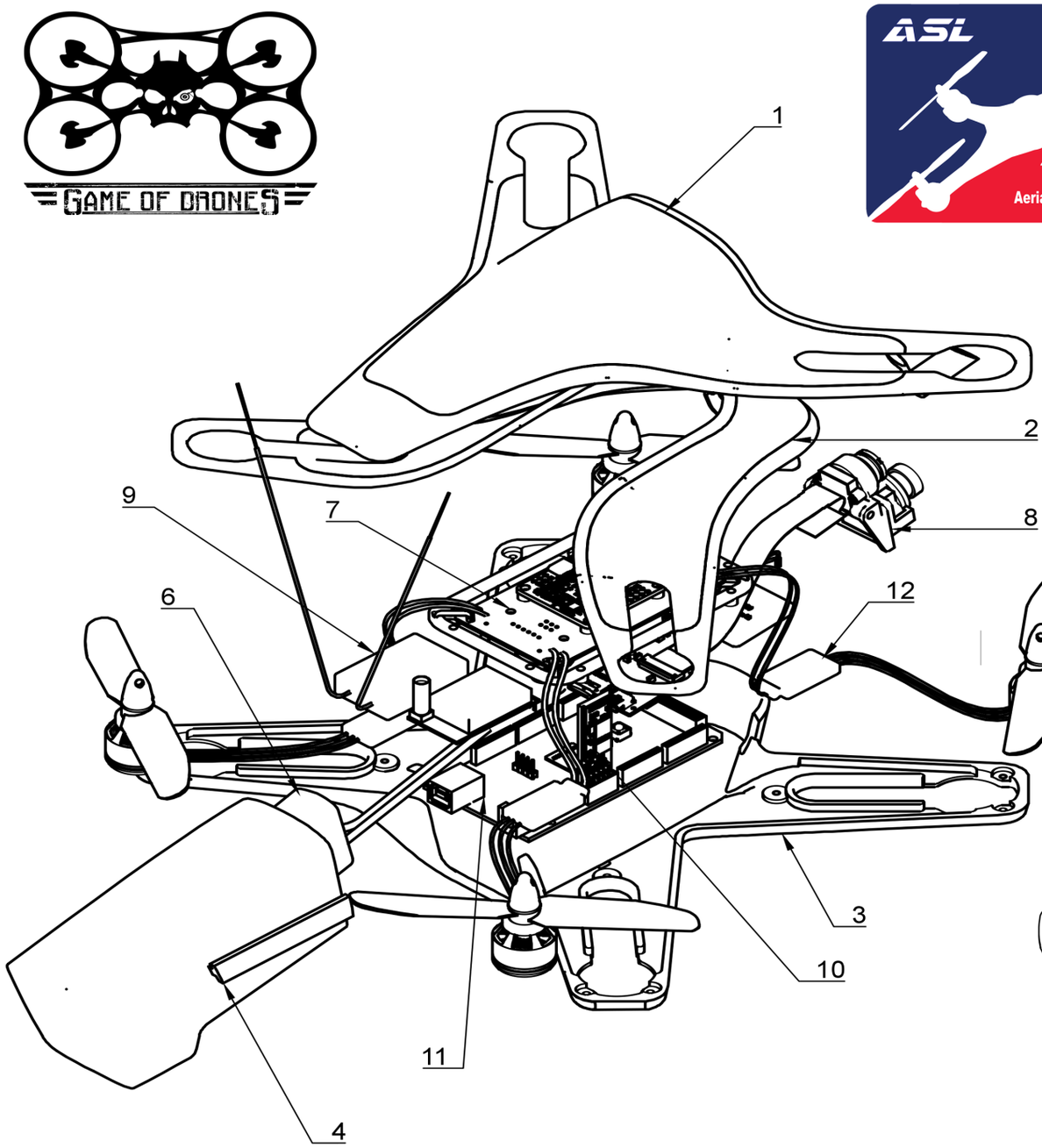
Commercial Drone Designer, Fusion360 Expert Elite.

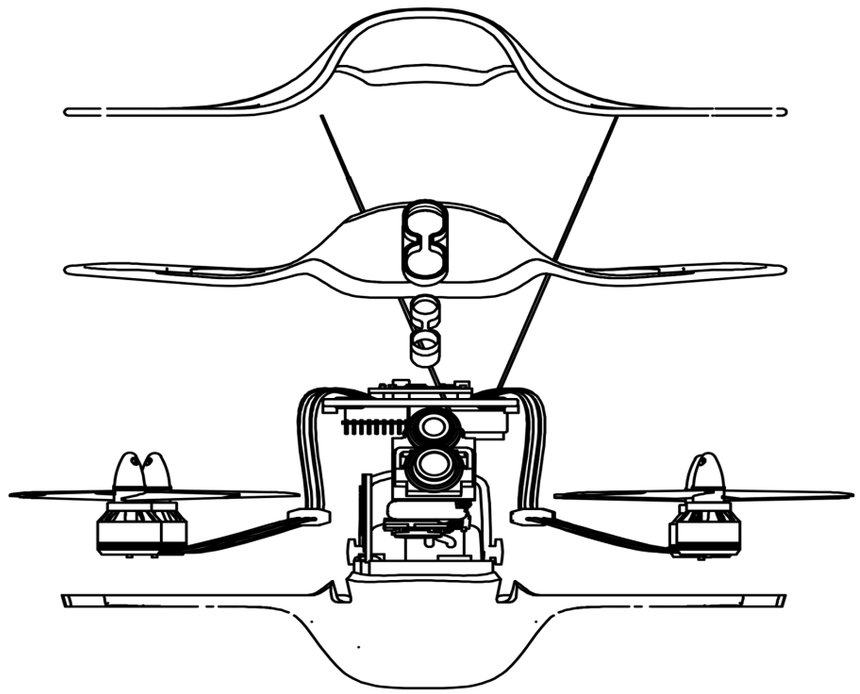
Founder of Game of Drones, Aerial Sports League. Owner Eagle Eye Metrics, Aerial Agronomy & Services

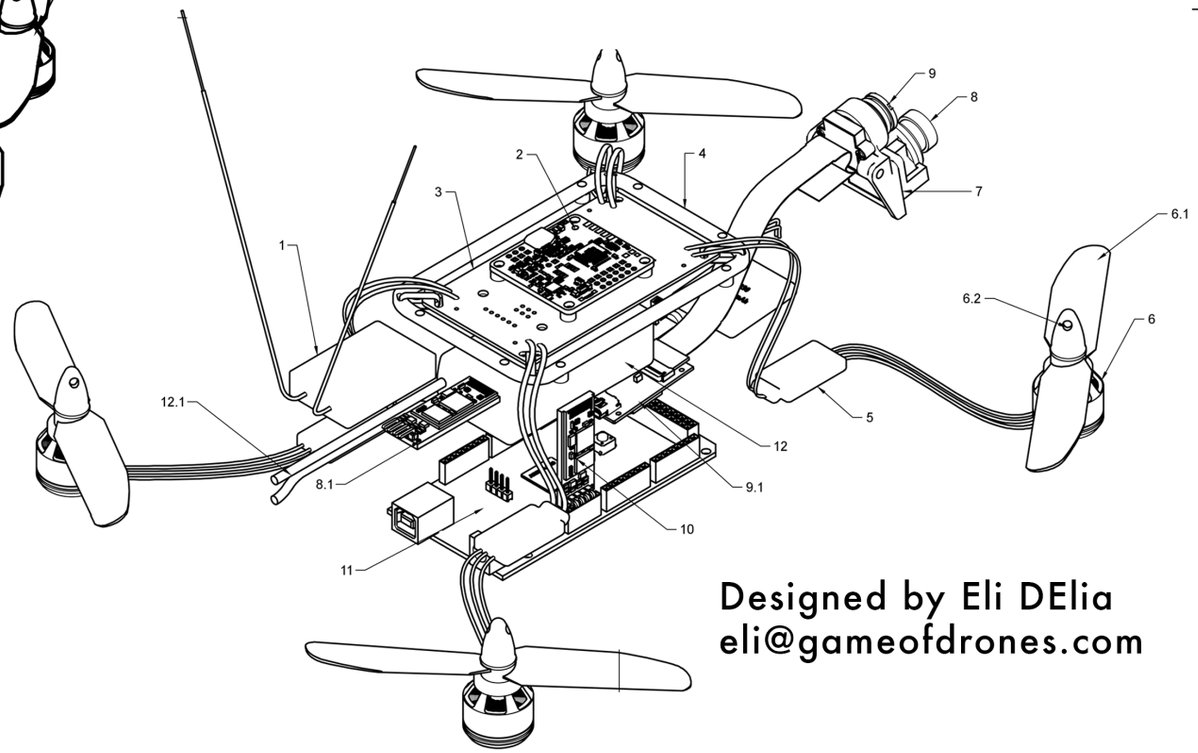
HIRO Sports Drone

Fire, Water & Impact Proof

“WEB RUNNER” IoT Racing Drone







Designed by Eli DElia
eli@gameofdrones.com

Taylor Stein

Product Evangelist at Autodesk, focusing on Fusion 360. Taylor aims to enable and inspire the next generation of designers, makers, and engineers by utilizing Autodesk's latest design and manufacturing software for real world applications.

Bryce Heventhal

Technical Marketing Manager for Fusion 360. Has 9+ years of CAD and FEA experience, with a B.S. in Mechanical Engineering. He creates many of the Fusion 360 videos you see on Youtube. Avid rock climber

(Presumed likeness)

Paul Sohi

Autodesk Product designer, mostly a snowboarder, comics/ games geek, doodler and occasionally a PhD person too.

Mickey Wakefield

Autodesk CAD and Simulation software manager. 20 years both helping individuals and companies improve their design and manufacturing processesWorld traveler, man in the know

DRONE RACING NOW

Pilots Compete In An Immersive, Adrenaline Driven AR Experience

2016 MINI DRONE RACING

ESPN

GoPro

Be a HERO.

Dubai
$1 Million
Prizes

IDRA

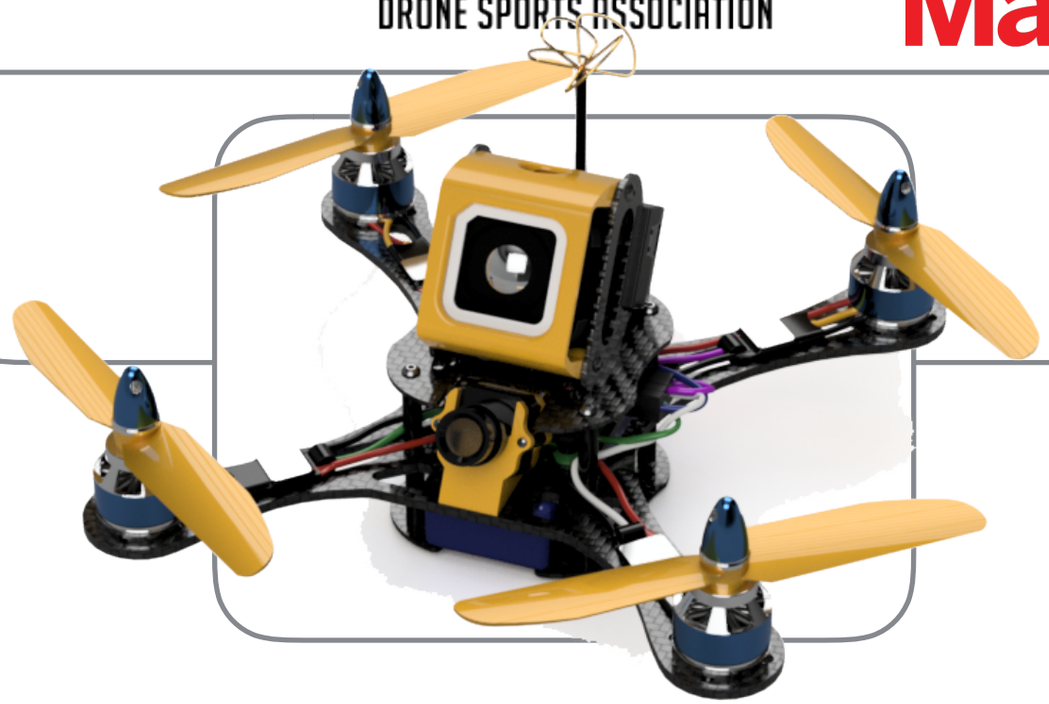
DRL

DSA
DRONE SPORTS ASSOCIATION

DRONE SPORTS ASL Aerial Sports League WORLD

Make:

WORLD DRONE RACING CHAMPIONSHIPS 2016 QUALIFIER EVENT



Hawaii
$60,000
Prizes

MINI FPV DRONE RACERS NOW

Exposed Components

Small, Fragile180mm thru 250mm

Airframes = Hard to Follow

2.5 gHz = Poor Video Range

3200+kv Motors = 110 mph

11.1 volt Batteries = 5 min flight times

HOOLIGAN AI X 1000

NVIDIA®

TEAM AUTODESK PRO RACING

DRONE DESIGN BY ELI DELIA

Next Generation Racing Drones

Larger, 1000mm +, Rugged, Monocoque Airframes

Smart, AI autonomy, Aerodynamics

HD Video • IoT Streaming

3200+kv = 110 mph • Longer Battery Life

Areas of Innovation

IoT • Rugged Element Proof • Machine Learning

Swarms

Intel Aerial

AI
Photogrammetry

NVIDIA

IoT

Qualcom

Autonomy • AI Photogrammetry Machine Vision

Pilot Side Tech

HD or 5.8 GHz RX Goggles

DRL

Pro Pilot Ken Loo

Fully Programable 2.4 GHz RC

Design Fundamentals

- **Battery size = Propeller size > motor size > ESC amps > airframe size**
- **Power to weight ratio = Battery > Prop size > Motor size > ESCs = Thrust x 4 motors**
- **Build and fly inline to the craft's center of gravity. CG = stability / clean flights**
- **Minimize overall airframe weight signature, every gram cut increases flight times by a few secs.**
- **Increased speed pitches drone forward. 30º is the sweet spot @ 70% power**
- **Current racing drones have been clocked doing 120 mph.**
- **Power to Weight Ratios / Battery charge + visual video transmission = range and flight time**

2 Flavors of Racing Drone

X configuration.

Small, tight, build with components stacked in line, vertically, center of gravity. Very acrobatic.

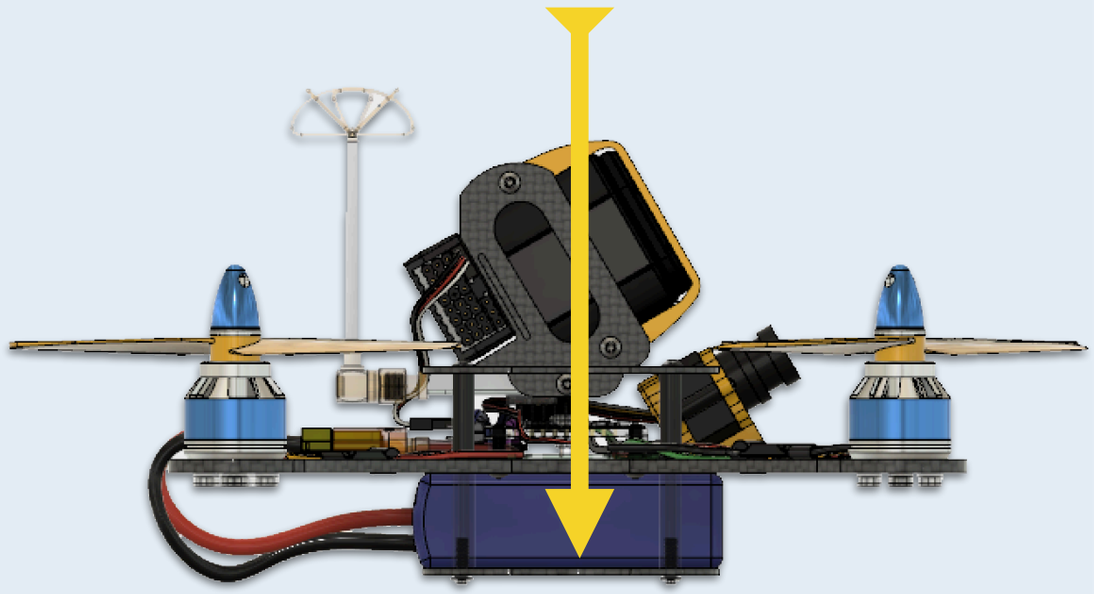
H Configuration.

Easy layout of components, spread out from front to back with the battery as the center of gravity.

2 Flavors of Racing Drone

X configuration.

Layout

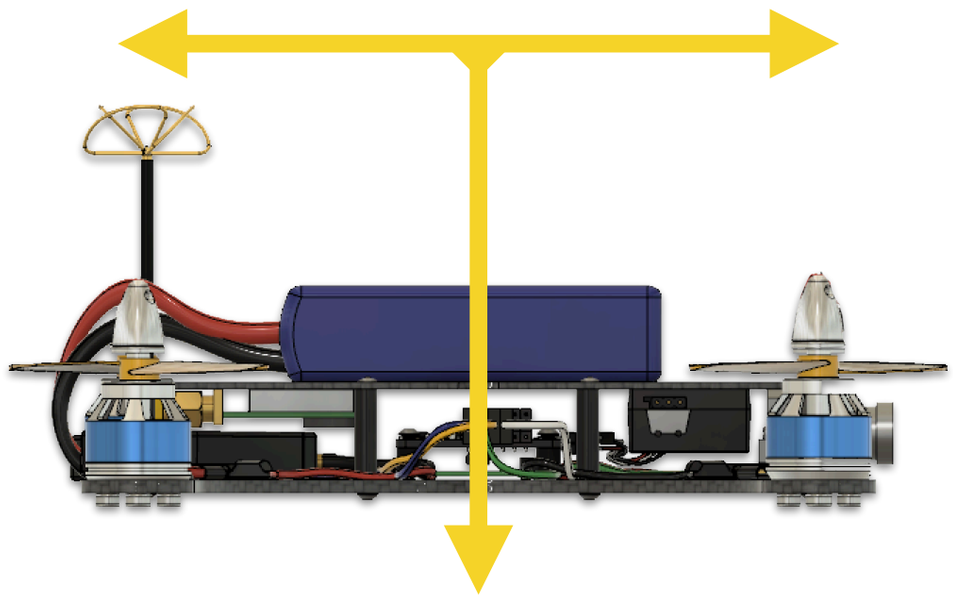


CG

Small, tight, build with components stacked in line, vertically, center of gravity. Very acrobatic.

H Configuration.

Layout



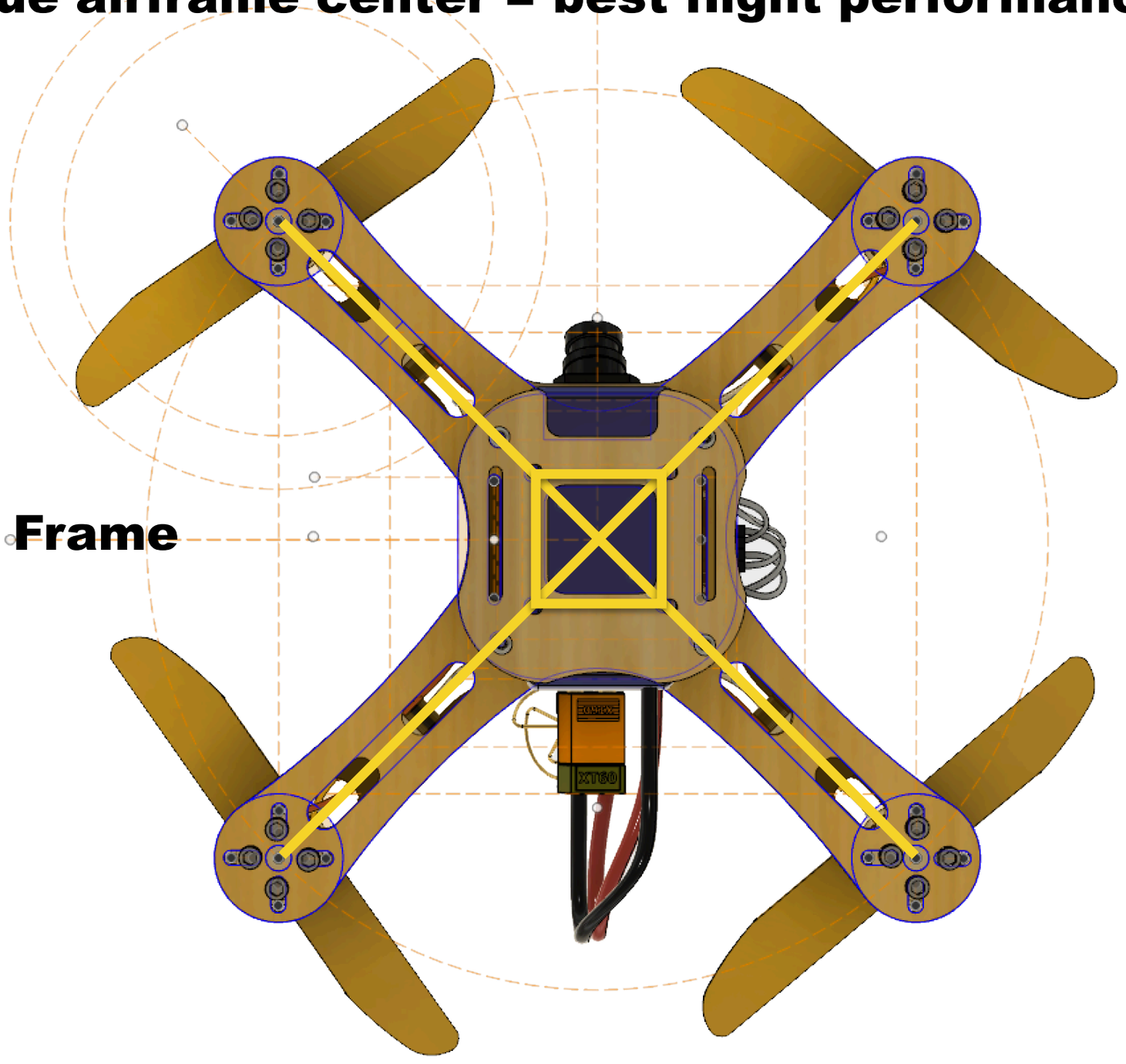
CG

Easy layout of components, spread out from front to back with the battery as the center of gravity.

Center Of Gravity

Components are stacked in line of
true airframe center = best flight performance.

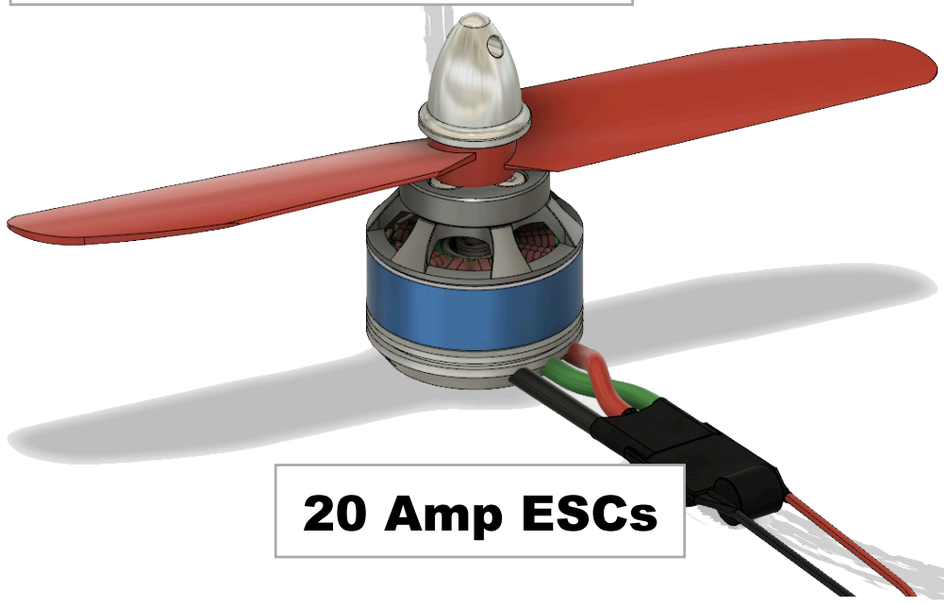
True X Frame



Off center alignment can overheat electronics
potentially killing ESCs and motors.

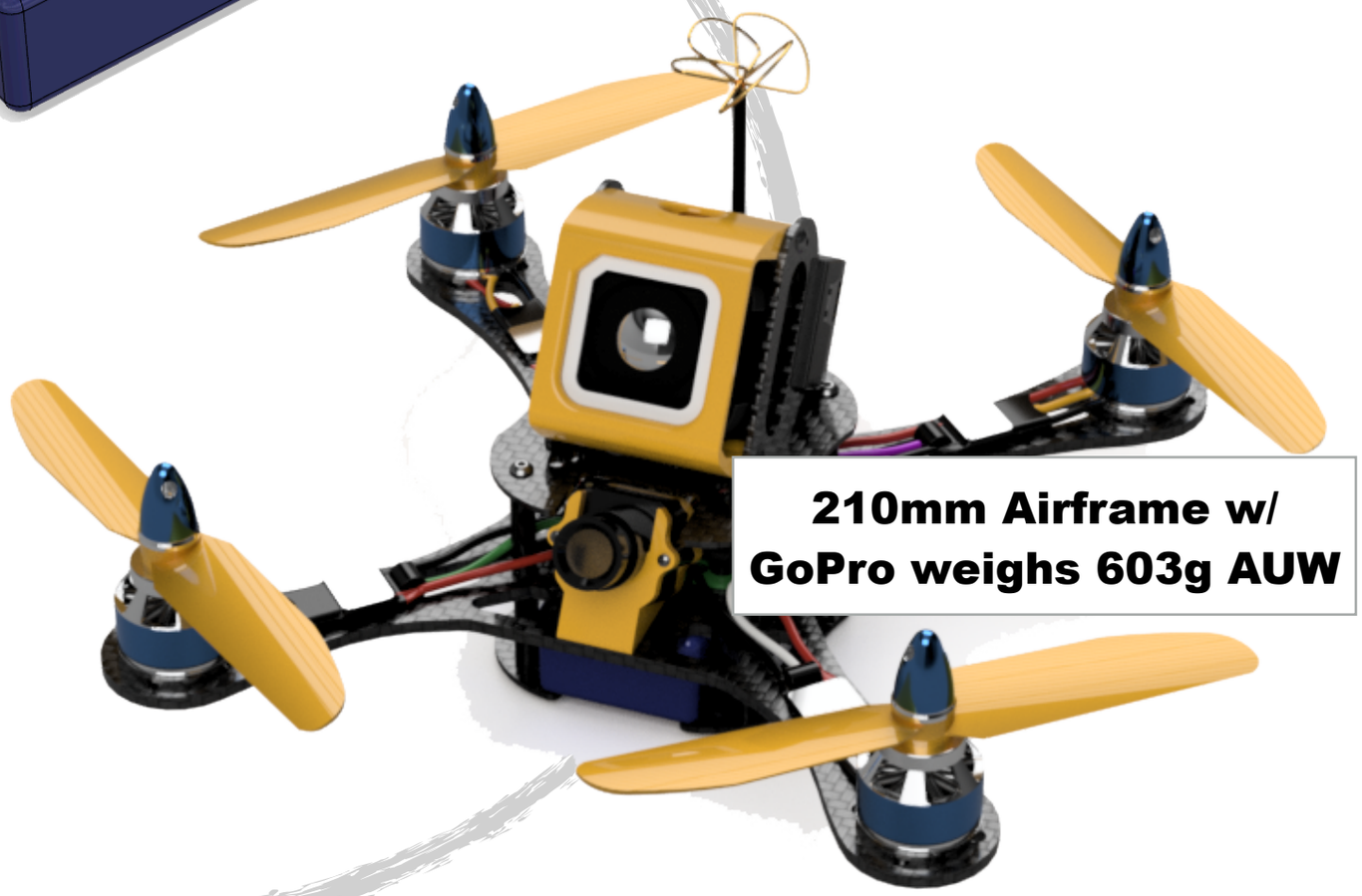
Power to weight ratio for the 210 X racer = 1:6.4
without cam or 1:5.6 with

4 Cell 1300mAH 35C_LIPO



2204/2300kv Motors
w/5x3” Propellers

20 Amp ESCs



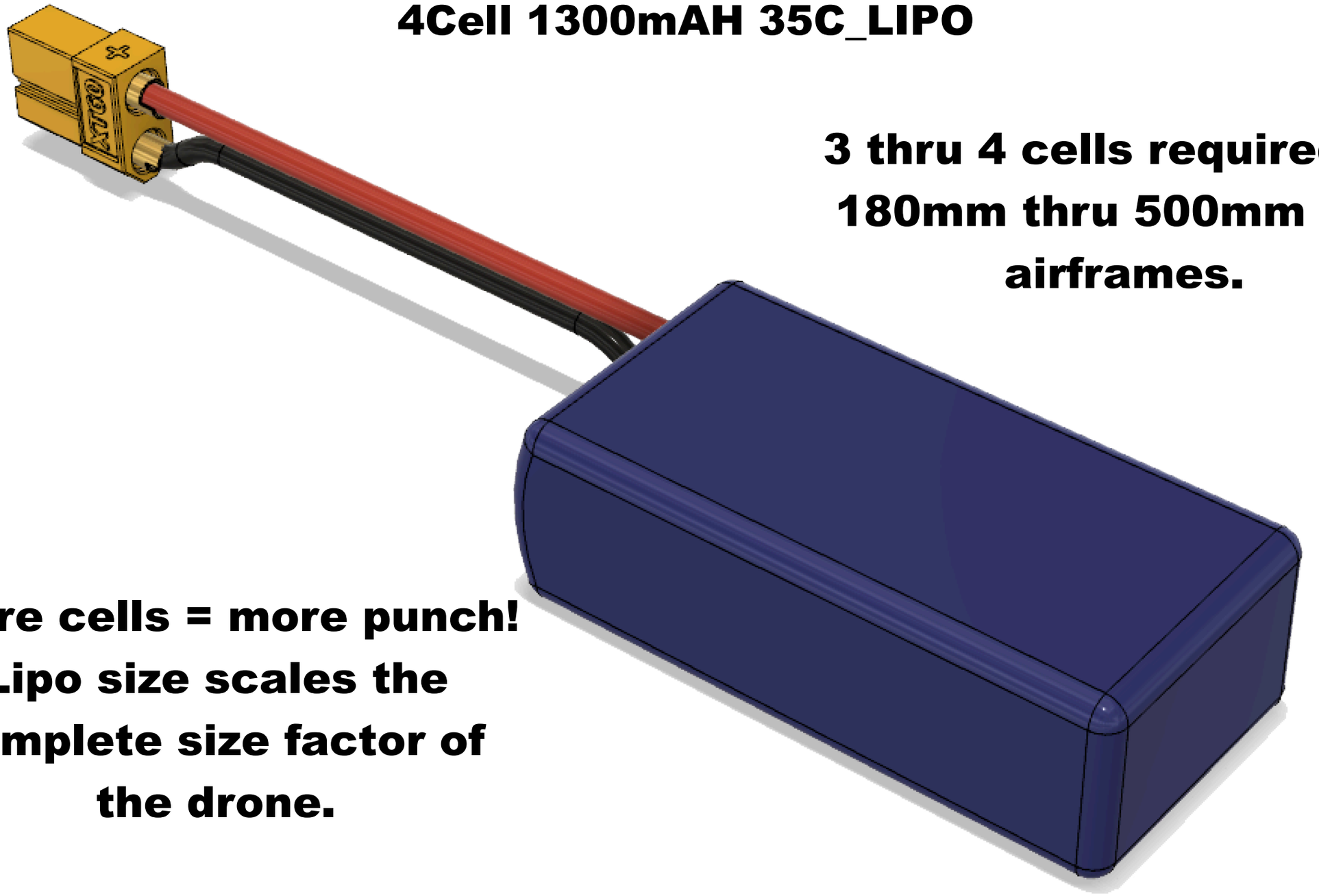
210mm Airframe w/
GoPro weighs 603g AUW

Battery + motors = 850g of thrust x 4 motors = 3400g
or 7.4 lb of thrust = approx. 118mph for 4 - 6 minutes

Lithium Polymer Power Packs

A.K.A Lipo Battery

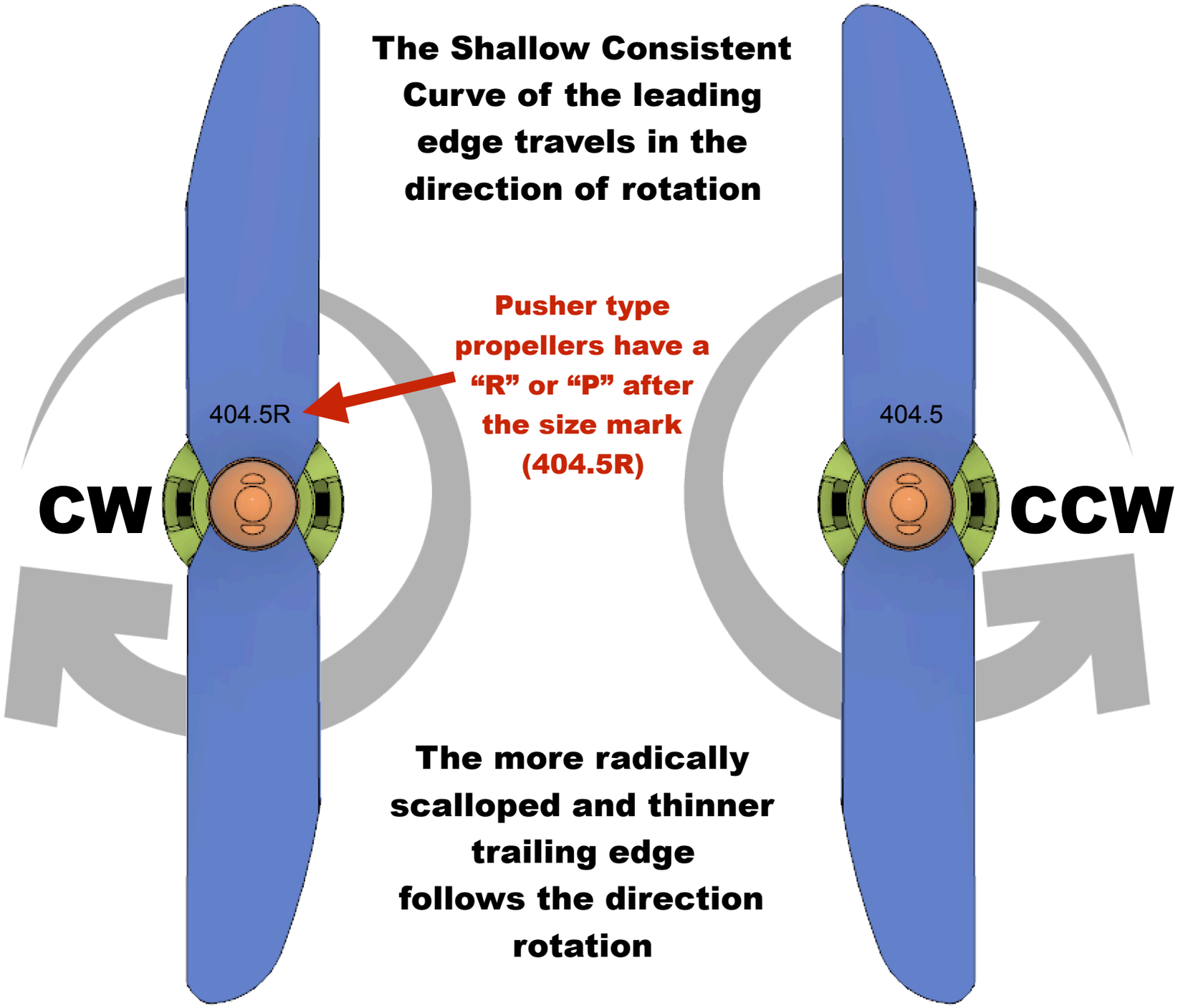
4Cell 1300mAH 35C_LIPO



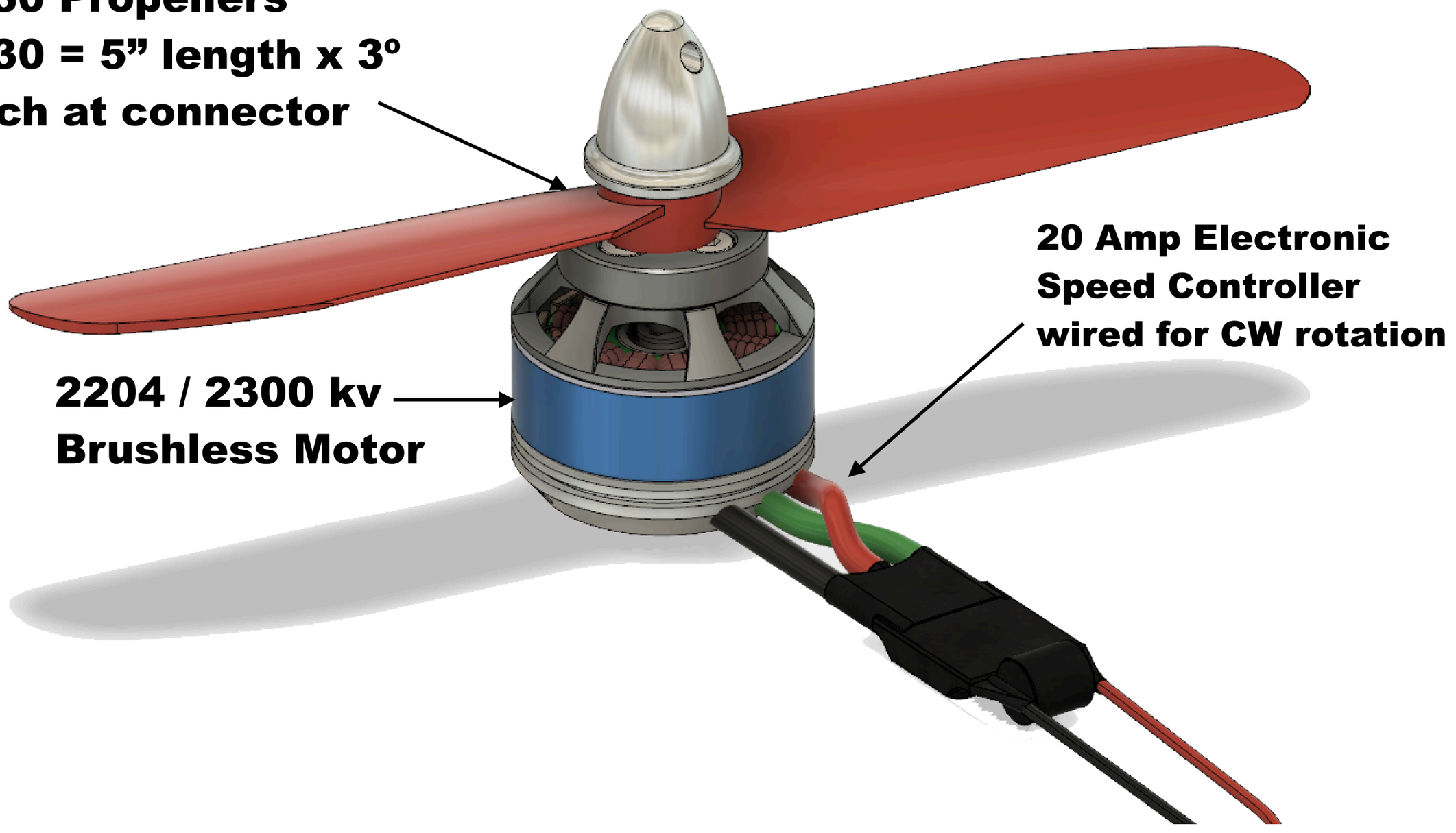
3 thru 4 cells required for 180mm thru 500mm size airframes.

More cells = more punch! Lipo size scales the complete size factor of the drone.

Propellers


The Shallow Consistent Curve of the leading edge travels in the direction of rotation
Pusher type propellers have a “R” or “P” after the size mark (404.5R)
404.5R
404.5
CW
CCW
The more radically scalloped and thinner trailing edge follows the direction rotation

Motor Configuration

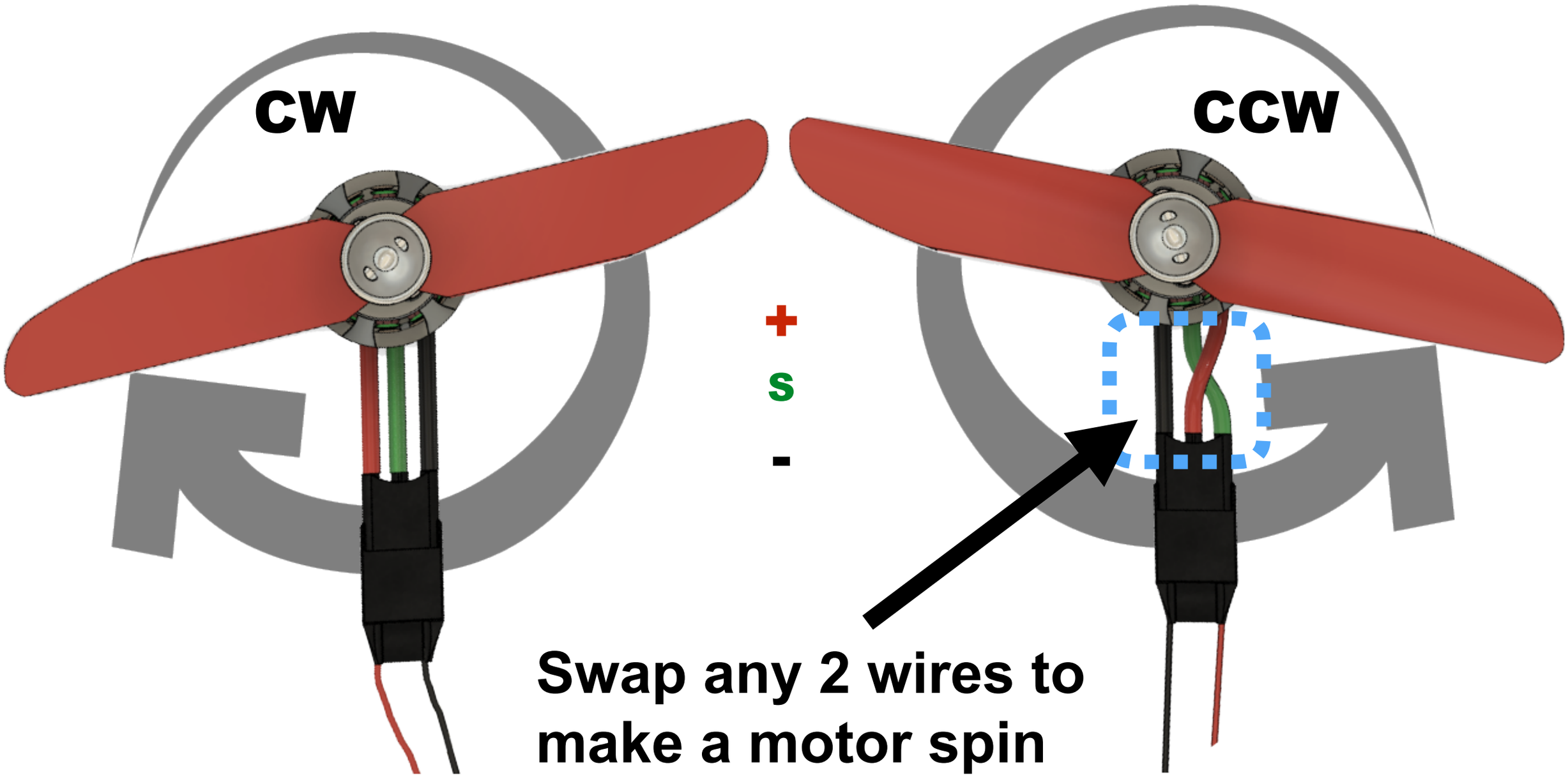


2204 = 22mm rotor diameter. 04mm = Rotor height.

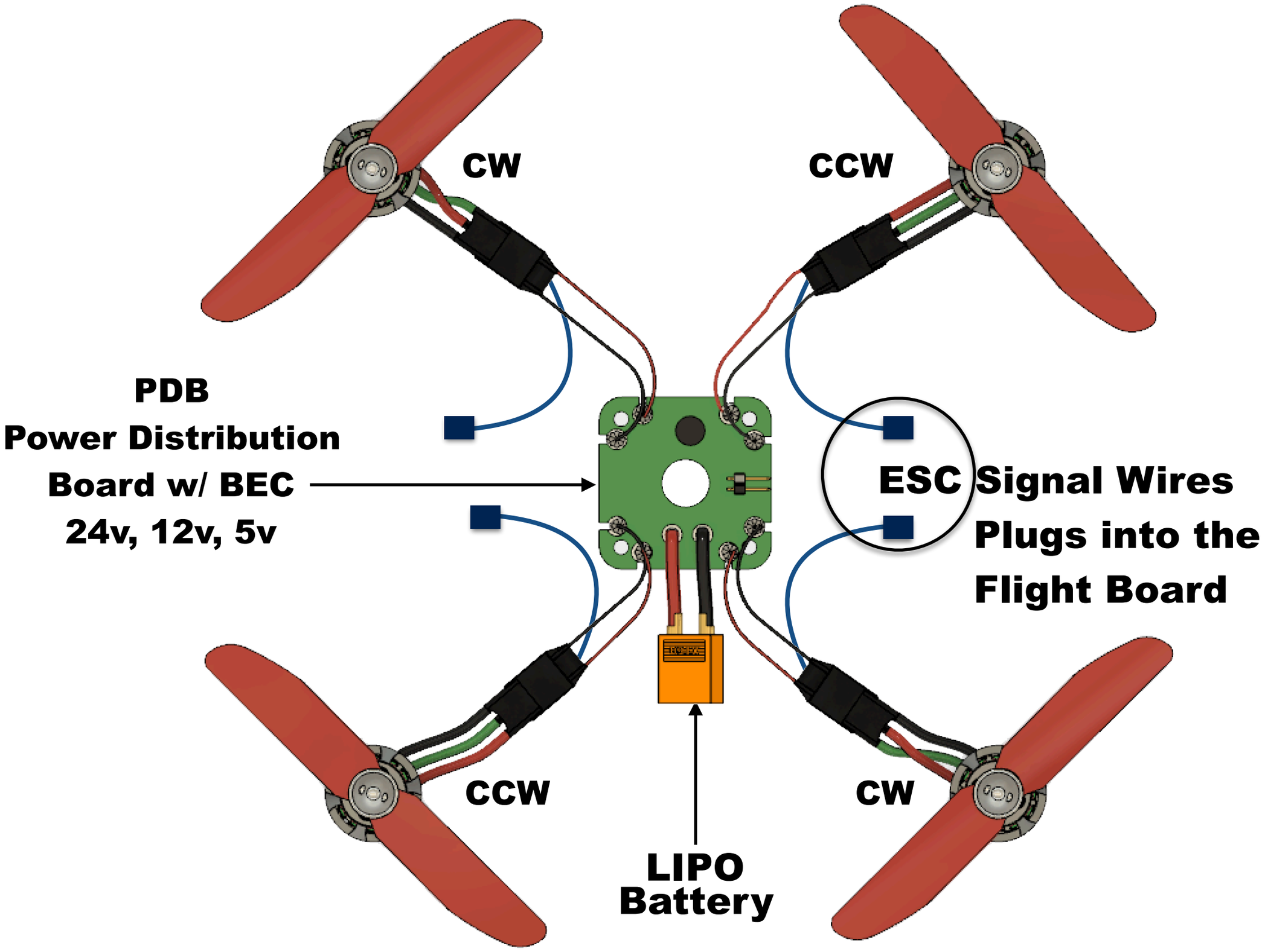
2300 kv = Revolutions per Volt.

RPM = KV x Voltage

Motor to ESC Wiring

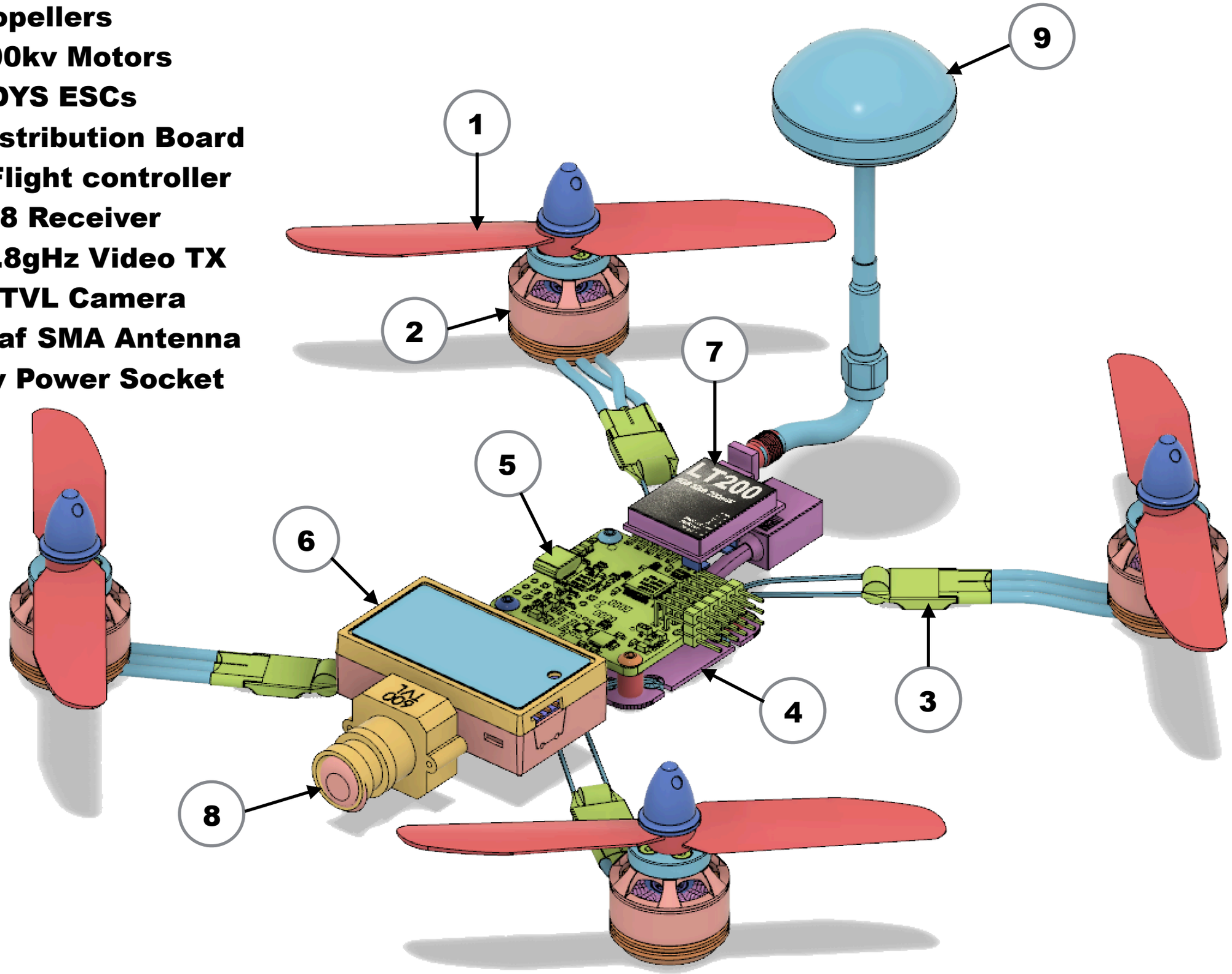


Power Train


CW
CCW
PDB
Power Distribution
Board w/ BEC
24v, 12v, 5v
ESC Signal Wires
Plugs into the
Flight Board
CCW
CW
LIPO
Battery

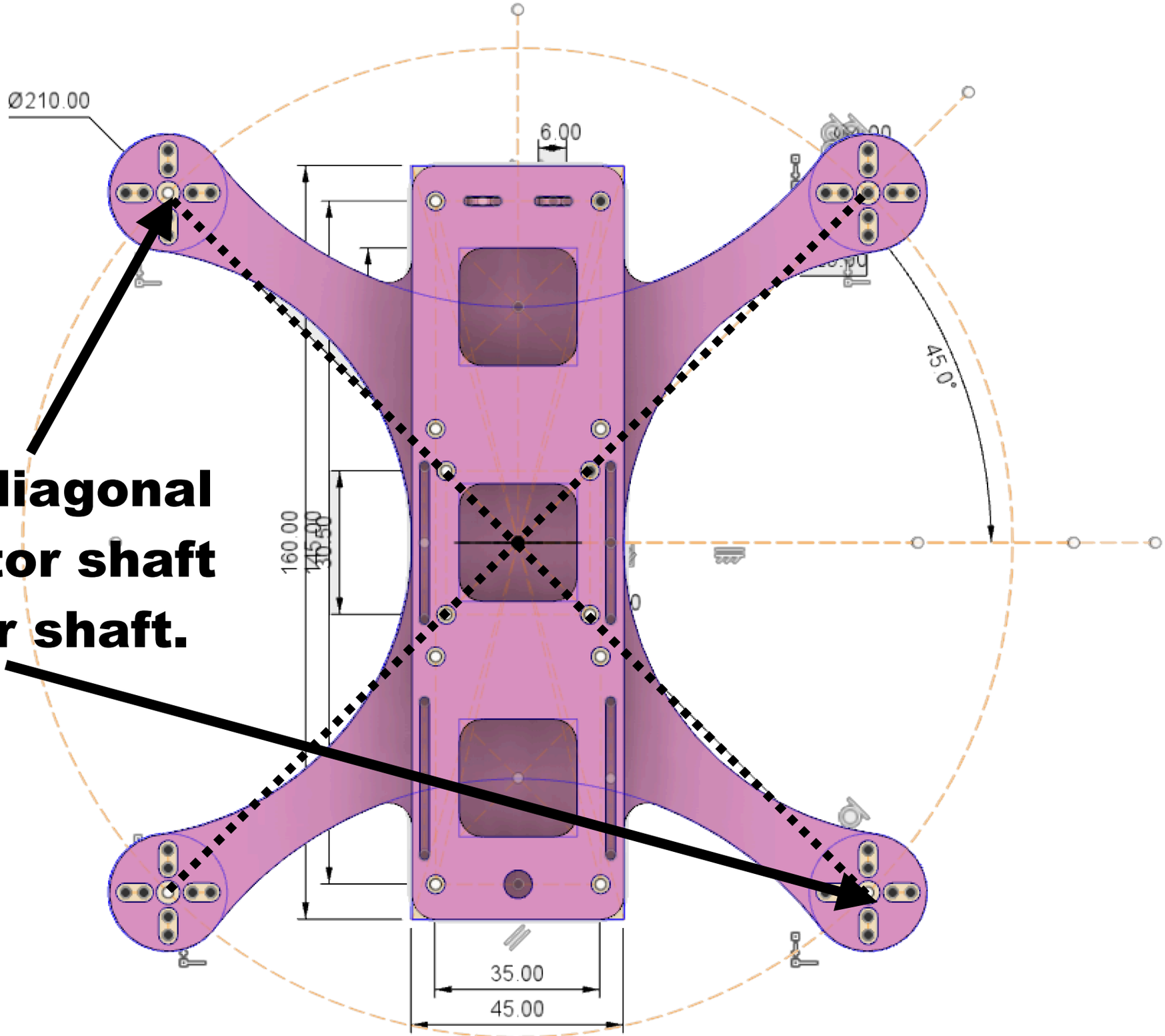
Basic Flight Components

1. 4”- 5” Propellers
2. 2204 2300kv Motors
3. 20 Amp DYS ESCs
4. Power Distribution Board
5. Naze32 Flight controller
6. FrySky X8 Receiver
7. LT 200 5.8gHz Video TX
8. FPV 600 TVL Camera
9. CloverLeaf SMA Antenna
10. XT60 24v Power Socket



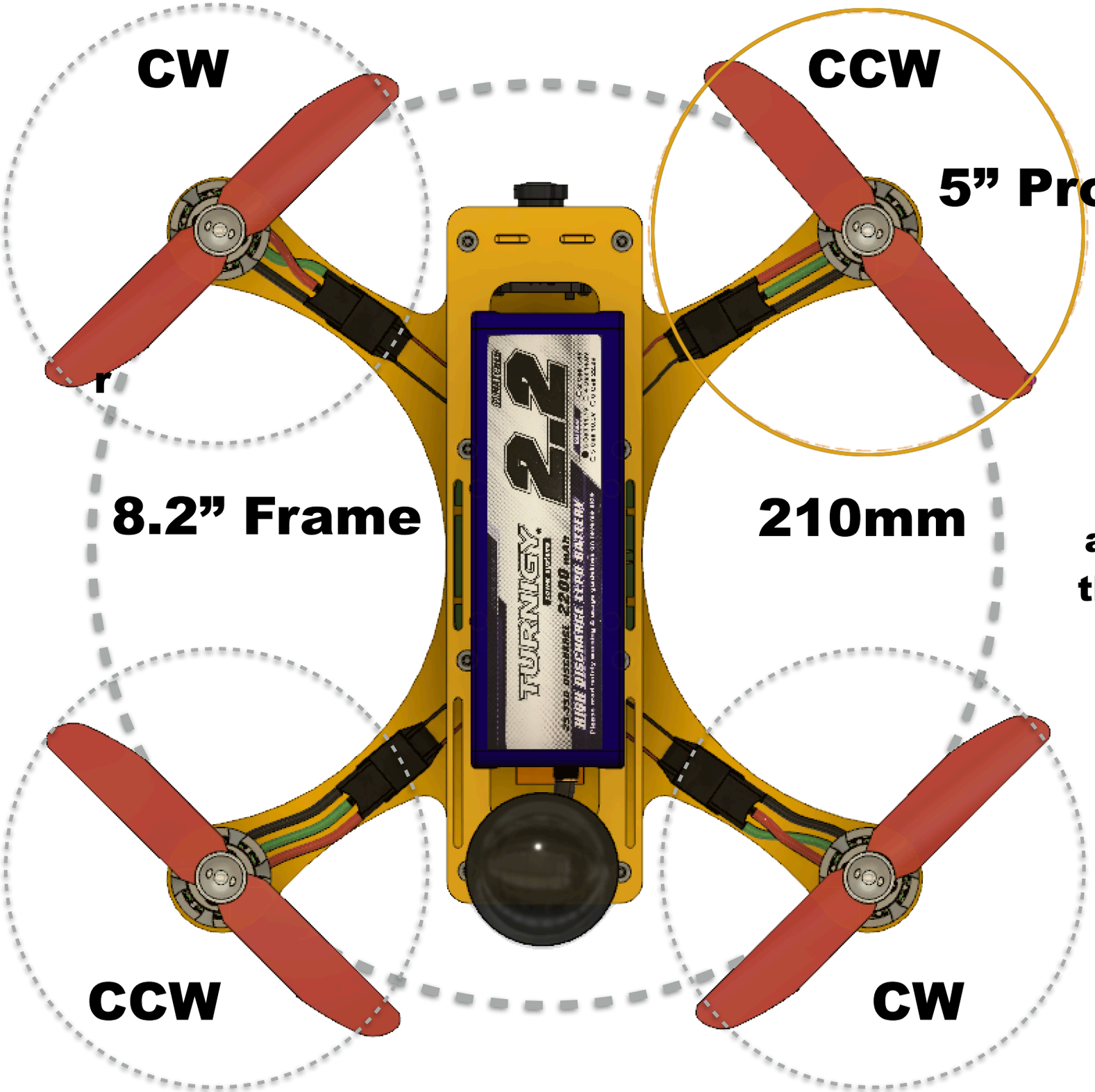
Square motor layout minimizes craft vibration.

Assures Stability, essential for clean flight performance



210mm diagonal from motor shaft to motor shaft.

Propeller Size > Motor Size > ESC Amps = Frame Size



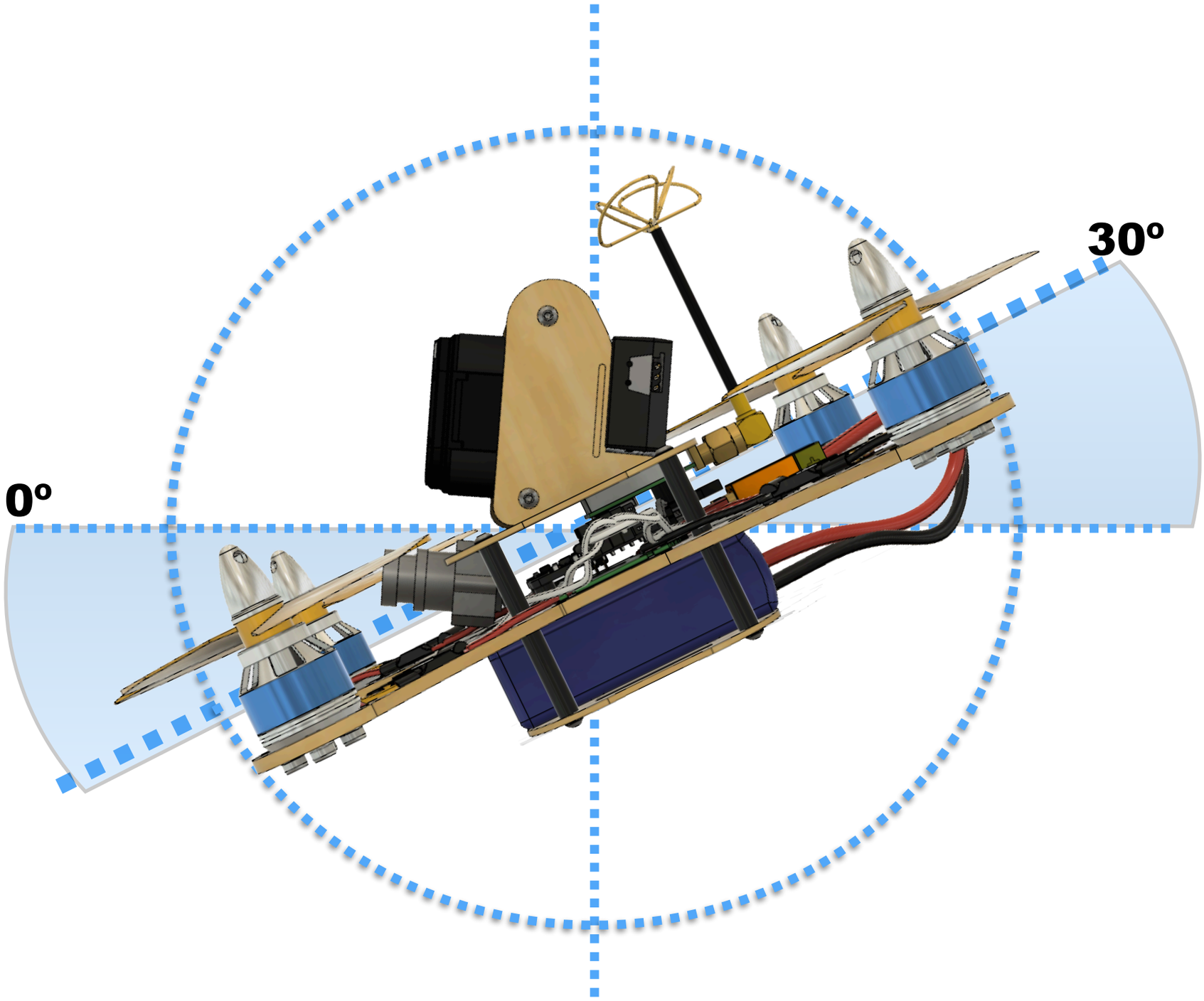
Pusher and Puller props = CW / CCW

210mm airframe fly 4” thru 5.5” props

30º Pitch

At speed drones angle forward.

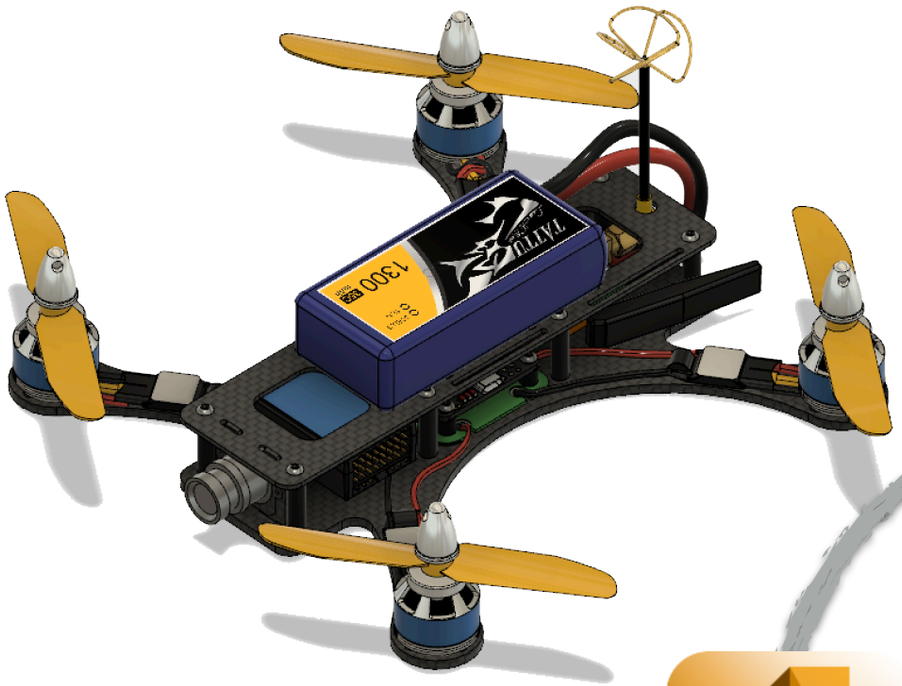
Cameras are pre angled to 30º to compensate



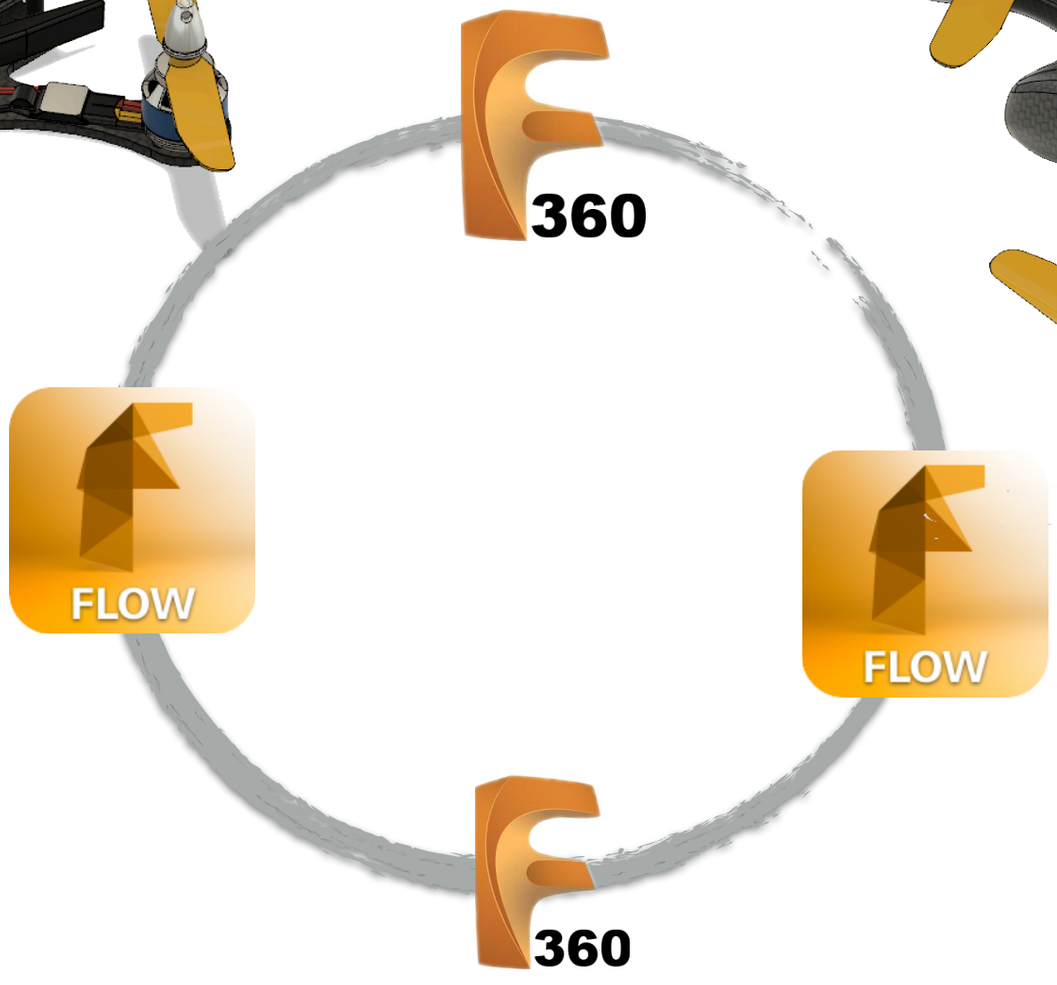
Monocoque / Singe Shell Design
Thru The Fusion / Flow / Fusion Cycle

Structural cowlings open performance potential in aesthetics, aerodynamics, durability & smart technologies

WIND TUNNEL SIMULATION IMPACTS DESIGN EVOLUTION



Before



After

The FUSION 360 / FLOW DESIGN cycle rapidly iterates the racer's aerodynamic characteristics

Eli DElia, UAV Designer, AutoDesk Expert Elite

RACING DRONE DESIGN
FUNDAMENTALS

By Eli DElia
UAV Designer

Email: dsfx@mac.com