

Object Detection Drone

Group 13

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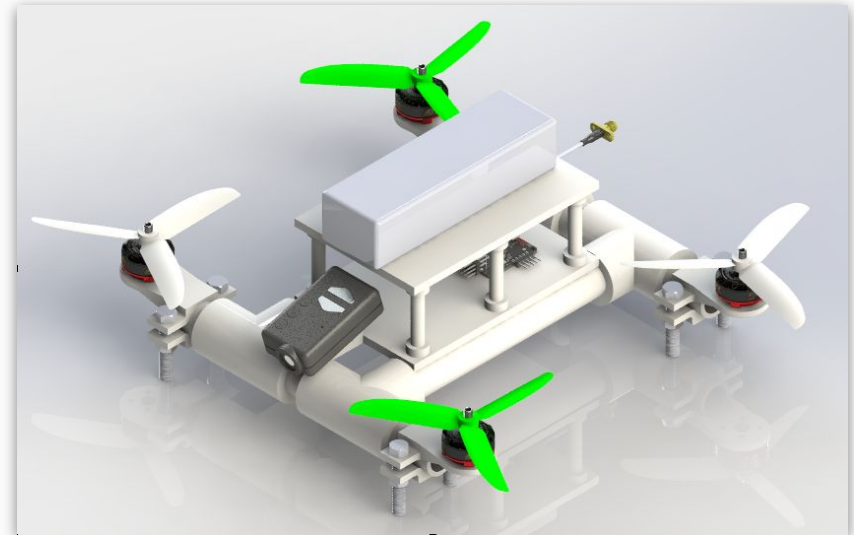
Anthony Pionessa - CpE



Description

What is the Object Detection Drone?

- Modular quadcopter drone
 - Replaceable chassis components
- Computer vision capabilities
 - Object Detection
 - Object Counting
- Companion application for pilot
 - Live view
 - Detection information





Motivations & Goals

Motivations:

- Groups interest in drones and computer vision
- Encompasses both Computer Engineering and Electrical Engineering

Goals:

- Accurate detection model
- Reliable video transmission
- Fabricatable chassis parts
- Usable flight time
- Intuitive controls

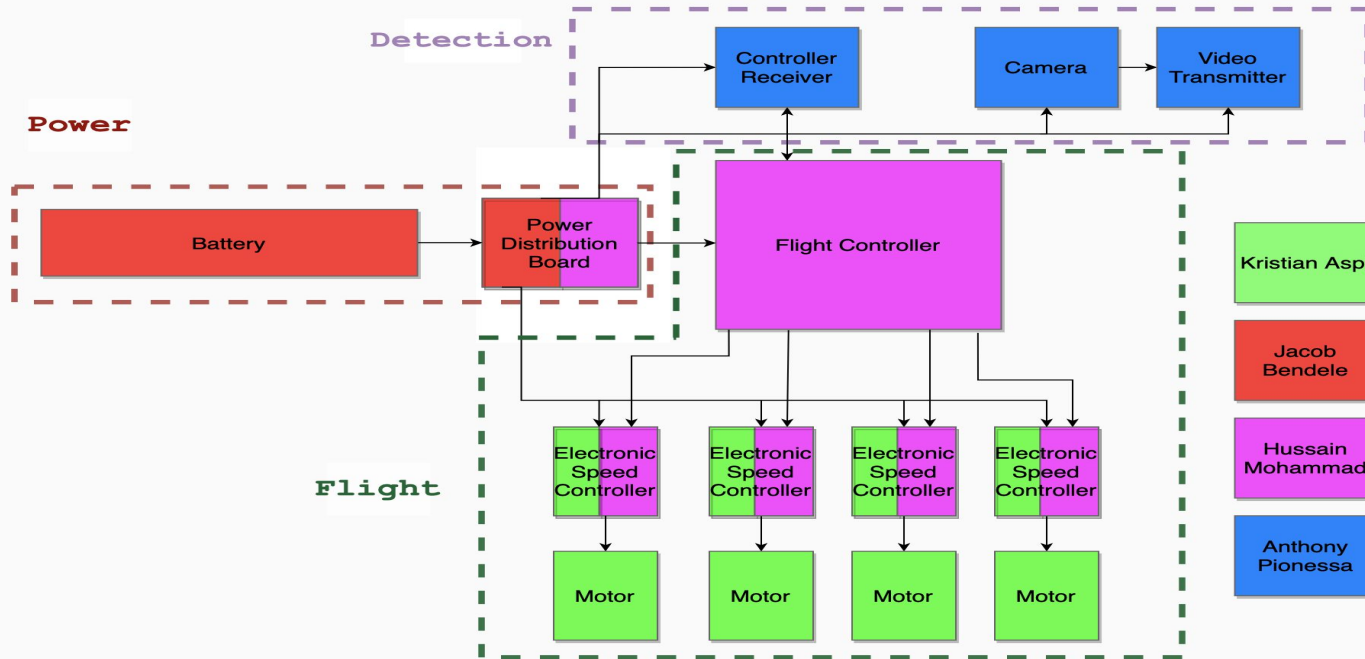


Specifications & Requirements

Requirement	Description	Value
Operational Distance	The distance the drone can be operated.	≤ 400 ft
Flight Time	The continuous time the drone can stay in flight.	≥ 5 min
Detection Accuracy	The accuracy of the object detection.	$\geq 80\%$
Thrust Ratio	The ratio between the thrust power and the weight.	$\geq 2:1$



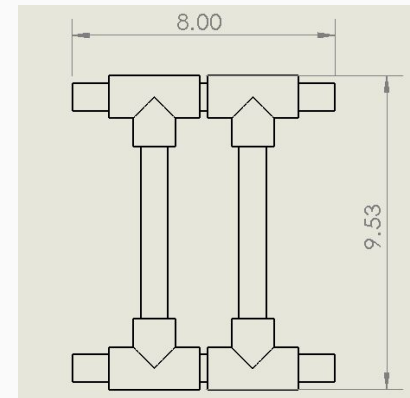
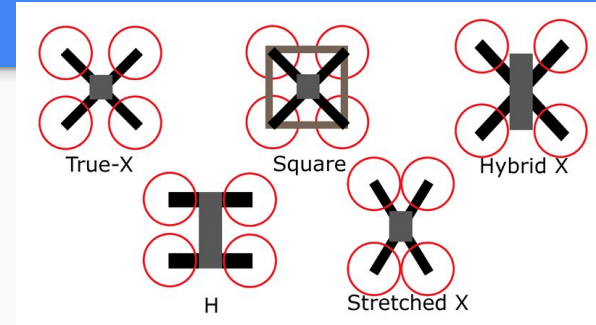
Hardware Systems Overview





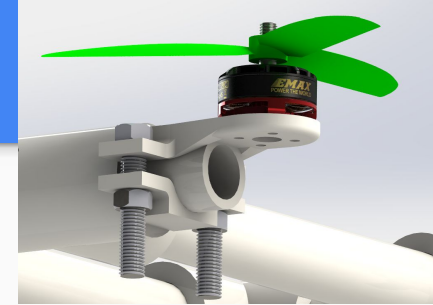
Drone Subsystem - Frame

- Describes physical aspects of our drone
- Incorporates H frame design
- 1/2" PVC pipes and Tee fittings
- Sturdy design and offers plenty of space for components
- Strong, lightweight, and cheap





Drone Subsystem - Motor Mount



- Designed with Solidworks and 3D printed
 - Fast Prototyping
- Mounts at ends of PVC pipe arms in a C-clamp manner
- Simple and modular
 - Easily assembled and disassembled
- Secured by nylon nuts and bolts
 - Also serves as landing gear



Flight Subsystem - Motors & Propellers

EMAX RS2205-S Motors

- Constant Velocity - 2300KV
- Max. Thrust - approx. 1126g
- Max. Current Draw - approx. 25A
- Weight - 28.8g x 4
- Cost - \$63.99 (4pcs)

QProp Ethix S3 Tri-Blade Propellers

- 5" Props
- 3.1 Pitch
- Weight - 3.6g x 4
- Cost - \$17.99 (16pcs)

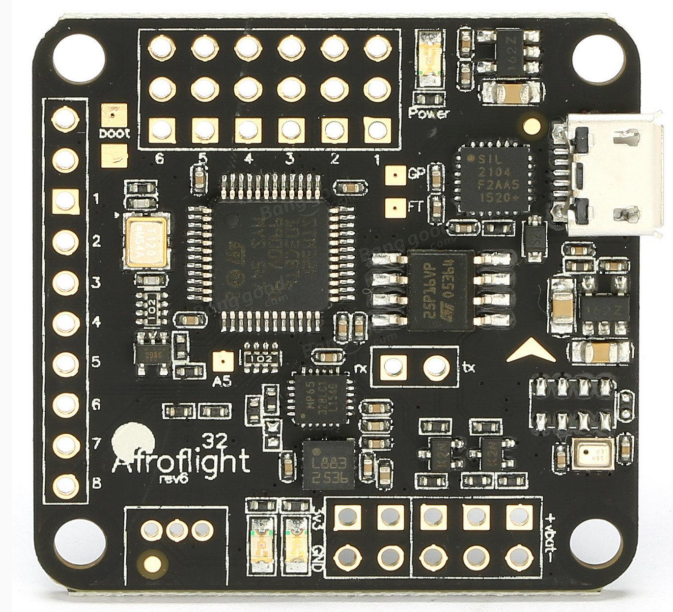




Flight Subsystem - Flight Controller

Naze32 Full Version Flight Controller

- The brain of the drone
- STM32 MCU at 72 MHz
- 10 DOF (Degrees of Freedom)
- 2 UART Ports
- Micro-USB for programming/firmware updates
- 7.3 grams (including headers)
- Cost - \$19.99





Flight Subsystem - Electronic Speed Controllers

NIDICI BLHeli_32 Bit

- Current Rating - 35 A
- Input Voltage - 2S-5S Li-Po Cell
- Weight - 5.98g x 4
- Cost - \$47.99 (4pc)





Power Subsystem - Battery

HRB Lithium Polymer Battery

- Cells - 4S
- Capacity - 3300mAh
- Discharge Rate - 60C
- Provides 11.77min flight time
- $11.77 \text{ min} = 3.3\text{Ah}/16.82\text{A} \times 60\text{min/hr}$
- Weight - 318g
- Cost - \$37.99

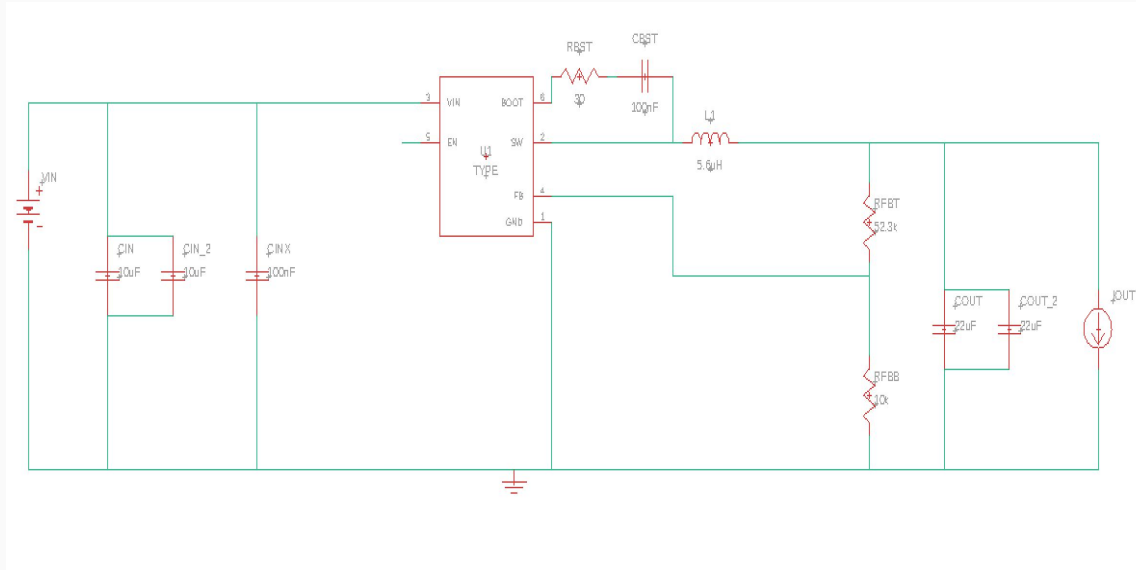




Power Subsystem - Power Distribution Board

Voltage Regulator Design

- TPS56339DDCR IC
- Buck Switching Regulator
- 14.8V_{in} - 5V_{out}
- 93.1% Efficiency

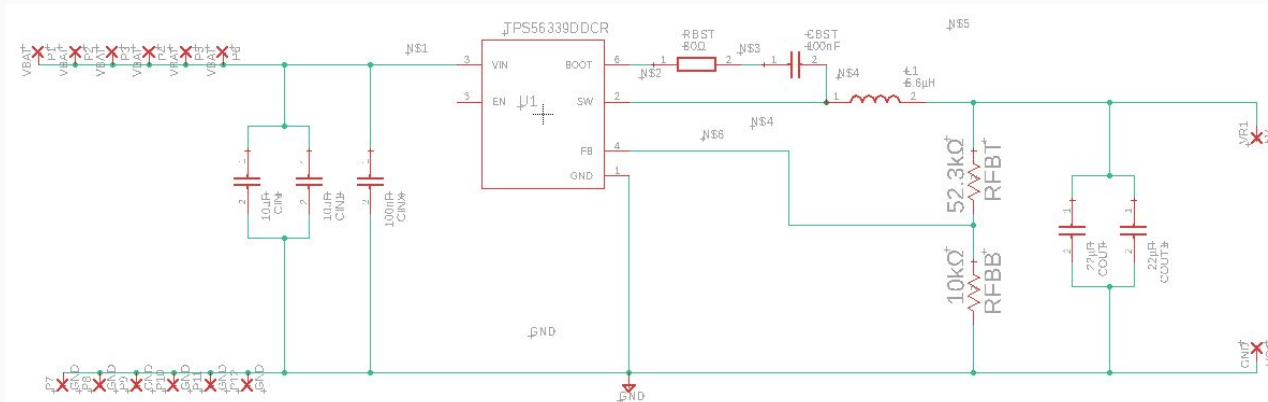




Power Subsystem - Power Distribution Board (continued)

Power Distribution Board Schematic

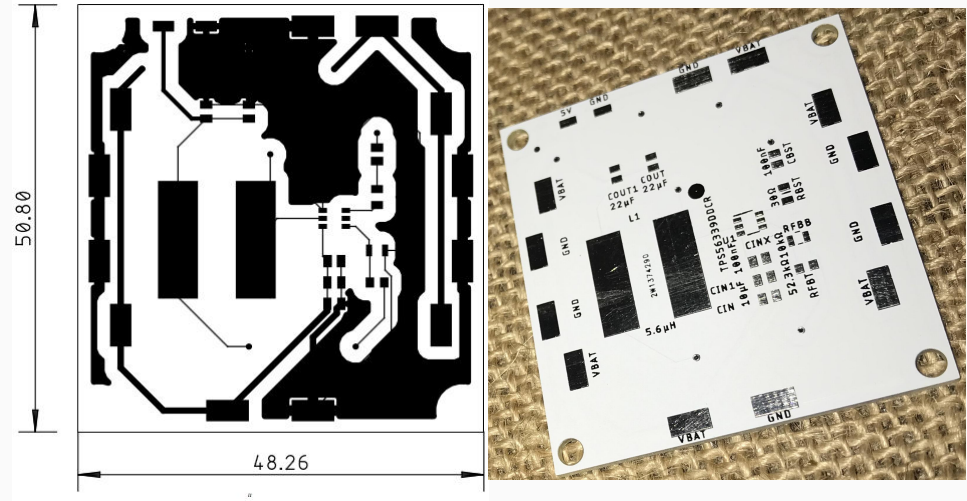
- Four battery voltage outputs (VBAT can be used with ESCs)
- One 5V output





Printed Circuit Board

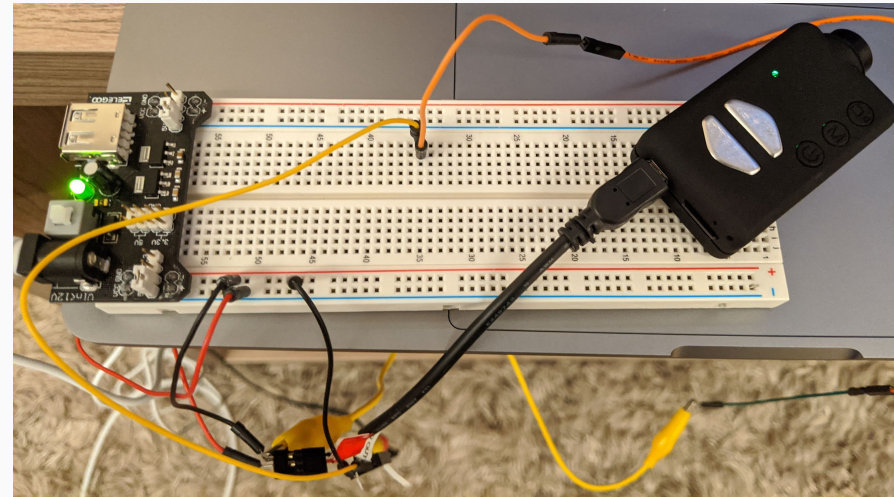
- PDB Design shown on previous slide
- Autodesk Eagle was used
- Top layer ground plane
- Bottom layer VBAT plane
- Planes help with heat sink





Detection Subsystem - Mobius Action Cam

- Offers 1080P at 30 FPS or 720P at 60 FPS.
- Offers video and audio out options.
- Computer software for configuration.
- Weight - 1 ounce
- Dimensions - 1.38 x 2.4 x 0.72 in
- Able to be connected to a video transmitter.
- Cost - \$83

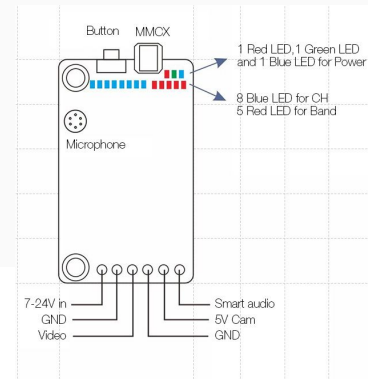




Detection Subsystem - Video Transmitter and Receiver

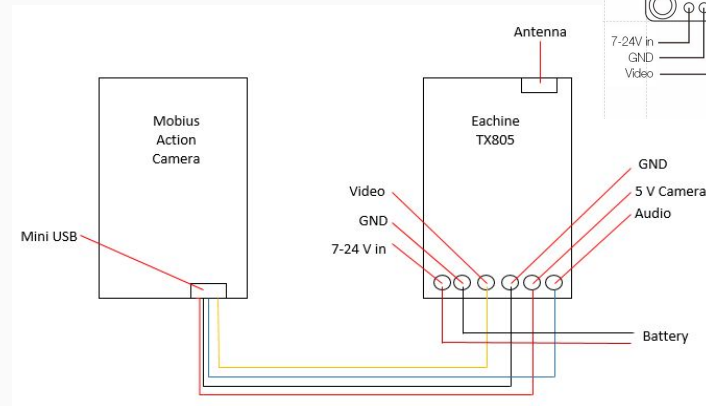
Eachine TX805 (Transmitter)

- Transmission Range - >3000 ft
- Weight - ~0.3 ounces
- Dimensions - 1.42 x 0.87 x 0.2 in
- Compatible with the selected camera.
- Antenna included on the transmitter.
- Cost - \$39



Eachine ROTG02 (Receiver)

- Phone connection compatible.
- Compatible with the selected video transmitter.
- Cost - \$24





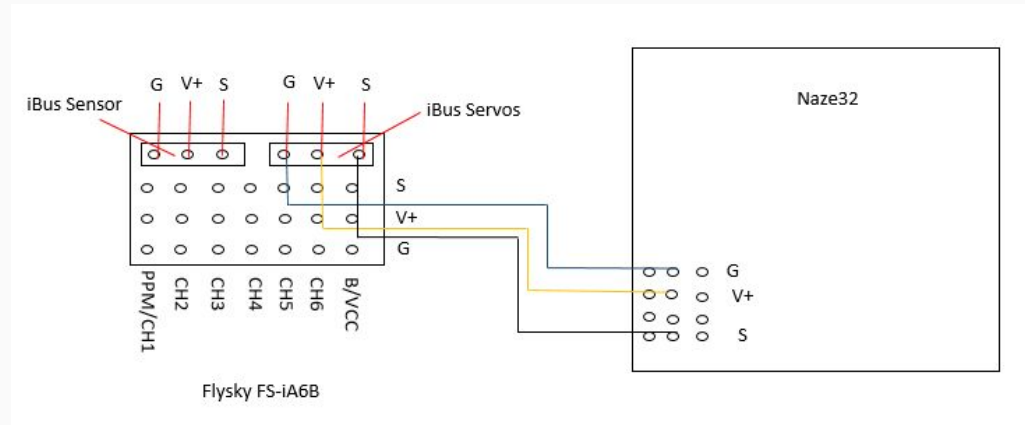
Ground Control System

Flysky FS-i6X (Controller)

- Transmission Range - ~3700 ft
- # of Channels - 6-10
- Cost - \$57

Flysky FS-iA6B (Receiver)

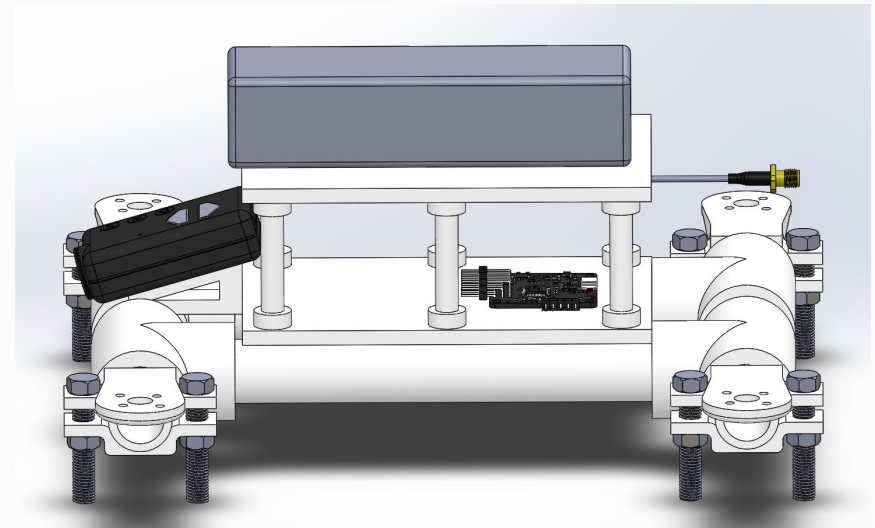
- # of Channels - 6
- Connection to flight controller available.
- Compatible with the controller.





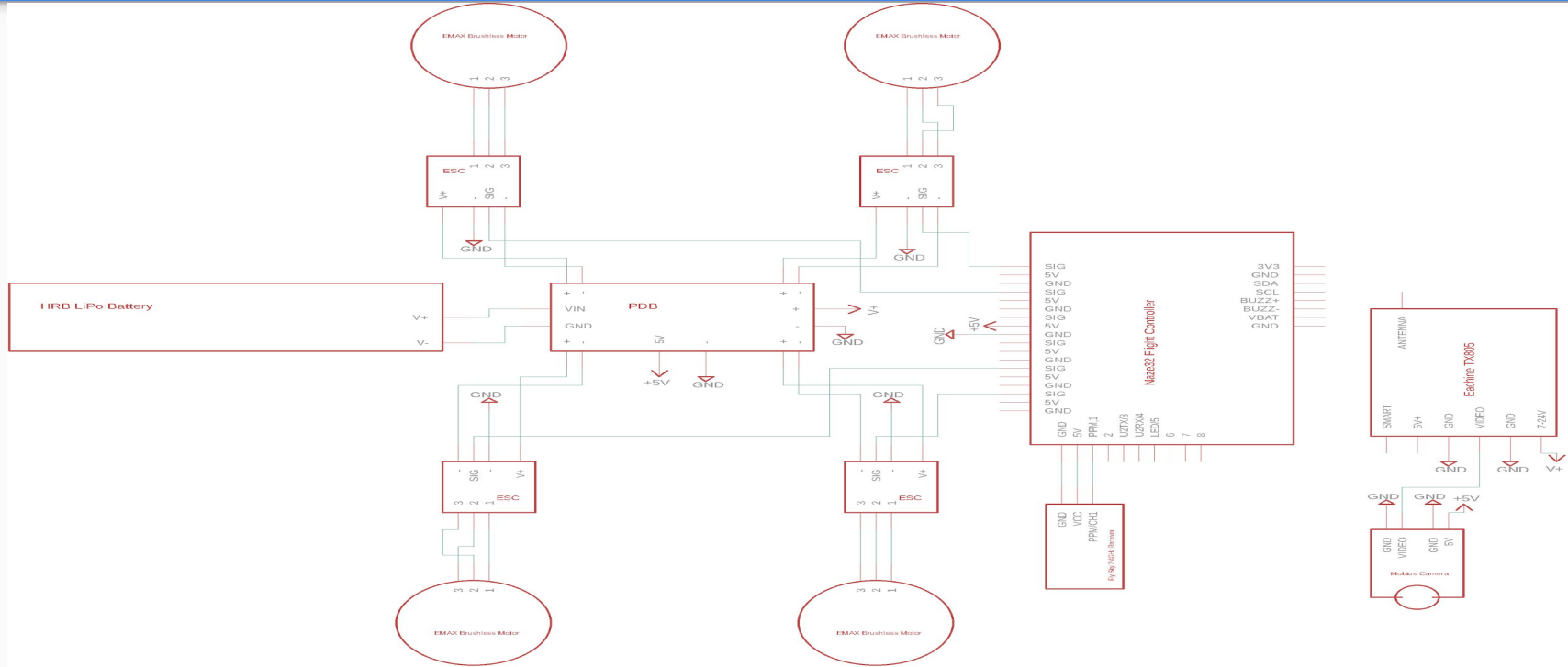
Component Placements

- SolidWorks CAD Assembly
- Customized 3D part models
 - Motor Mounts and Body Plate
- Standard models were sourced/modified from GrabCAD
- Dimensions and mass made as accurate as possible
- Useful for prototype planning





Overall Schematic





Drone Weight

- SolidWorks Assembly
Mass: 963.91g
- Estimated Table Mass:
945.20

Mass properties of DroneAssembly2
 Configuration: Default
 Coordinate system: -- default --

* Includes the mass properties of one or more hidden components/bodies.

Mass = 963.91 grams

Volume = 732783.71 cubic millimeters

Surface area = 375428.14 square millimeters

Item	Mass/Item	Amount	Total Mass (g)
1/2" PVC Tee	0.032lbs or 14.5g	4	58
1/2" x 2' PVC Pipe	0.16 lb/ft or 72.57 g/ft	26 inches	157.24
1/4" x 1-1/2" Nylon Hex Bolt + Nut Nylon 1/4	1.5g	4	6
3D Printed Motor Mounts (Assembly)	24g	4	96
3D Printed Body Plate Assembly	80g	1	80
EMAX RS2205-S 2300KV	30g	4	120
HQProp Ethix S3 Prop	3.6g	4	14.4
HRB 4S 3300mAh 14.8v Lipo RC Battery	330g	1	330
Mobius Camera	1.3oz or 36.85g	1	36.85
Naze32 Rev6 Full	10g	1	10
ESC	5.89g	4	23.56
Miscellaneous	50g	1	50
Total			945.20



Thrust to Weight

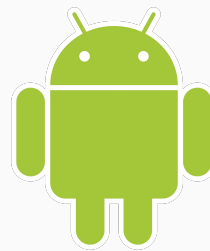
- Power source 14.8 - 16.8 V
- Hovering requires 1:1 thrust to weight
- 50% throttle is where we want to be for hovering
- Max thrust to weight achievable 4:1

Motor type	The voltage (V)	Paddle size	current (A)	thrust (G)	power (W)	efficiency (G/W)	speed (RPM)
RS2205-2300KV	12	HQ5045 BN	1	62	12.00	5.17	6400
			3	162	36.00	4.50	10080
			5	236	60.00	3.93	12070
			7	311	84.00	3.70	13730
			9.1	374	109.20	3.42	15100
			11	439	132.00	3.33	16320
			13	490	156.00	3.14	17350
			15.3	548	183.60	2.98	18350
			17.3	611	207.60	2.94	19210
			20.7	712	248.40	2.87	20080
	16	HQ5045 BN	1	76	16.00	4.75	7220
			3	183	48.00	3.81	10790
			5	283	80.00	3.54	13030
			7.1	352	113.60	3.10	14720
			9.1	426	145.60	2.93	16180
			11	497	176.00	2.82	17150
			13	560	208.00	2.69	18460
			15	628	240.00	2.62	19270
			17	692	272.00	2.54	20270
			19	754	304.00	2.48	21060
			21	812	336.00	2.42	21840
			23.3	878	372.80	2.36	22590
			25.4	936	406.40	2.30	23210
			27.3	997	436.80	2.28	23920
			29.9	1024	478.40	2.14	24560



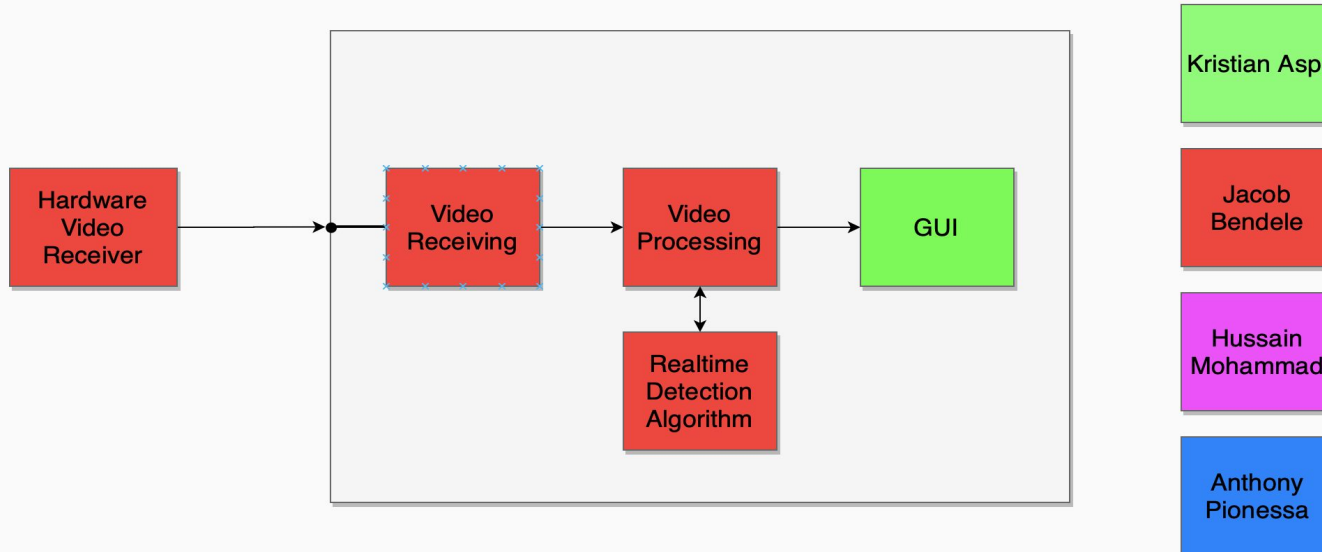
Pilot Application

- Provides live view video stream from the drone
- Offloads machine learning tasks
- Displays bounding boxes on detected objects
- Provides count info on detected objects





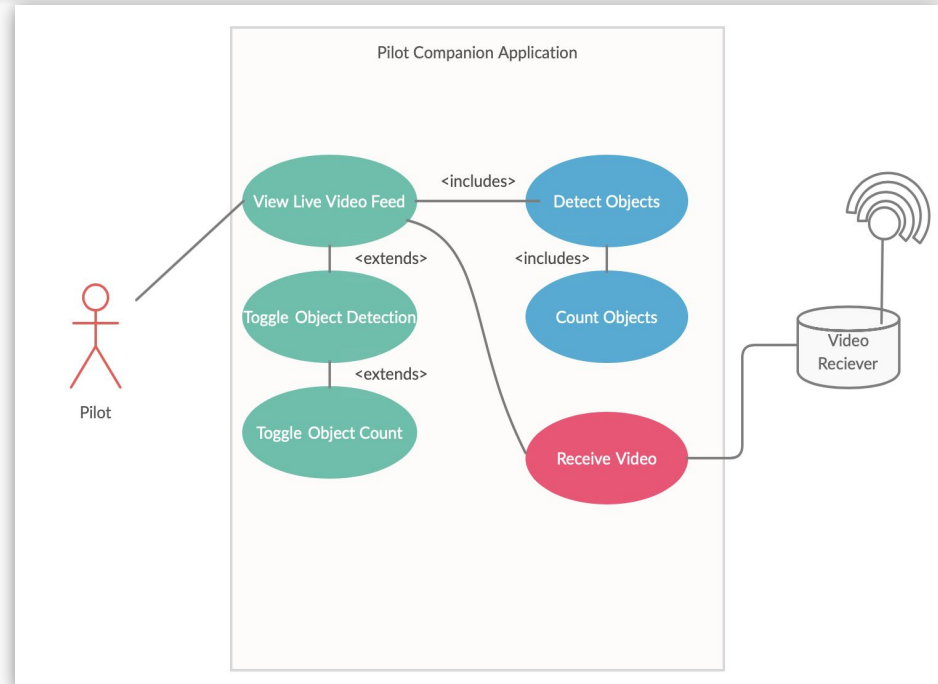
Pilot Application - Block Diagram





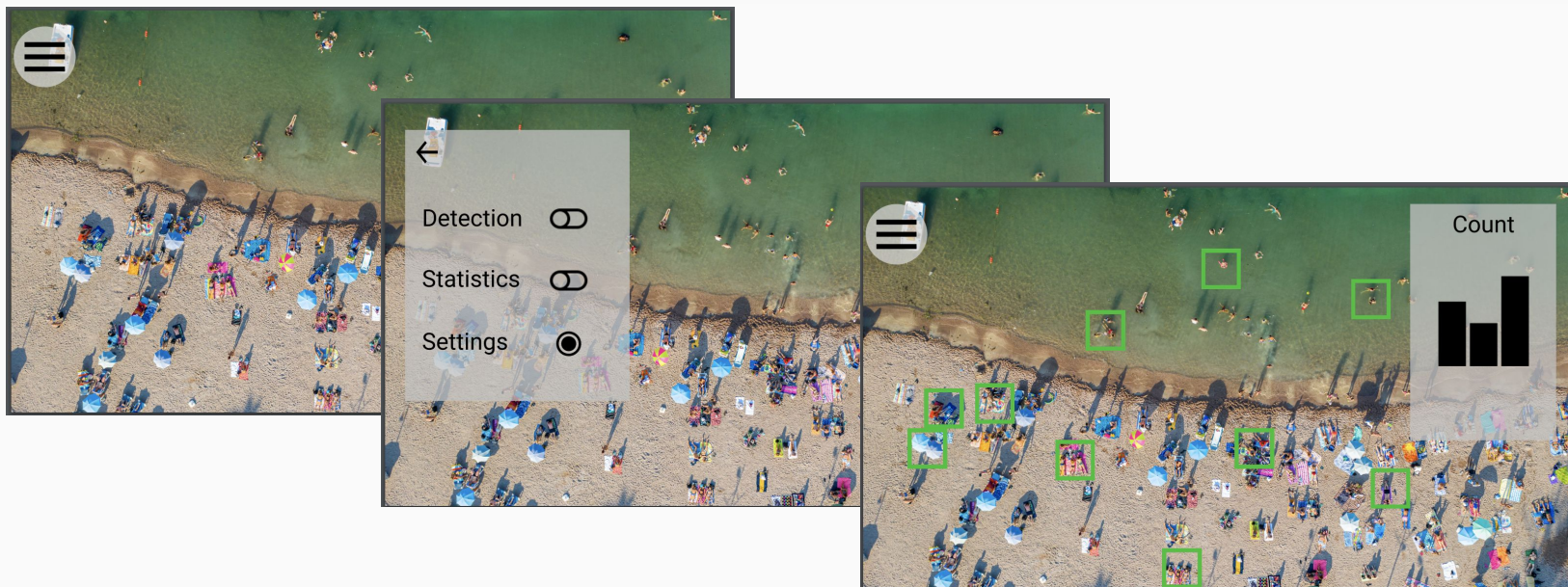
Pilot Application - Use Case

- Pilot sees live feed
- Can toggle object detection
- Can toggle object counting





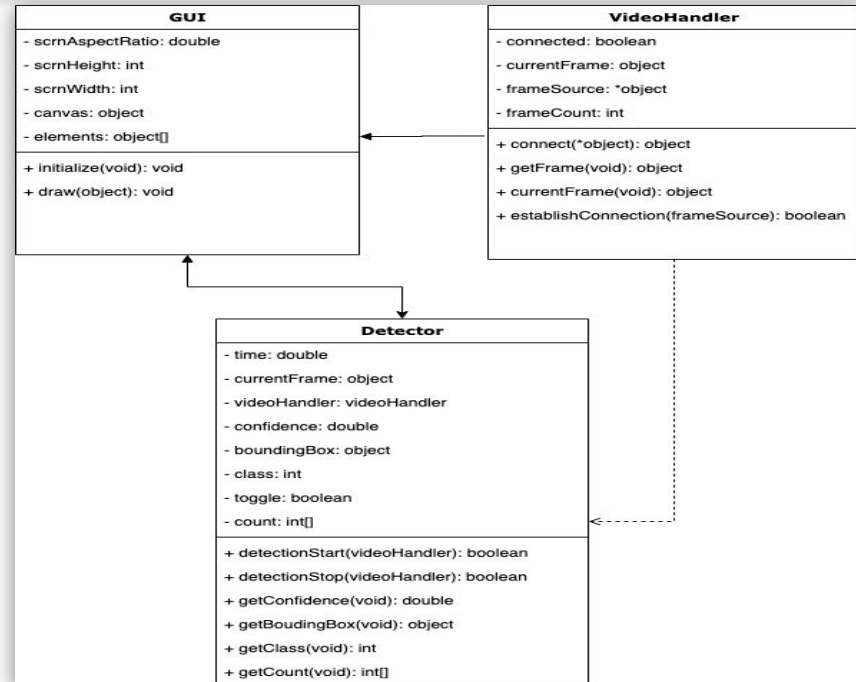
Pilot Application - Front End





Pilot Application - Structure

- Detector class receives frames detects objects
- VideoHandler provides interface between HW and SW
- Dependency between classes Detector and VideoHandler





Pilot Application - Video Input

Three Paths:

- 1) Eachine Manufacturer Driver
- 2) Reverse Engineer apk
- 3) Screen Capture





Pilot Application - Detector

- Popular Android ML tools
 - TensorFlow Lite
 - Google's ML Kit
- Detection ML Model
 - Device Local
 - Based on popular single shot detectors (YOLO, SSD)
 - Trained to for single or multi class detection





Budget and Financing

- Budget of \leq \$500
- Sought sponsorships no response
- Group funded
- Under budget

Bill of Materials (BOM)			
Item	Price (\$)	Amount	Total (\$)
Mobius Action Camera	83	1	83
Breakout Cable for Mobius	5	1	5
Eachine TX805	39	1	39
Flysky FS-i6X	57	1	57
1/2" PVC Tee	0.46	4	1.84
1/2" x 2' PVC Pipe	1.31	3	3.93
1/4" x 1-1/2" Nylon Hex Bolt	0.96	4	3.84
Nut Nylon 1/4	0.87	4	3.48
4cs EMAX RS2205-S 2300KV	63.99	1	63.99
HQProp Ethix S3 Prop (16 pcs)	17.99	1	17.99
HRB 4S 3300mAh 14.8v Lipo RC Battery	37.99	1	37.99
Naze32 Rev6 Full	19.99	1	19.99
NIDICI BLHeli_32 Bit 35A ESC (4 pack)	50	1	50
Eachine ROTG02 UVC OTG 5.8G 150CH Diversity Audio FPV Receiver	23.99	1	23.99
			411.04



Successes and Difficulties

Successes:

- Early PCB design
- Below Budget
- Clear future goals

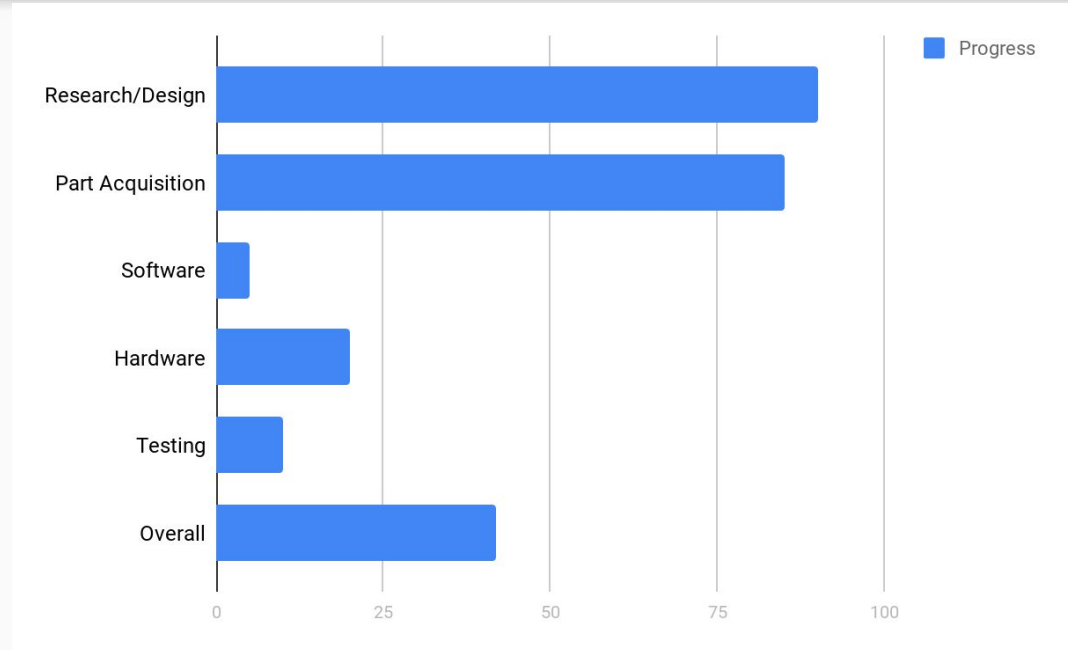
Difficulties:

- Bought fake camera
- First PCB vendor gave outrageous price
- SMD soldering (very small)
- COVID related inconveniences
 - Increased delivery times



Current Progress

- All parts tested and working
- Received PCB
- Eachine apk decompiled for static analysis
- Real camera ordered and received



Questions?