Object Detection Drone

Group 13
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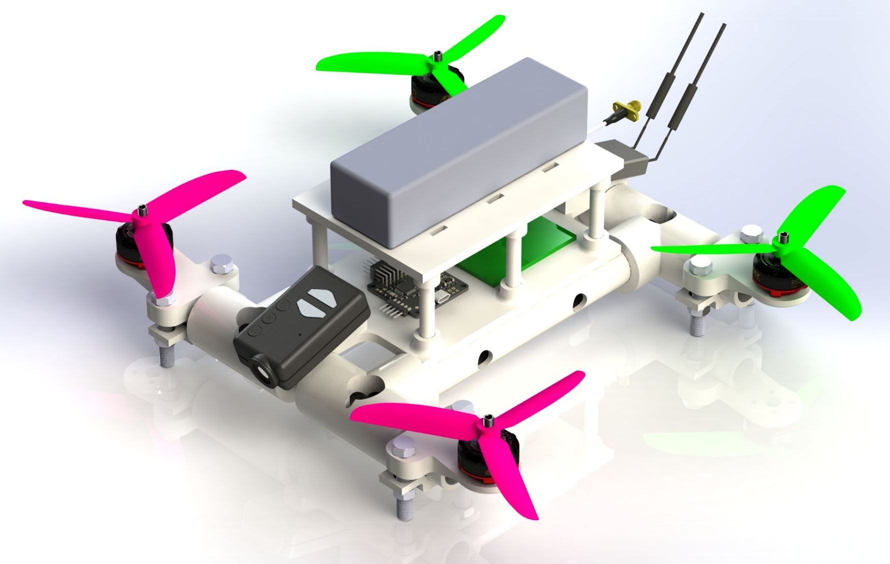
Kristian Aspi, CpE

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



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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

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Specifications & Requirements

Requirement	Description	Value	Progress
*Operational Distance	The distance the drone can be operated.	<= 400 ft	Verified
Flight Time	The continuous time the drone can stay in flight.	>= 5 min	Verified
*Detection Accuracy	The accuracy of the object detection.	>= 80%	Verified
Thrust Ratio	The ratio between the thrust power and the weight.	>= 2:1	Verified
*PCB Design 5V Output	Offers one 5V output with 3 amp capacity for peripheral components.	=5V@3A	Verified
PCB Design Burst Rating	The PCB should withstand high current draw periods greater than 100 amps for 2 seconds.	>= 2 sec	Verified
Safety Disarm	Procedure for safely disarming drone in real time	< 2 sec	Verified
*Modular Chassis	General chassis components replaceable in under 5 minutes.	<= 5 min	Verified

Hardware and Chassis Systems Overview

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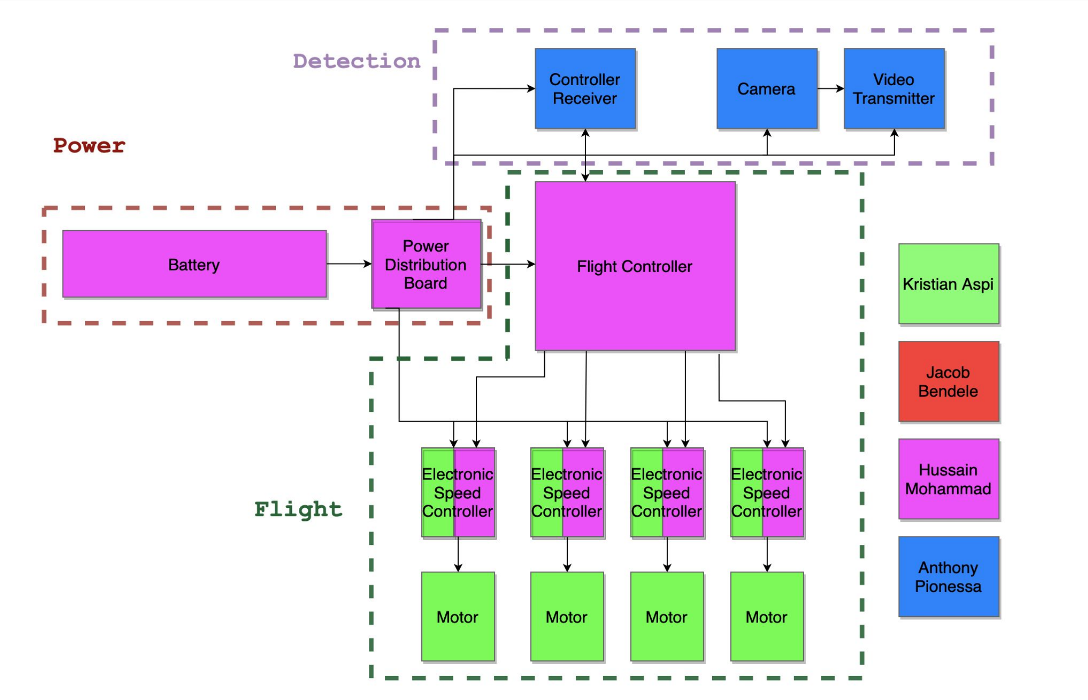

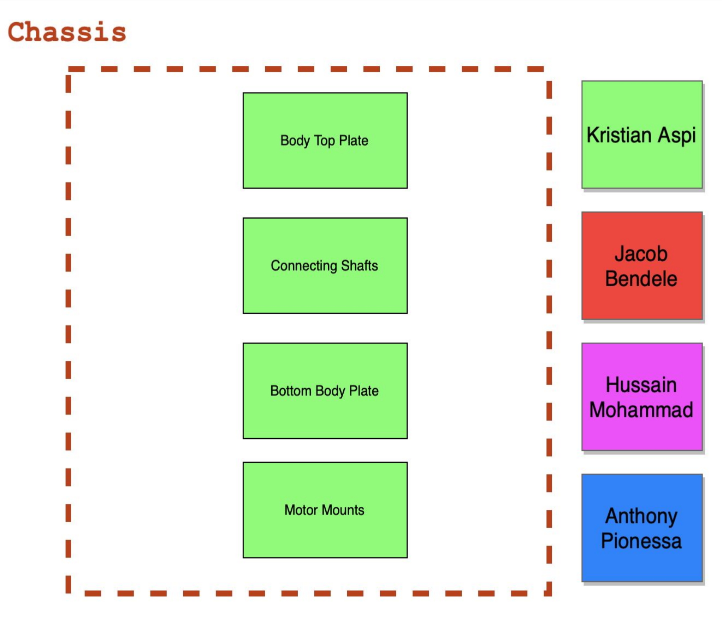

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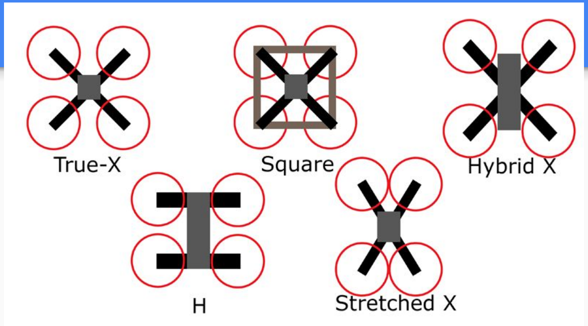
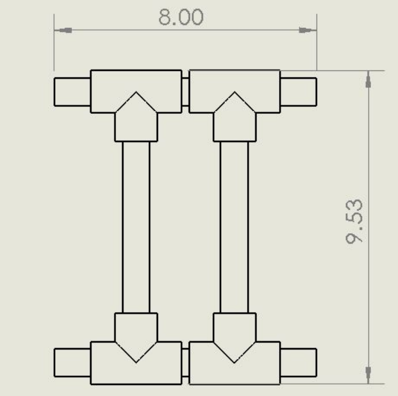
Drone Subsystem - Frame

- Describes physical aspects of our drone
- Incorporates H frame design
- ½” PVC pipes and Tee fittings
- Sturdy design and offers plenty of space for components
- Strong, lightweight, and cheap





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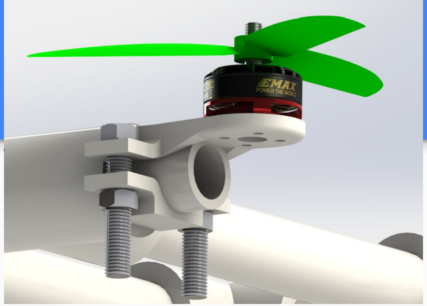
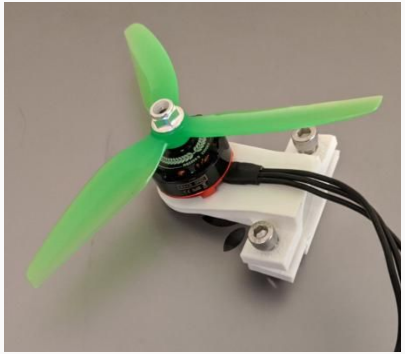
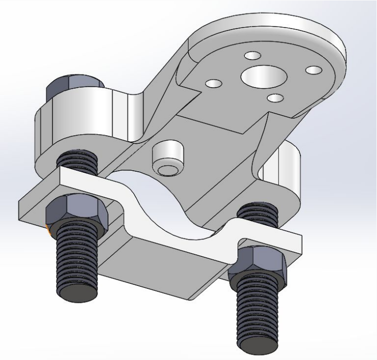
Drone Subsystem - Motor Mount



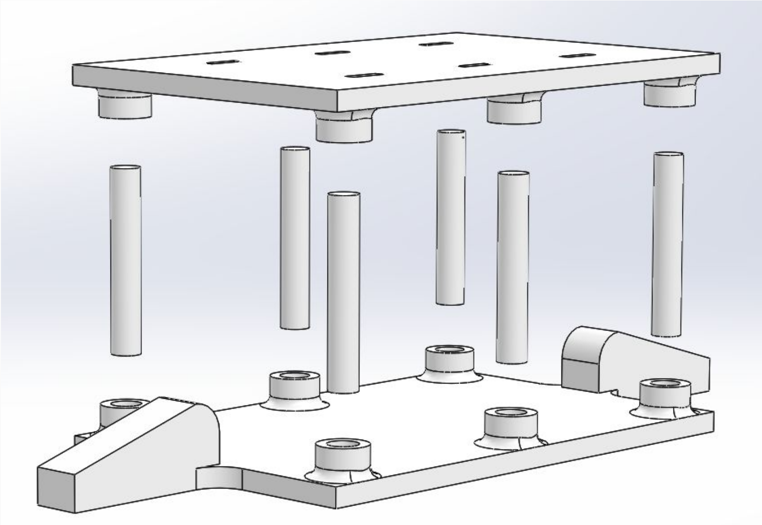
- Designed with Solidworks and 3D printed
  - Fast Prototyping
- Mounts at ends of PVC pipe arms in a C-clamp manner
- Simple and modular
  - Easily assembled and disassembled
- Secured by nylon nuts and bolts
  - Also serves as landing gear





Drone Subsystem - Body Plate Assembly

- The body plate assembly consists of three parts:
  - Bottom Plate
  - Top Plate
  - Standoffs
- Mounted on top of the vertical length pipes of the frame
- Holds all the components besides the motors



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Flight Subsystem - Motors

- **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)
- Great thrust for small size
- Lower 2300KV means less current efficiency

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Flight Subsystem - Propellers

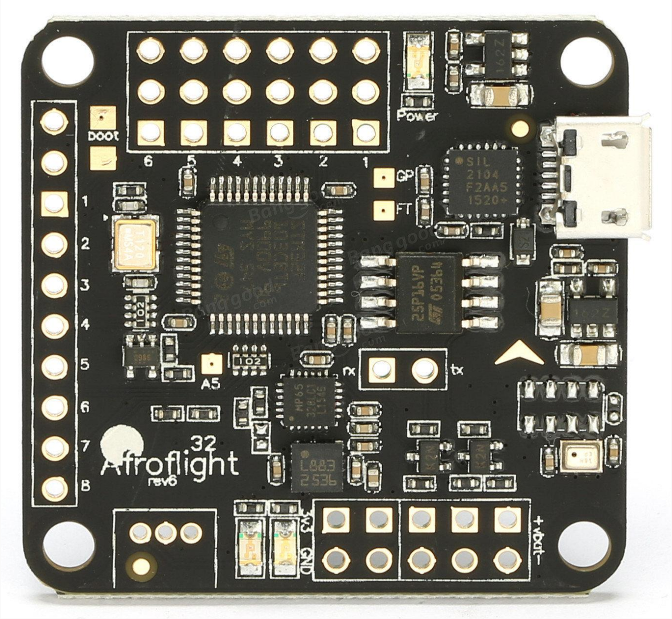
- **QProp Ethix S3 Tri-Blade Propellers**
  - Standard 5” Props
  - 3.1 Pitch
  - Weight - 3.6g x 4
  - Cost - $17.99 (16pcs)
- Benefits of a lower pitch cor ty of 5” props with a pitch of 4 and 4.5.
- Overall less max thrust and ys less current with increased efficiency

Hussain Mohammad, EE

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



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Flight Subsystem - Flight Controller Comparison

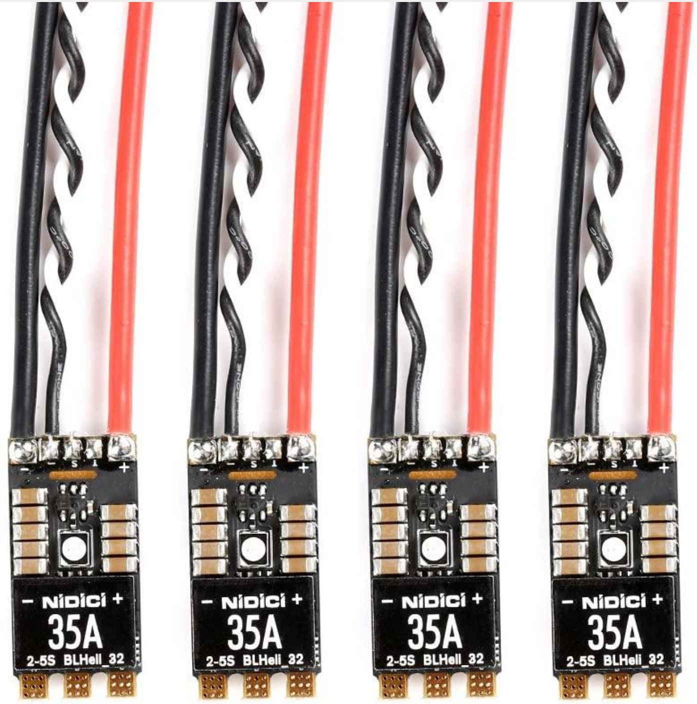
Flight Controller	Cost	CPU	Sensors
Naze32	$19.99	32-bit STM32 F1 MCU at 72MHz	Gyro, Accelerometer, Barometer, Magnetometer
X-Racer F303 v2.0	~$15	32-bit STM32 F3 MCU at 72MHz	Accelerometer, Gyro
Navio2	$168	64-bit quad-core ARMv8 CPU at 1.2GHz	Gyro, Accelerometer, Barometer, Magnetometer, GPS

Hussain Mohammad, EE

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)



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Power Subsystem - Battery

HRB Lithium Polymer Battery

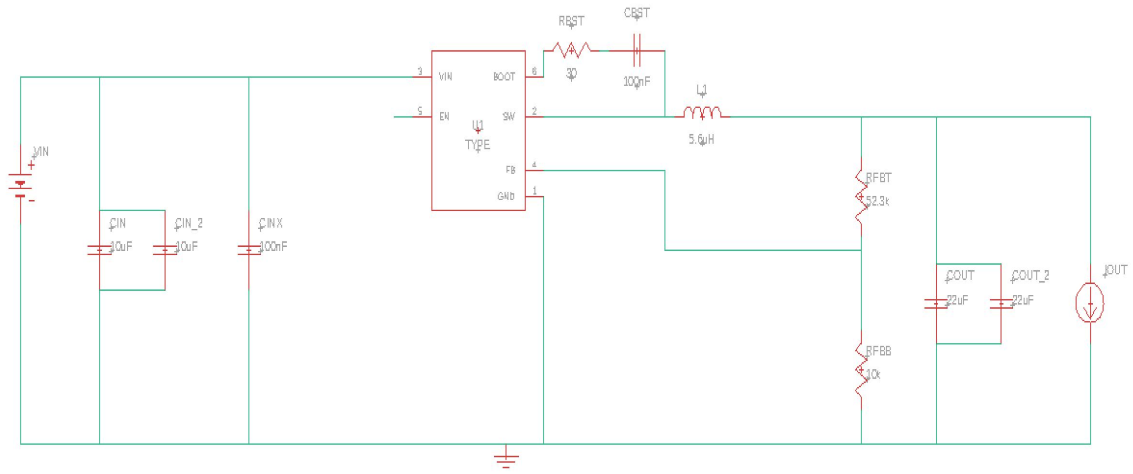
- Cells - 4S
- Capacity - 3300mAh
- Discharge Rate - 60C
- Provides 11.77min flight time
- 11.77 min = 3.3Ah/16.82A x 60min/hr
- Weight - 318g
- Cost - $37.99

Hussain Mohammad, EE

Power Subsystem - Power Distribution Board

Voltage Regulator Design

- TPS56339DDCR IC
- Buck Switching Regulator
- 14.8Vin - 5Vout
- 93.1% Efficiency



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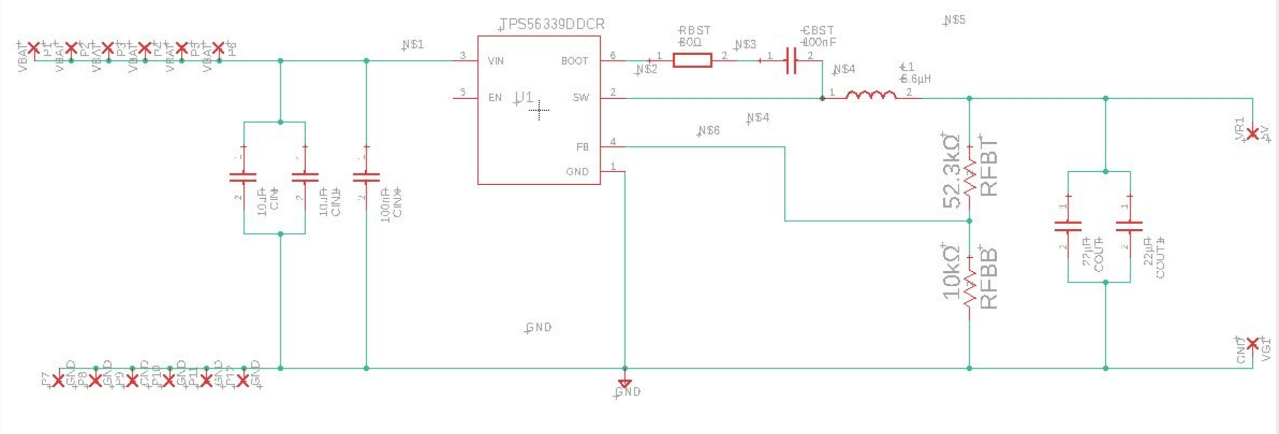
Power Subsystem - Power Distribution Board (continued)

Power Distribution Board Schematic

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



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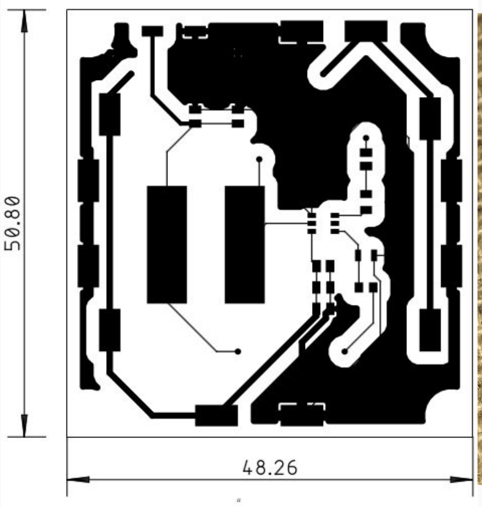
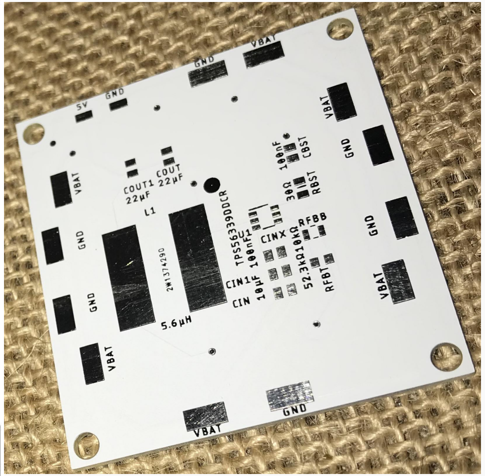
Printed Circuit Board

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





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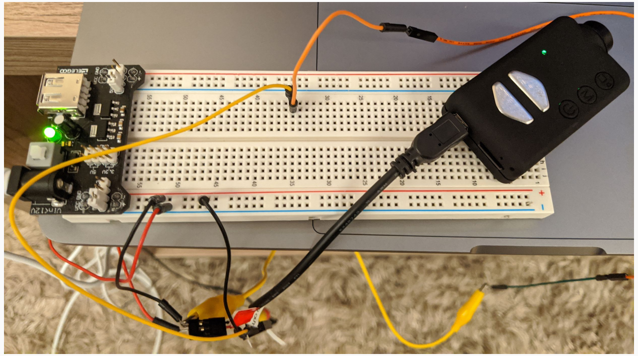
Detection Subsystem - Mobius Action Cam

	Cost ($)	**Weight (ounce)**	**Dimensions (inch)**	**Resolution (TVL)**	**Able to Have a Live Feed**
GoPro HERO	30 - 40	~4	1.5 x 2.4 x 1.2	1920/1280	Yes (WiFi + Phone App)
Mobius Action Camera	83	1	1.38 x 2.4 x 0.72	1920/1280	Yes (External Transmitter)
BETAFPV Z02	41	~0.1	0.71 x 0.55 x 0.18	600	Yes (Builtin Transmitter)

- Chose video for ease with object detection and piloting.
- Camera that is commonly used as a dash cam.
- Also needed the ability for video transmission.
- Capable with transmission other than Wi-Fi.
- At least 720p (1280 TVL) resolution.



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Detection Subsystem - Video Transmitter and Receiver

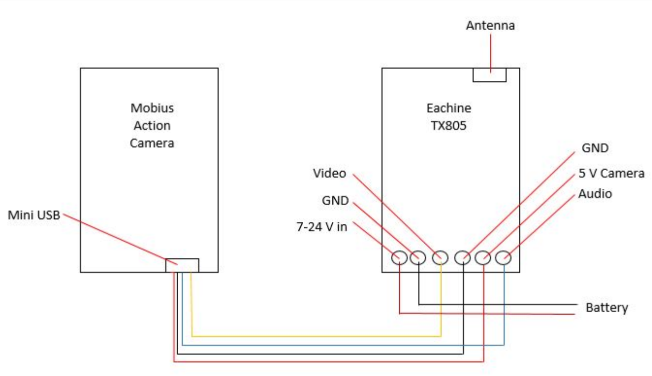
Eachine TX805 (Transmitter)

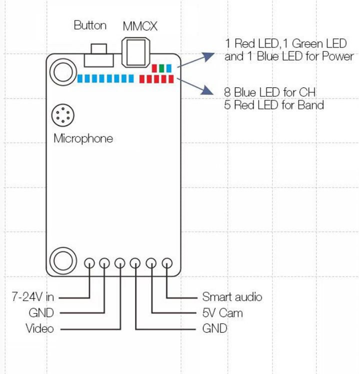
- No onboard processing.
- Processing requires significant resources to be fast and efficient.
- Phone provides more resources.

Eachine ROTG02 (Receiver)

- Phone connection compatible.
- Compatible with the selected video transmitter.

	Cost ($)	Weight (ounce)	Dimensions (inch)	Range (feet)	Frequency (GHz)
GOQOTOMO E-600	25	~5.5	4.6 x 4.6 x 1.8	50	5.8
Eachine TX805	21 - 28	~0.3	1.42 x 0.87 x 0.2	>3000	5.8
TBS Unify Pro32	50	~0.3	1.46 x 0.98 x 0.23	>19000	5.8





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Ground Control System

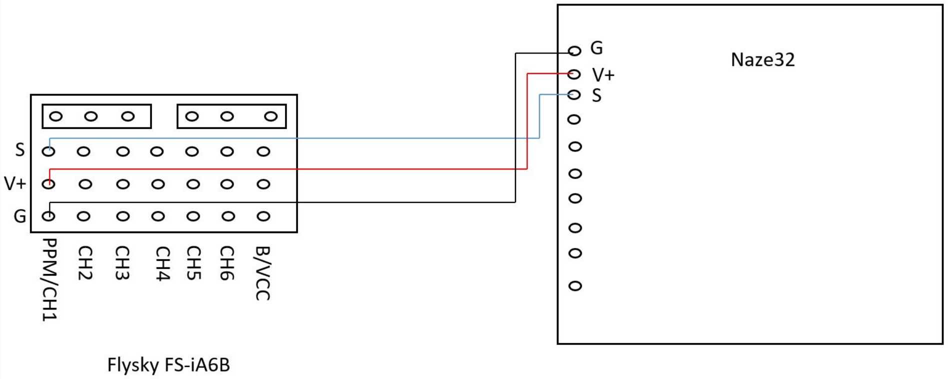
Flysky FS-i6X (Controller)

- 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.

	Cost ($)	Weight (ounce)	Dimensions (inch)	Number of Channels	Range (feet)	Frequency (GHz)
Flysky FS-i6X	57	~25	9.45 x 8.27 x 4.33	6 - 10	~3700	2.4
Taranis X-Lite	148	~11	~8.66 x 6.3 x 3.94	16	~4900	2.4



Component Placements

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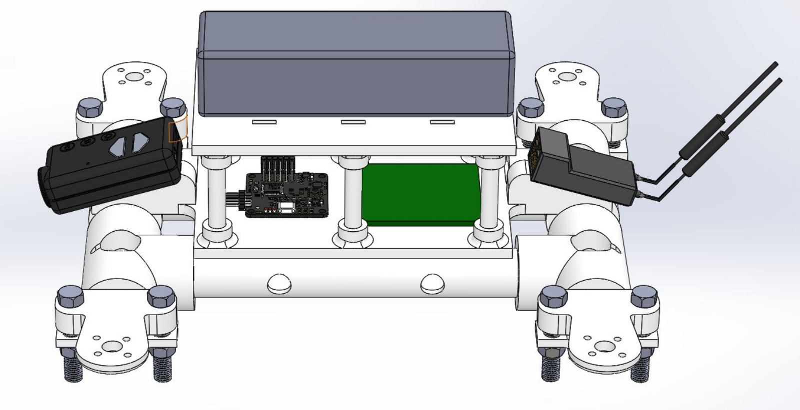
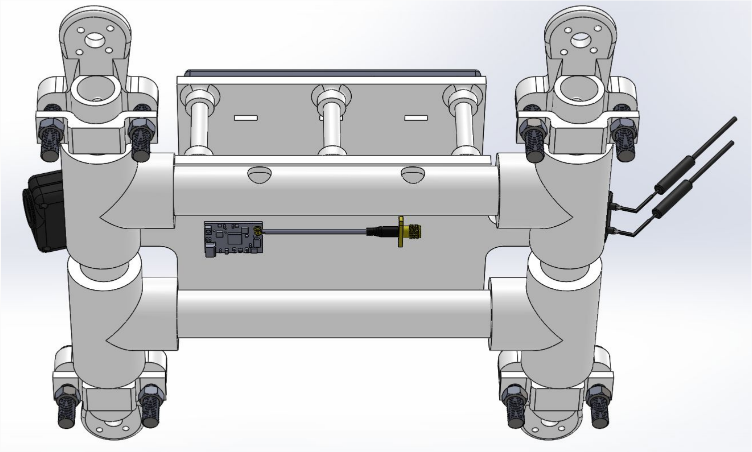
- SolidWorks CAD Assembly
- Customized 3D part models
  - Motor Mounts and Body Plate Assembly
- Standard models were sourced/modified from GrabCAD
- Dimensions, tolerances, and mass were made as accurate as possible
- Useful for prototype planning





Overall Schematic

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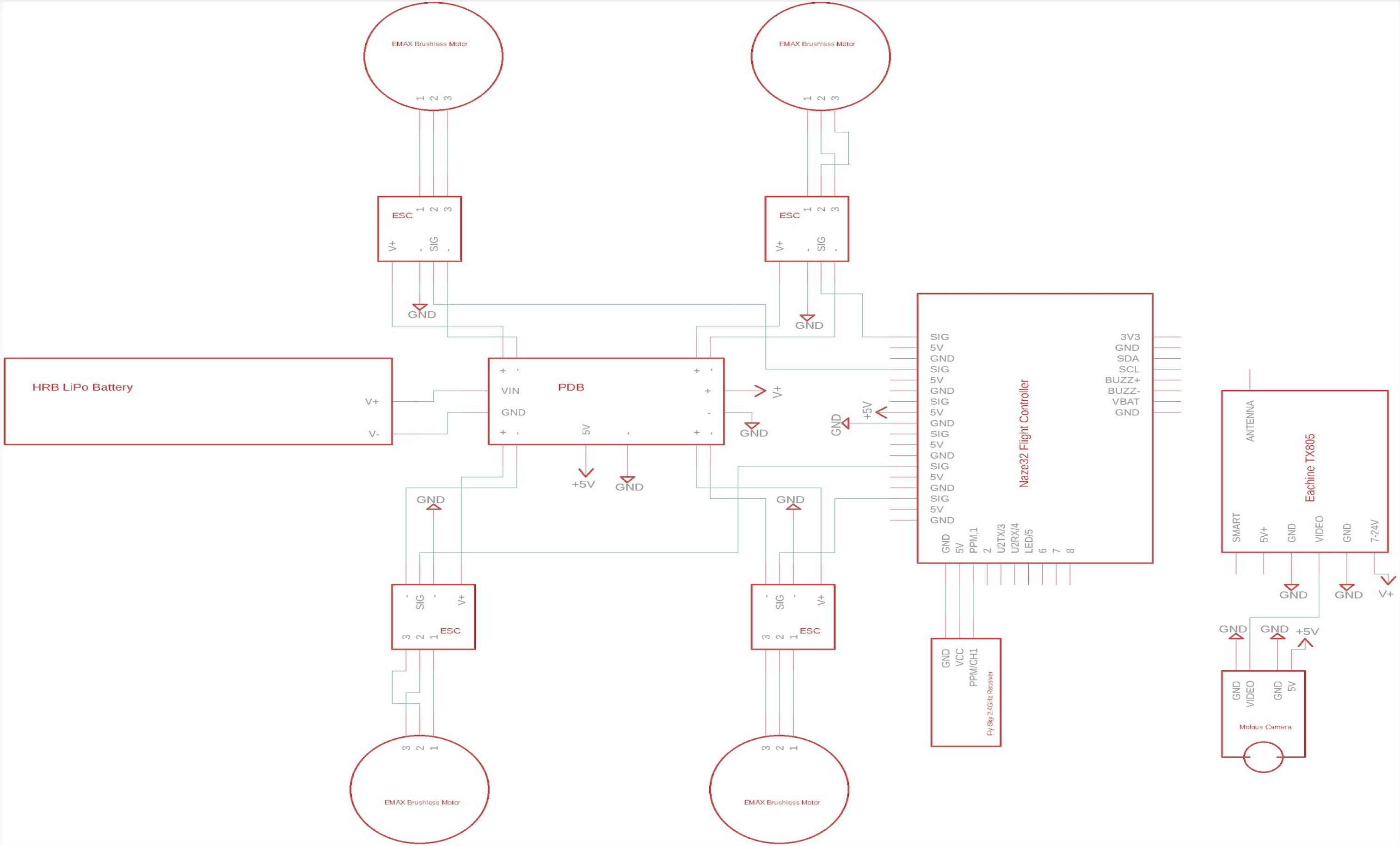

Drone Weight

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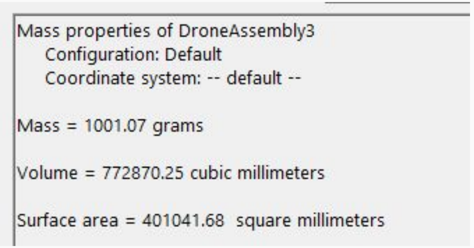
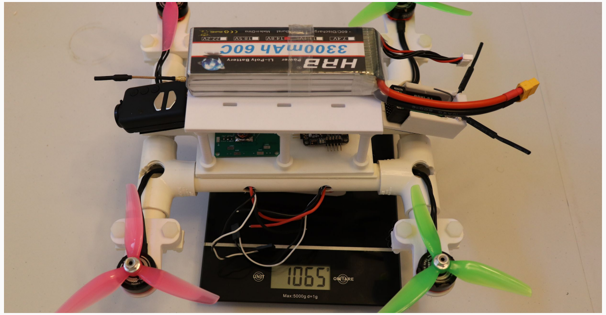
- SolidWorks Assembly Mass: 1001.07g
- Estimated Table Mass: 1039.95g
- Actual: ~1100g


Mass properties of DroneAssembly3
Configuration: Default
Coordinate system: -- default --

Mass = 1001.07 grams

Volume = 772870.25 cubic millimeters

Surface area = 401041.68 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)	25g	4	100
3D Printed Body Plate Assembly	100g	1	100
3D Printed Controller Receiver Mount	10g	1	10
EMAX RS2205-S 2300KV	30g	4	120
HQProp Ethix S3 Prop	3.6g	4	14.4
HRB 4S 3300mAh 14.8v Lipo RC Battery	380g	1	330
Mobius Camera	1.3oz or 36.85g	1	36.85
Naze32 Rev6 Full	10g	1	10
ESC	5.89g	4	23.56
Eachine TX805 (Video Transmitter)	8.1g	1	8.1
Flysky FS-iA6B (Receiver)	14.9g	1	14.9
Miscellaneous	50g	1	50
Total			**1039.05**

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Pilot Application

- Offloads machine learning tasks to a background process
- Displays bounding boxes on detected objects
- Provides count info on detected objects

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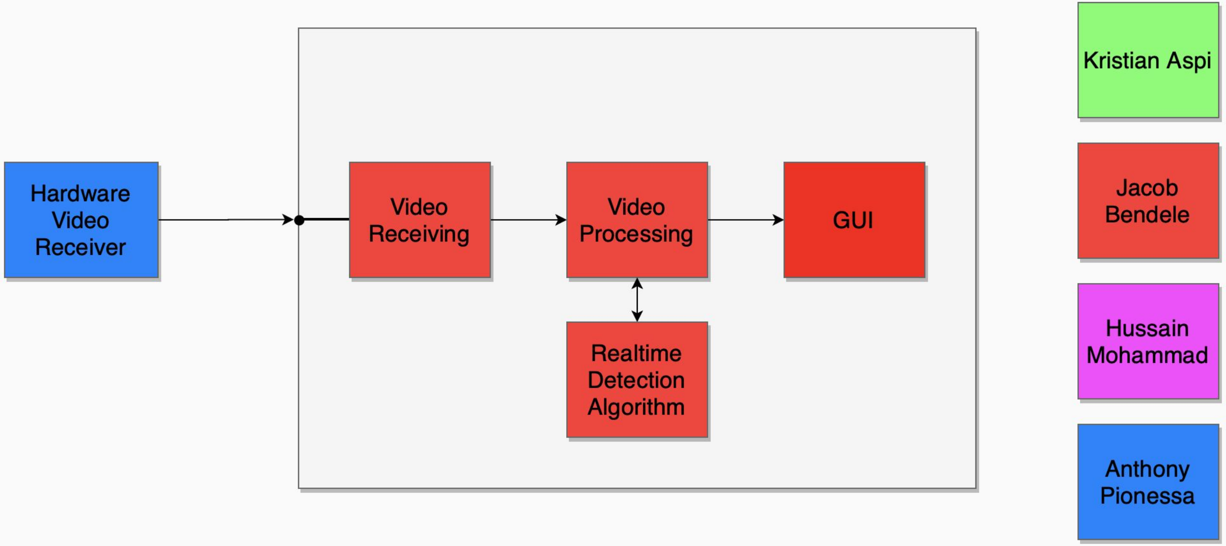
Pilot Application - Block Diagram



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Pilot Application - Video Input

Four Paths:

1) ~~Eachine Manufacturer Driver~~
2) ~~Reverse Engineer apk~~
3) ~~Screen Capture~~
4) Capture Frames

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Technology Selection

Platform	Cost ($)	Language	Support
Apple	99/yr	Swift	Mac Only
Android	25/onetime	Java	Mac, Windows, Linux

Library	Size	Platform	Use
OpenCV	>200 MB	iOS and Android	Computer Vision/Image Manipulation
TensorFlow Lite	~1 MB	iOS and Android	Machine Learning
FFmpeg	~79 MB	iOS and Android	Video, Image, & Audio Manipulation

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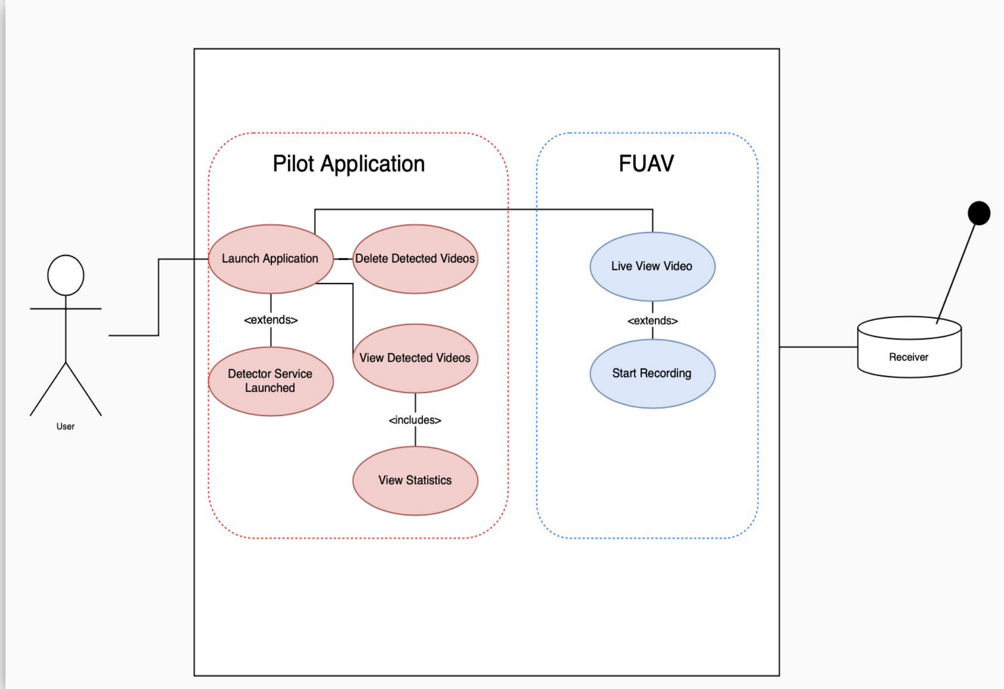
Pilot Application - Use Case

- Pilot App service is launched
- FUAV application launched when video receiver plugged in
- FUAV saved a flight video
- Pilot app display detected video w/ stats



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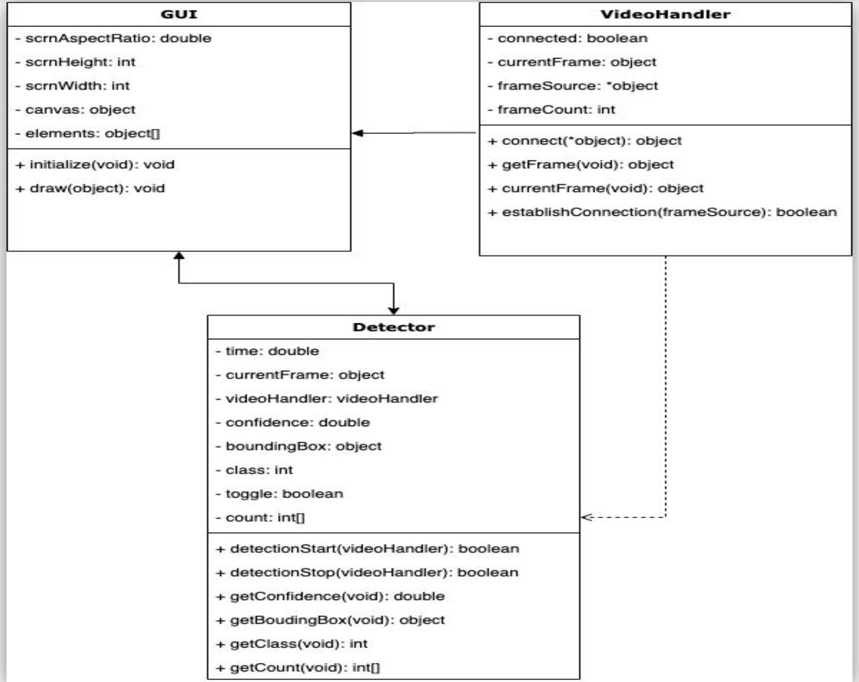
Pilot Application - Structure

- VideoHandler class parses frames
- Frames get detected by Detector
- Frames are encoded to MP4
- Dependency between classes Detector and VideoHandler



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Pilot Application - Detector

- Single Shot Detector: COCO SSD MobileNet v1
- Realtime inference on mobile: 25-45 ms
- Easy to implement via TensorFlow Lite

Detectors	**Inference Time**	**Model Size**	**Type**
COCO SSD MobileNet v1	24-45ms	27 Mb	2D
MediaPipe Objectron	N/a	N/a	3D
YOLObile	52-58ms	~244 Mb	2D

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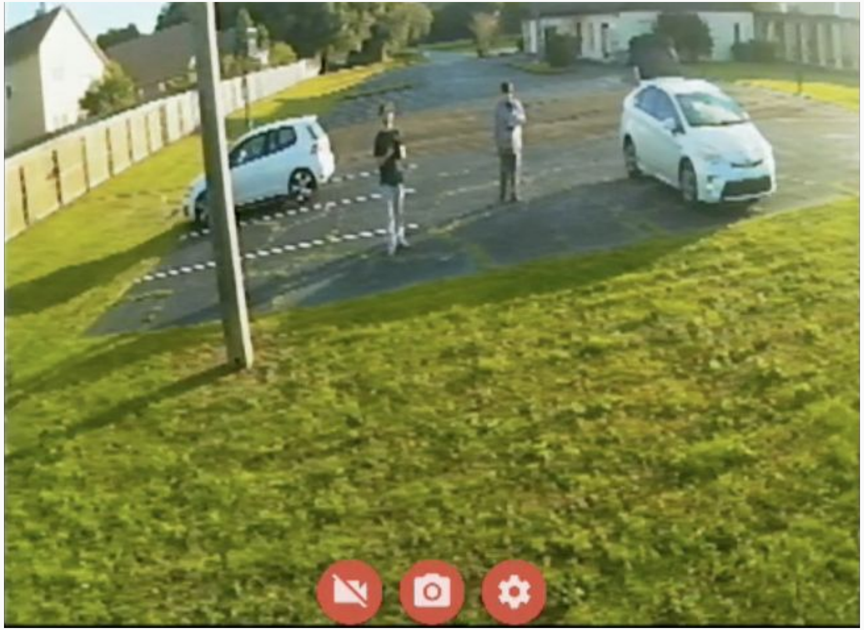
Eachine FUAV



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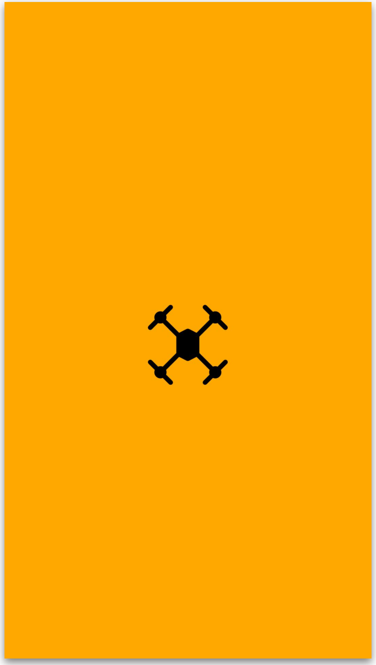
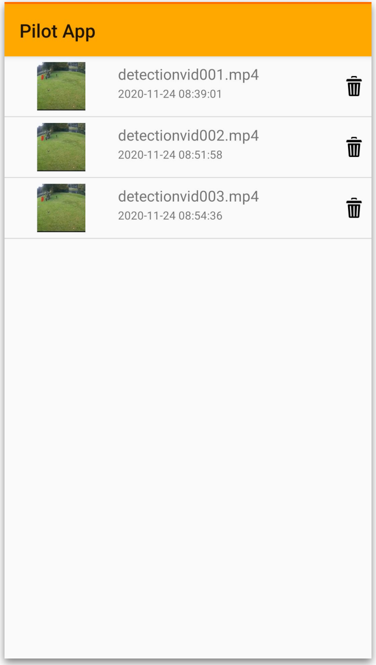
Pilot Application - Front End





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Stretch Goal - GPS Recovery

- Drone Crashes/Lost/Stolen
- GPS module gathers coordinate
- MCU sends data to GSM module
- Send SMS message to pilot’s phone

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Stretch Goal - GSM Module

- Drone operation distance can exceed 400 ft under crash conditions
- Drone can be lost or stolen
- WiFi and BT proximity based, not as useful

Comm Modules	Price	Size	Weight	Features	Range
SIM800C	$30-35	1.97 x 1.20 x 0.06 inches	10 g	GSM (2G), GPRS (2G)	35 km
ESP8266	$8-15	0.95 x 0.63 x 0.13 inches	3 g	802.11b (WiFi)	45-100 m
HM-10	$8-10	1.2 x 0.6 x 0.1 inches	8 g	Bluetooth 4.0, BLE	< 100 m

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Stretch Goal - GPS Module

- Provides location data
- Has support with well known and easy to use libraries
- Faster fix time results in less waiting on first coordinate

GPS Modules	Price	Size	Weight	Features
GT-U7	$9-10	1.09 x 1.09 inches	10.9 g	20 sec fix, w/ passive antenna, TinyGPS library support
BN-880	$17-22	1.11 x 1.11 inches	10 g	30 sec fix, no antenna, poor support

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Stretch Goal - MCU

- Both were convenient as already owned (free)
- Atmega2560 chosen for its 4 UART channels (gps, gsm, PC)
- Additionally, Arduino IDE has support for previously mentioned TinyGPS library

MCU	Price	Size	Weight	Features
ATmega2560-16U	$9-10	0.55 x 0.55 inches	0.58 g	4 UART channels, 8-bit, 16Mhz
TI MSP430fr5969	$4-5	0.48 x 0.41 inches	~0.50 g	2 UART channels vie eUSCI, 16-bit, 16Mhz

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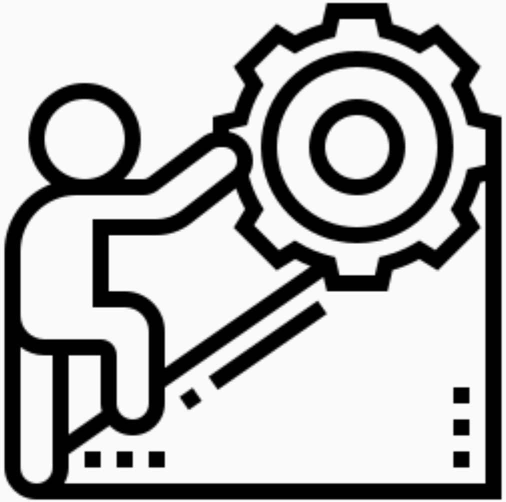
Stretch Goal - Challenges

- Major US cellular carriers such as T-Mobile and Verizon cancelled legacy services this year. (AT&T back in 2017)
- New 4G modules $60+ and shipping times from china 3+ weeks
- Time simply ran out



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Related Standards & Constraints

- Battery Standards:
  - **e-Stewards**: Disposing of spent LiPo batteries properly
- Drone Standards/Constraints:
  - **ISO 21384-3:2019**: standard is developed to provide a minimum safety and quality to the unmanned aircraft systems (UAS)
  - **FAA 14 CFR Part 107:** Drones shall not be flown higher than 400 ft altitude
  - **FL934.50:** Comply with filming/recording and appropriate flight of drones within Florida
- Additive Manufacturing Standards:
  - **ISO/ASTM 52910:2018:** Requirements and guidelines for (AM) additive manufacturing

Anthony Pionessa, CpE

Budget and Financing

- Budget of <= $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

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Successes and Difficulties

Successes:

- Early PCB design
- Below Budget
- Clear goals and timeline
- Able to adapt to challenges

Difficulties:

- Having to reorder devices
- First PCB vendor gave outrageous price
- SMD soldering (very small)
- Redesigning of the PCB
- COVID related inconveniences
  - Increased delivery times

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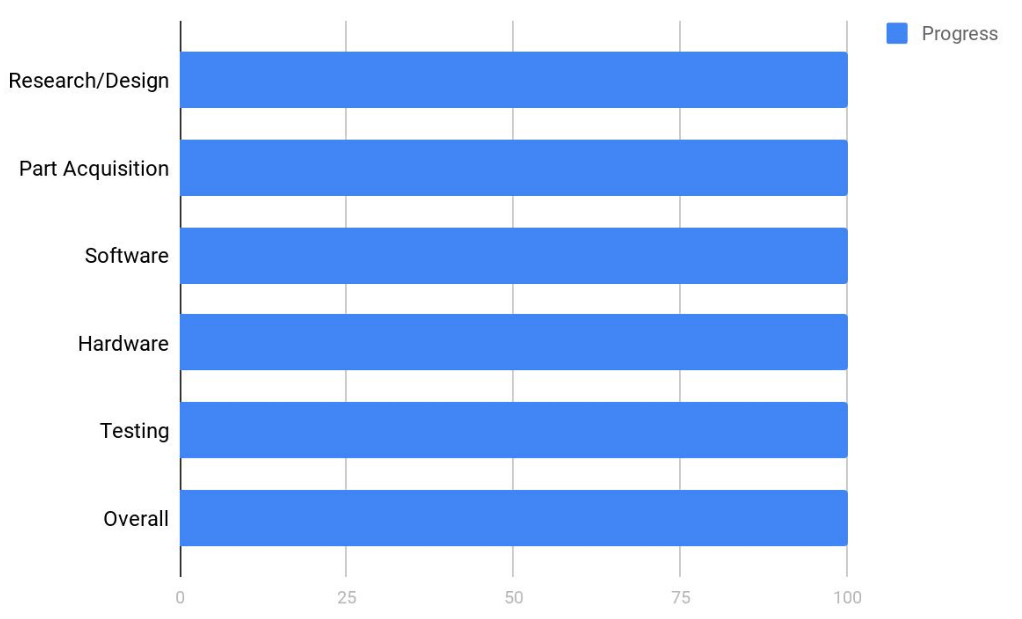
Current Progress

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



Questions?