D.E.A.R Drone

Group B:

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UCF

Project Description

- D.E.A.R Drone is an autonomous delivery drone that will deliver a package of ½ pounds.
- The D.E.A.R drone will use sensors such, as GPS and a camera to ensure the package makes it to the destination safely.
- Our mission is to help streamline supply chains to get people their products faster

Project Pros/Cons

Pros

- Fast Delivery
- More Efficient than Truck Delivery
- No human delivery person
- Fully electric
- Cheaper
- Can deliver to remote or inaccessible areas
- Multi-rotors are more maneuverable than fixed-wing aircraft

Cons

- Short range
- Single delivery per trip
- Low payload capacity
- Multi-rotors are less efficient than fixed wing aircraft
- Multi-rotors are slower than fixed wing aircraft

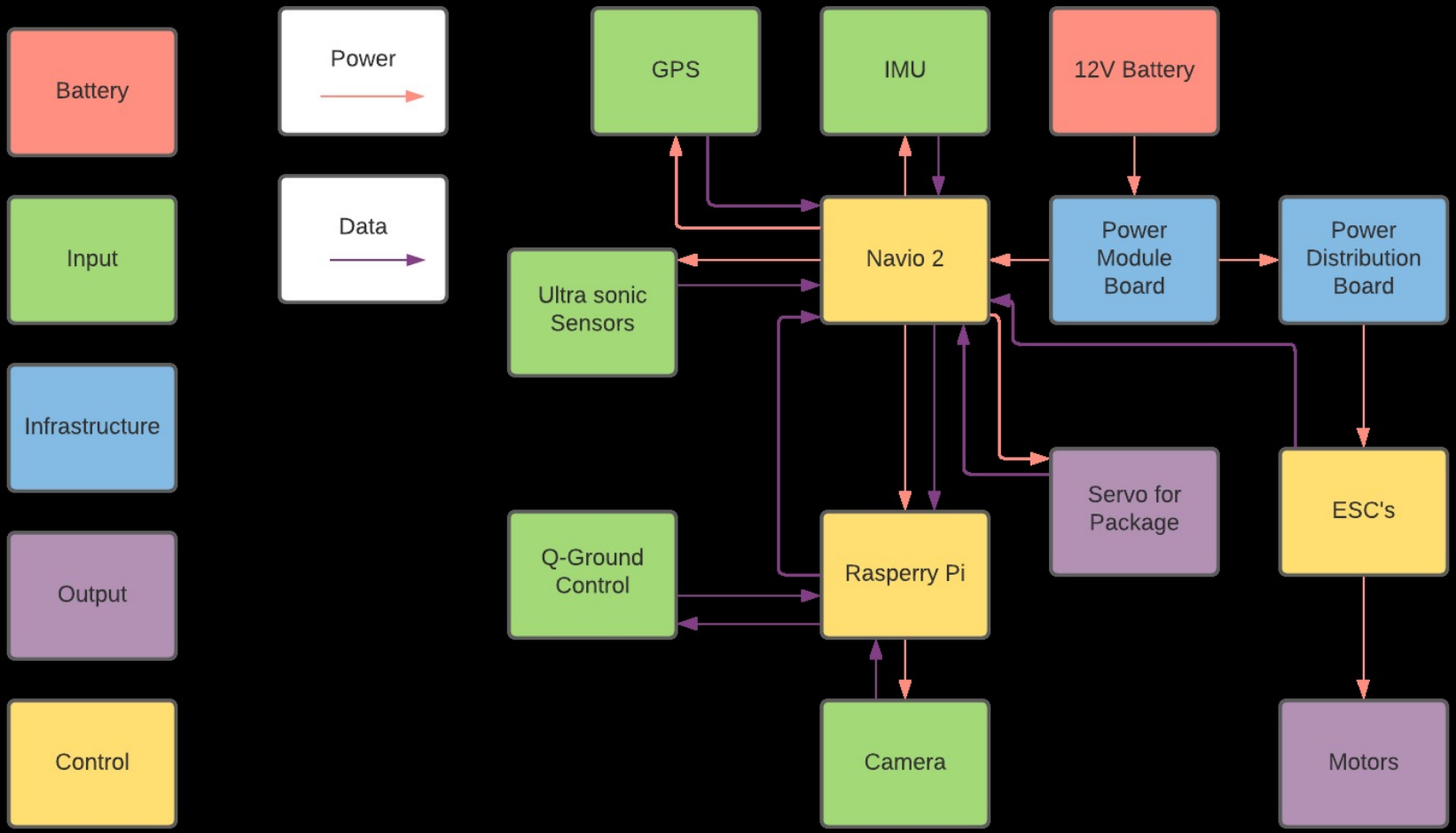
Specs/Requirements

Specifications	
Payload Weight	.5 Pounds
Battery Capacity	6000mAH
Flight time	20min(+-10 vertical)
Field of view	60 degree horizonal
Range of view	.5-10feet
Measuring Frequency	10Hz
Autopilot	GPS

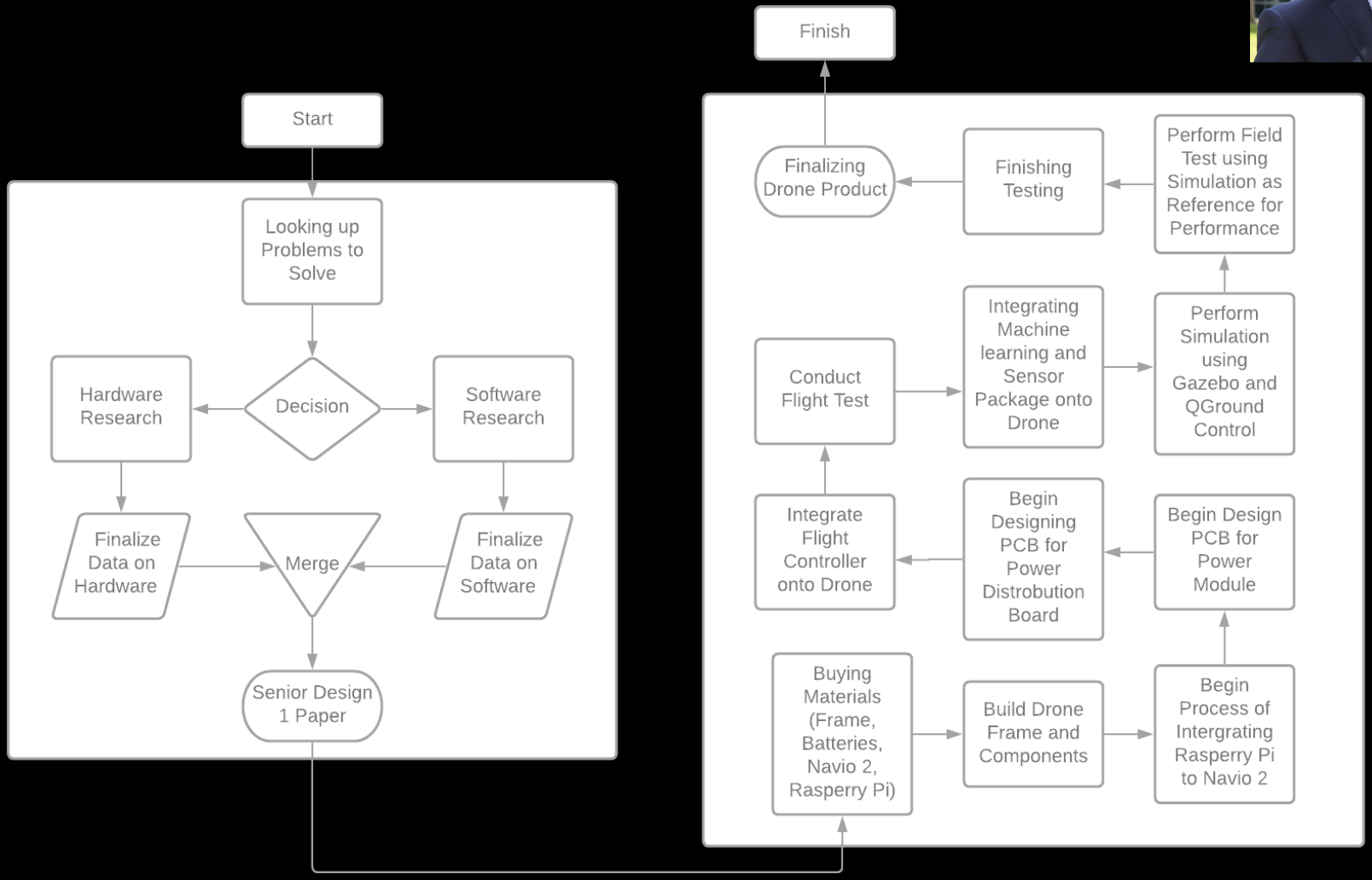
Standards

Standard	Component
IPC-2221 PCB Standard	PCB design and manufacturing
NFPA Electrical Safety Standards	Safety standards for electrical components
PEP8	Python style guide
IEEE standard 802.ac/n	Wi-Fi
Batteries IEEE 485-2010	Standard for Lead Acid and LiPo Batteries
FAA part 107 UAS	Drone Flight

Project & System Diagram



Block Diagram – Overall System or Project



Drone Design and Frame

- Our frame was chosen for cost as well as functionality
- Plastic when it breaks snaps apart, while carbon fiber splitters
- Carbon fiber also interferes with RF signal
- The cost was kept down using a bundle deal that included the ESCs, rotors, motors, and PDB

Battery

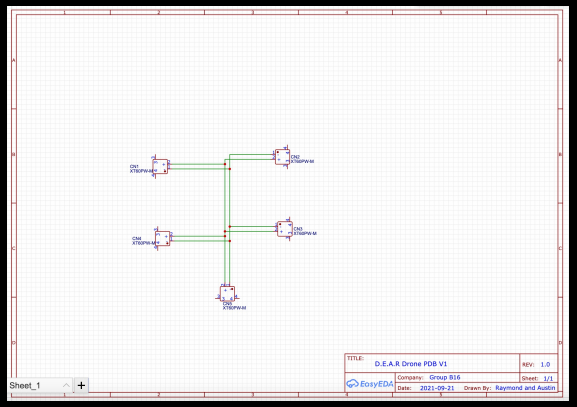
- We decided on the Turnigy nanotech 6000-mAh 3s LiPo
- This battery provided us, after utilizing the rate of consumption formula, that we could achieve a flight time of 20 minutes

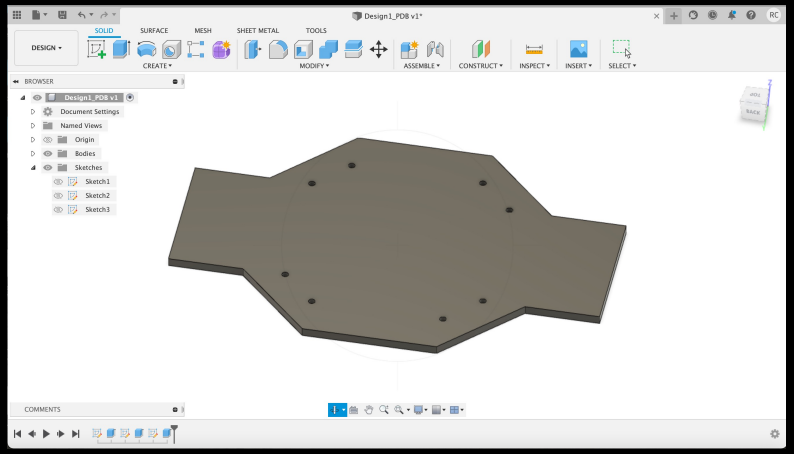
Consumption Formula:
(Milliamp hours/ avg amp draw) * 60 = amount of flight time in minutes

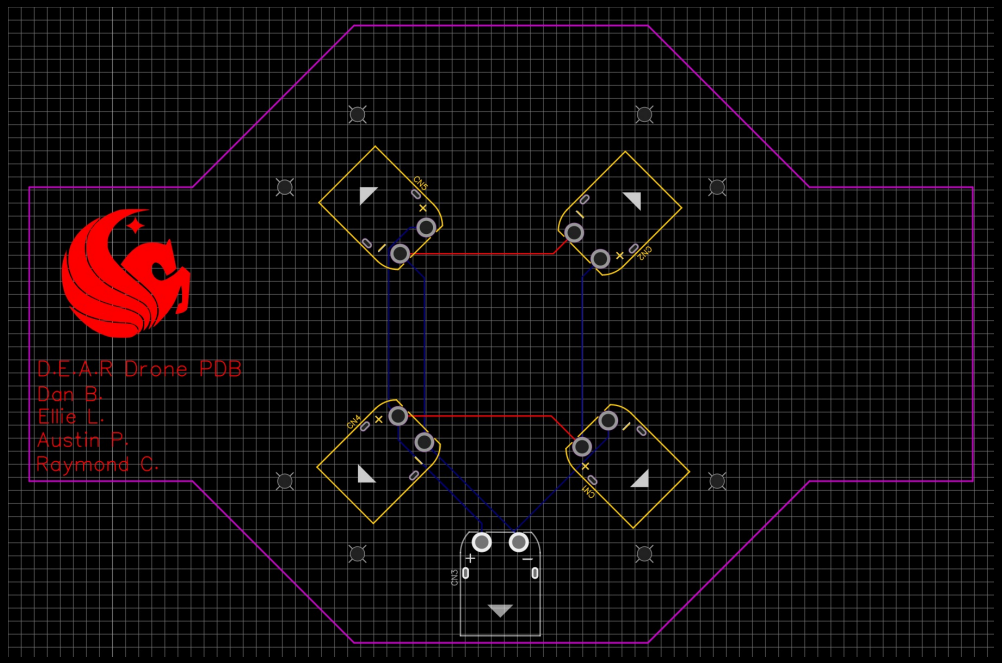
PCB Designs

PCB Design

- Power Distribution Board
  - Send 11V evenly to all our ECS's

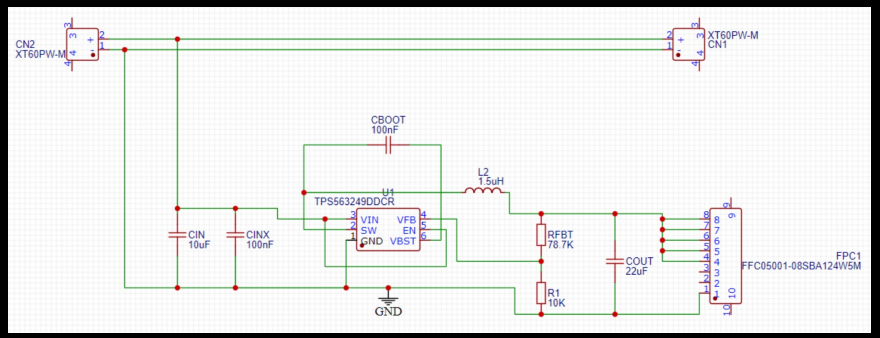


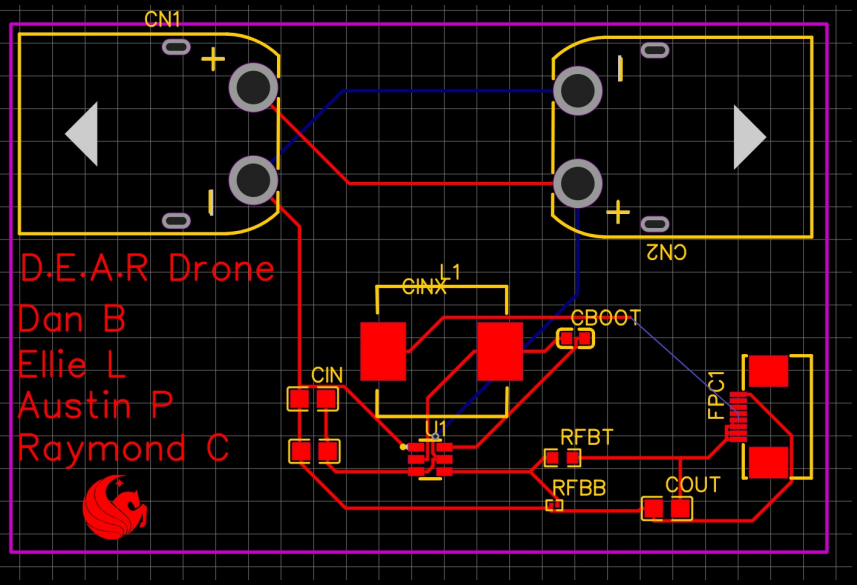




PCB Design

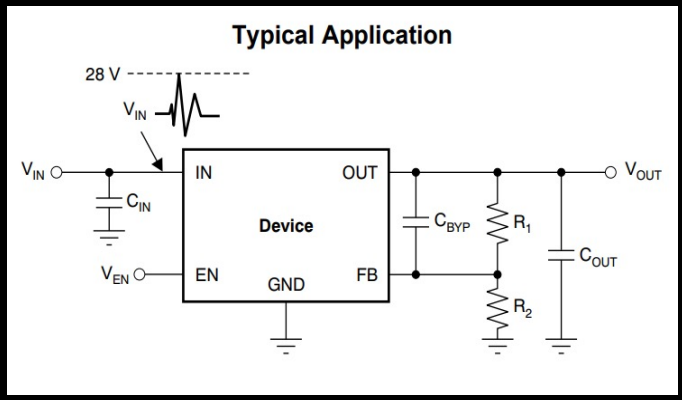
- Power Module
  - Sends 11V to our power distribution board
  - Steps down 11V to 5V and 2.5mA for the flight controller
  - XT60 to XT60 connection

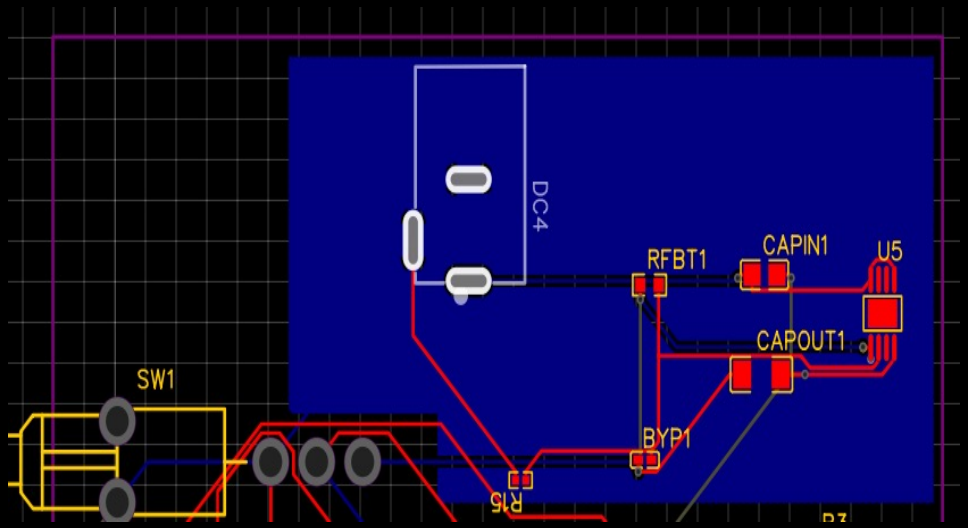


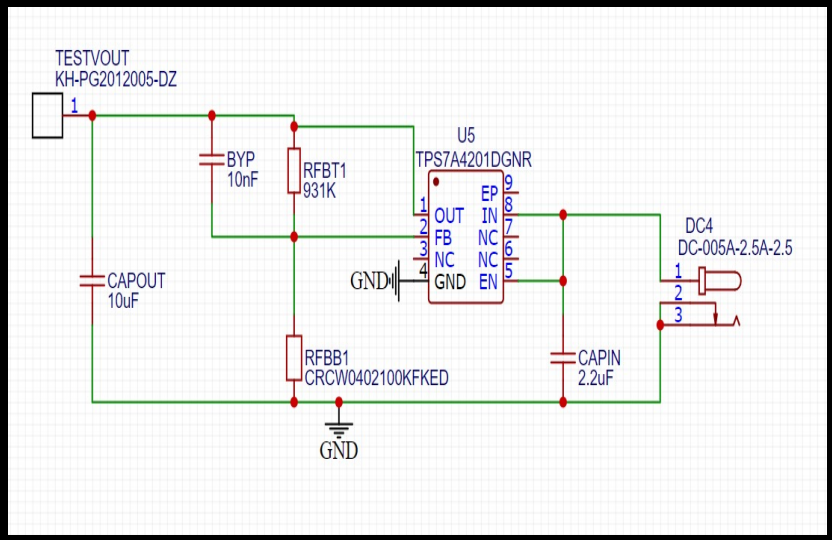


PCB Schematic [DC-DC Converter]

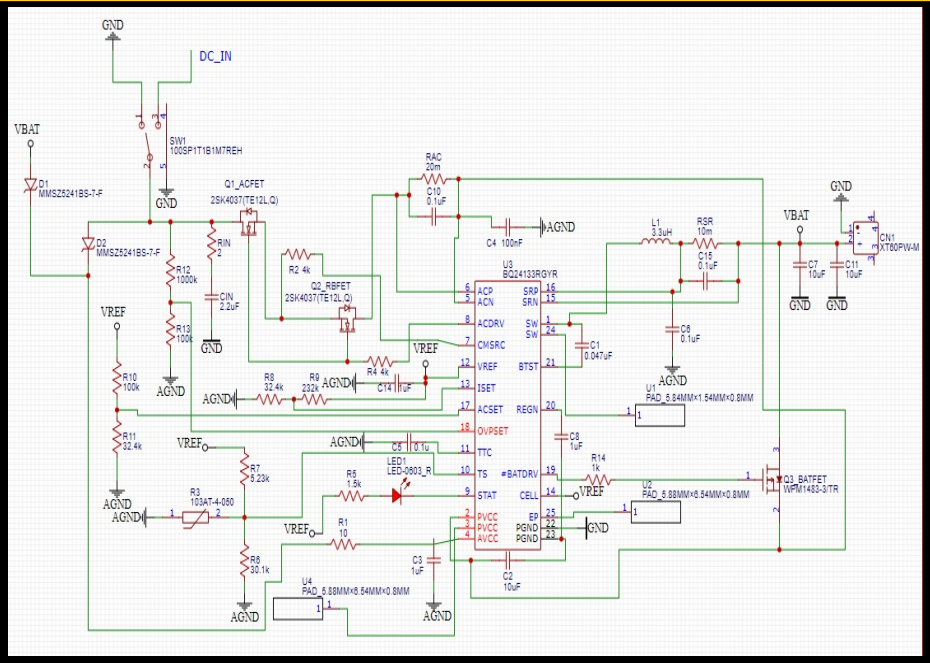
- DC-DC Converter
- Barrel Jack/ Laptop Charger
- Input DC Power 19V
- Output to Battery IC 12V at 1.5mA

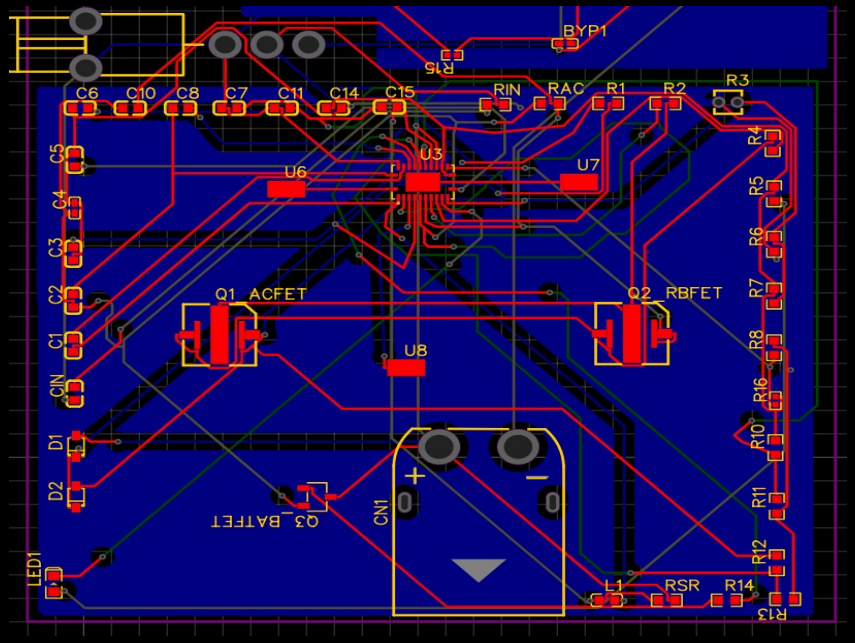






PCB Schematic [Battery Management IC]





- The design of the Battery Management system was done using the “Typical Application” provided by the Datasheet
- Main Chip component: BQ24133RGYR under the Family component: BQ24133
- Using this aspect of our chip, we can charge 3 Cells at one time, protect them, and manage them, it was an ideal choice.

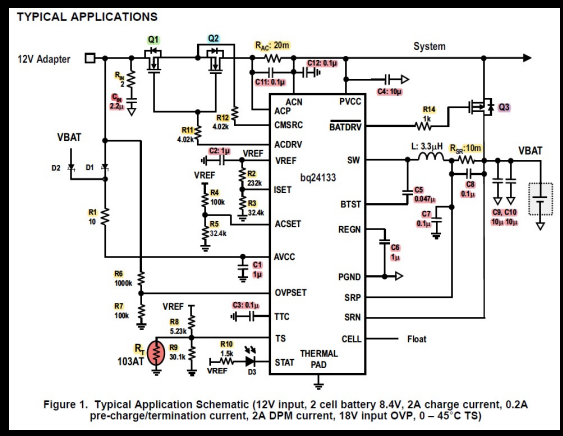
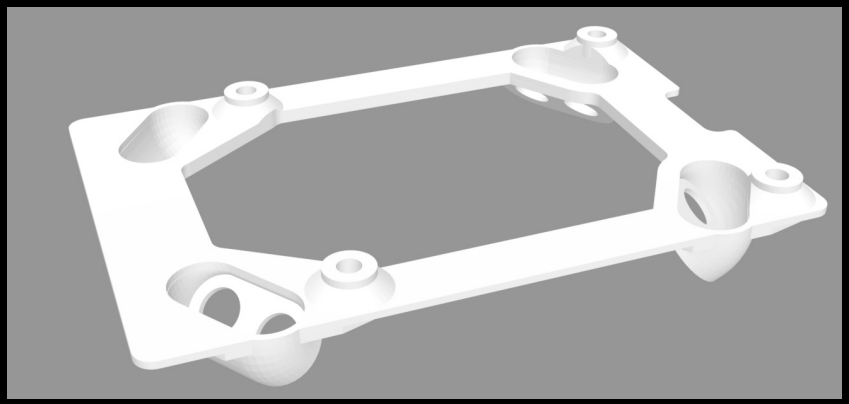
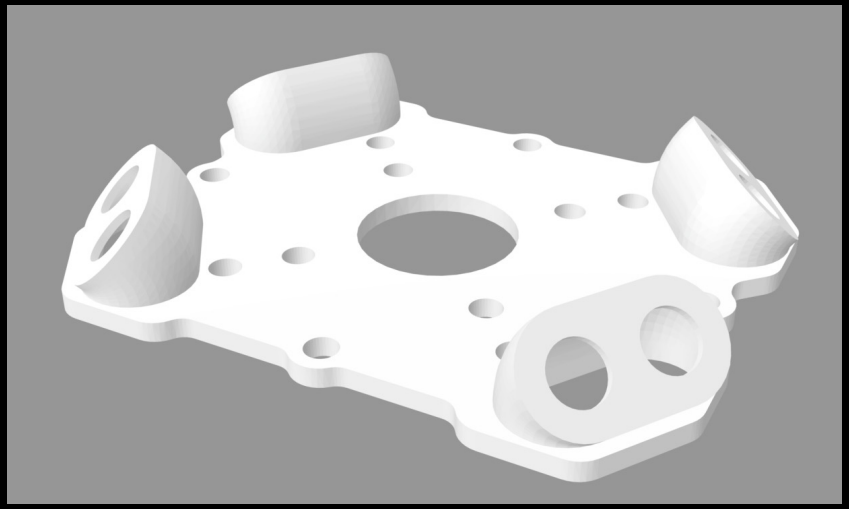
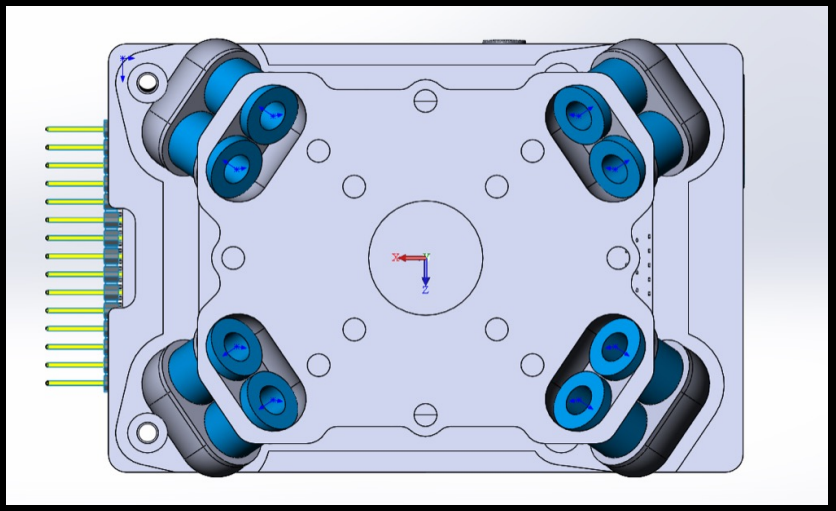


Figure 1. Typical Application Schematic (12V input, 2 cell battery 8.4V, 2A charge current, 0.2A pre-charge/termination current, 2A DPM current, 18V input OVP, 0 – 45°C TS)

Vibration Dampening Mount







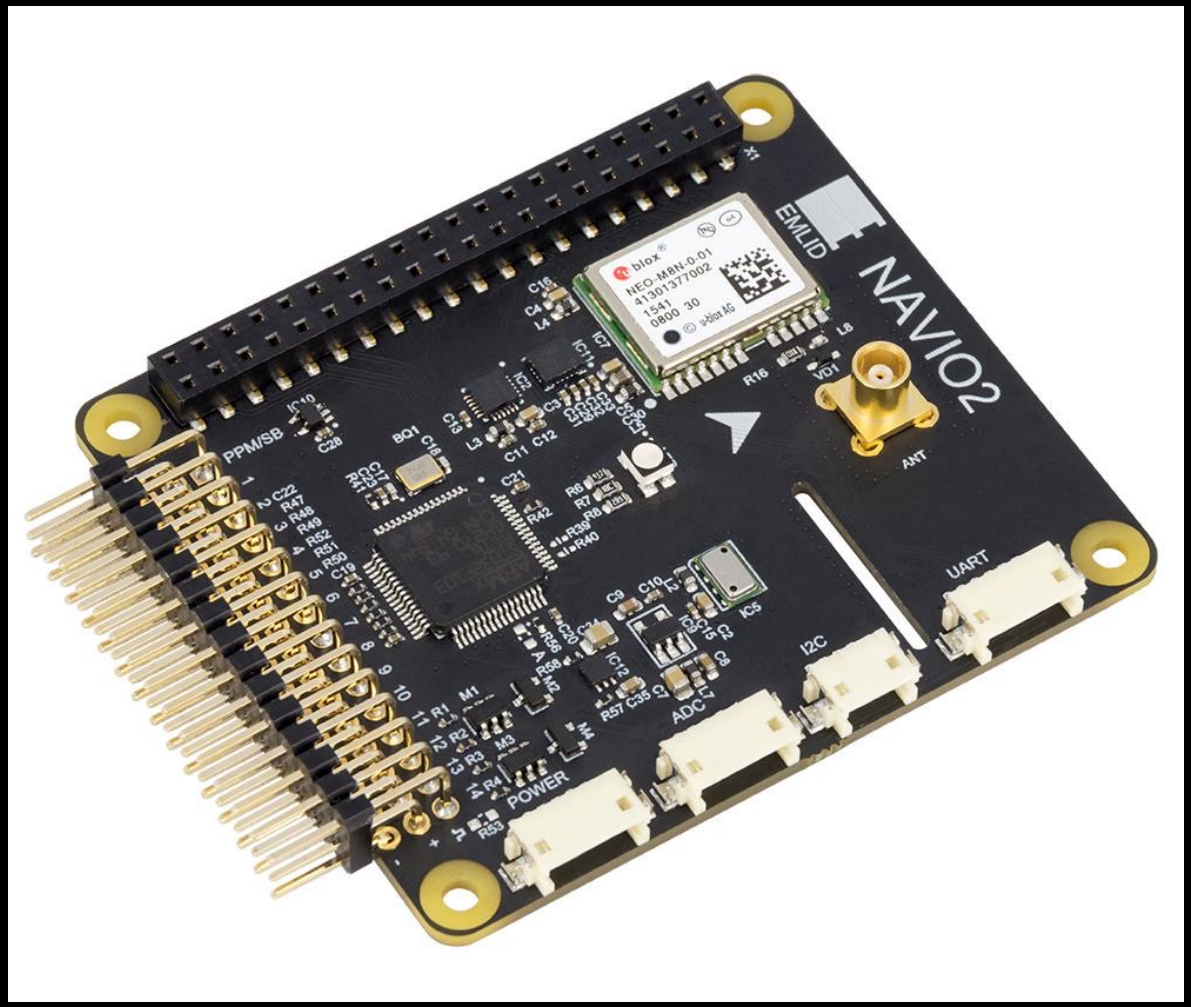
Flight Control Board

Board	Price ($)	Weight (g)	Firmware	OS	Popularity	Bus Width
Pixhawk	80	60	ArduPilot, PX4	No	High	32 Bit
Pixhawk Cube	250	150	ArduPilot, PX4	No	High	32 Bit
Navio2 + Raspberry Pi 4	168 + 35/55/ 75	23	ArduPilot, PX4	Linux	Medium	64 Bit
BeagleBone Blue	80	52	ArduPilot, PX4	Linux	Low	32 Bit

Flight Control Board

Board	Processor	RAM	Ports	Sensors	Networking
Pixhawk 1	180 MHz ARM® Cortex® M4 with single-precision FPU	256 KB	I2C, CAN, ADC, UART, CONSOLE, PWM, PWM/GPIO/PWM input, S.BUS/PPM/SPEKTRUM, S.BUS out, microUSB	gyroscope, accelerometer/ magnetometer, accelerometer/gyroscope, barometer	wifi, DSM-X
Pixhawk Cube	180 MHz ARM® Cortex® M4 with single-precision FPU	256 KB	Same as Pixhawk 1 but more UART ports + UART HW flow control	gyroscope, accelerometer/ magnetometer, accelerometer/gyroscope, barometer	wifi, DSM-X
Navio2 + Raspberry Pi 4	Broadcom BCM2711, Quad core Cortex-A72 (ARM v8) 64-bit SoC @ 1.5GHz	2GB, 4GB or 8GB	UART, I2C, ADC, 12 PWM servo outputs, PPM/S.Bus input, HDMI, MIPI display port, MIPI camera port, microSD, USB3.0, USB 2.0	Accelerometers, gyroscopes, and magnetometers, Barometer	2.4GHz WiFi, Bluetooth, BLE
BeagleBone Blue	Octavo Systems OSD3358 1GHz ARM Cortex-A8	512 MB	4x UART, 2-cell LiPo, 2x SPI, I2C, 4x A/D converter, CAN bus (w/ PHY), 8x 6V servo motor, 4x DC motor, 4x quadrature encoder, USB 2.0 480Mbps Host/Client Port, USB 2.0 Host Port	9 axis IMU (access, gyros, magnetometer), barometer, thermometer	2.4GHz WiFi, Bluetooth, BLE

Navio2



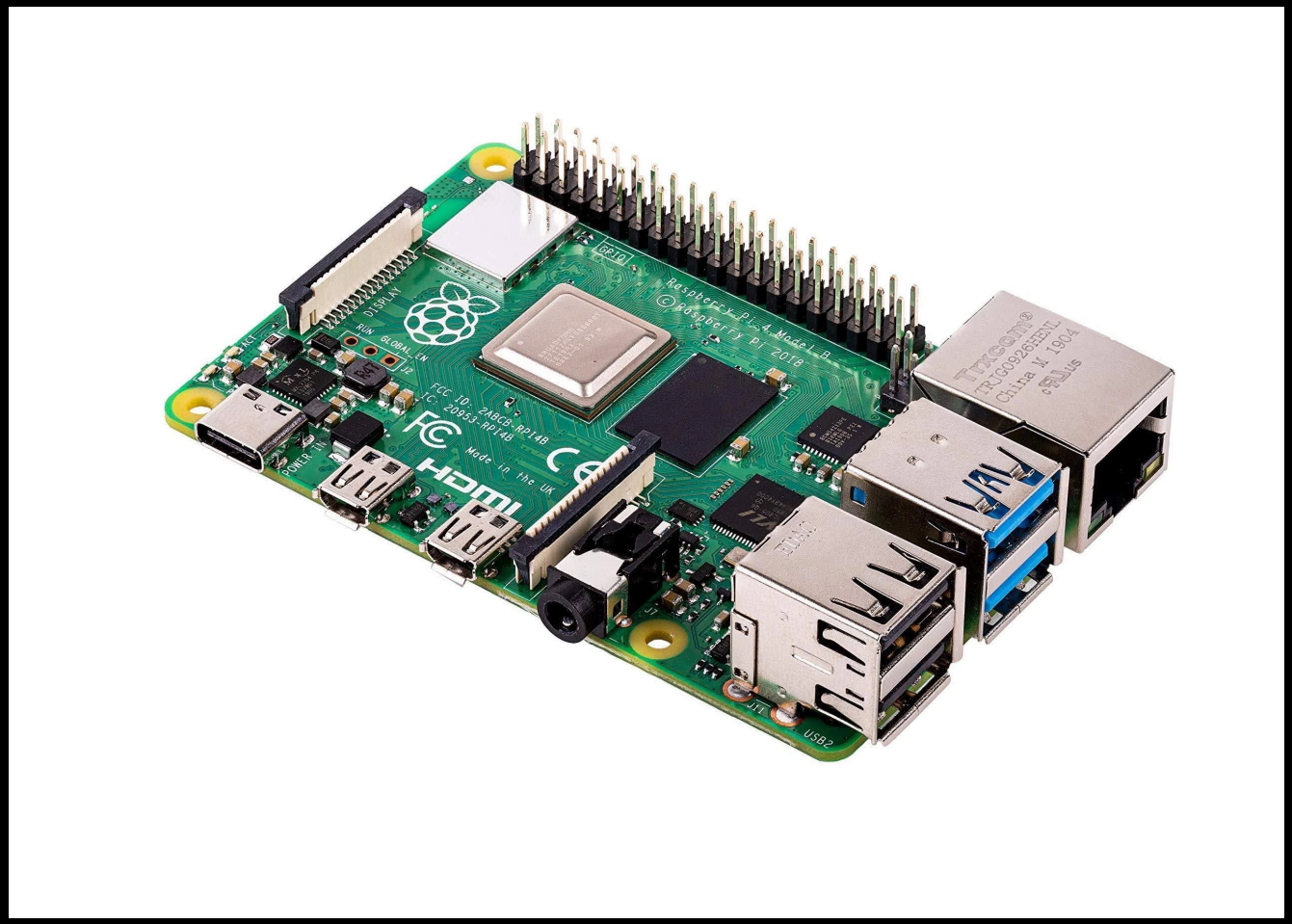
Data Processing Computer

	Raspberry Pi 4B	NVIDIA Jetson Nano
CPU	Quad-core ARM Cortex-A72 64-bit @ 1.5 Ghz	Quad-Core ARM Cortex-A57 64-bit @ 1.42 Ghz
GPU	Broadcom VideoCore VI (32-bit) (Integrated)	NVIDIA Maxwell w/ 128 CUDA cores @ 921 Mhz
Memory	4 GB LPDDR4**	4 GB LPDDR4
Networking	Gigabit Ethernet / Wifi 802.11ac	Gigabit Ethernet / M.2 Key E (for Wifi support)
Display	2x micro-HDMI (up to 4Kp60)	HDMI 2.0 and eDP 1.4
USB	2x USB 3.0, 2x USB 2.0	4x USB 3.0, USB 2.0 Micro-B
Other	40-pin GPIO	40-pin GPIO
Video Encode	H264(1080p30)	H.264/H.265 (4Kp30)
Video Decode	H.265(4Kp60), H.264(1080p60)	H.264/H.265 (4Kp60, 2x 4Kp30)
Camera	MIPI CSI port	MIPI CSI port
Storage	Micro-SD	Micro-SD
Price	$55 USD	$99 USD

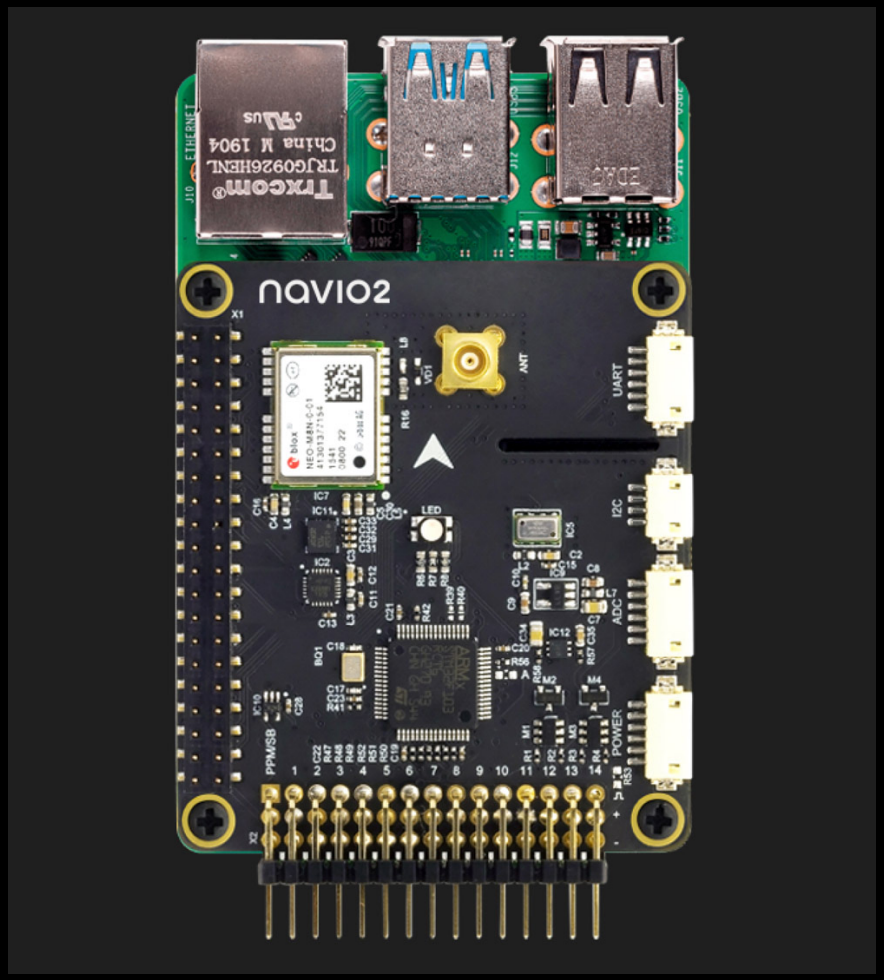
Data Processing Computer

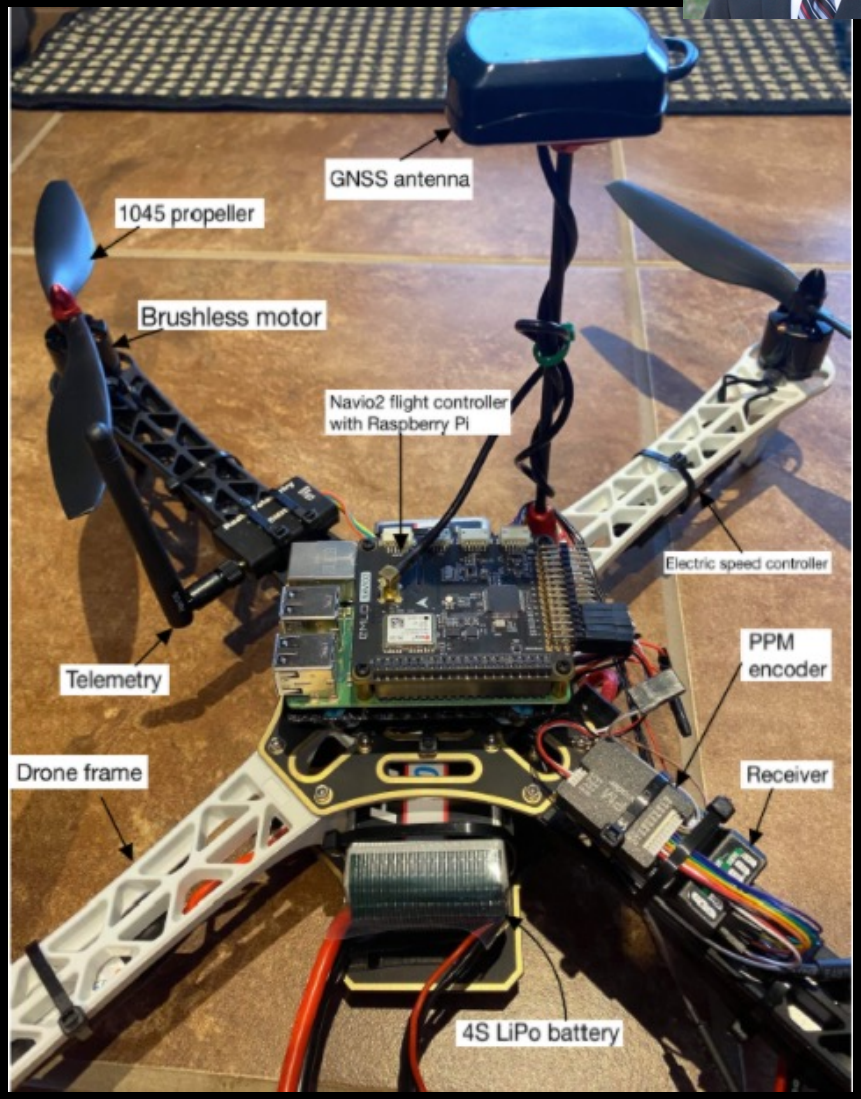
Test	Raspberry Pi 4 B 8GB	Jetson Nano 4GB
Tinymembenc Standard Memcpy	2526.8 MB/s	3501 MB/s
TTSIOD 3D Renderer Phong Rendering With Soft-Shadow Mapping	32.3075 FPS	41.00 FPS
7-Zip Compression Compress Speed Test	3701 MIPS	3501 MIPS
C-Ray Total Time – 4K, 16 Rays Per Pixel	609.431 Seconds	932 Seconds
Primesieve 1e12 Prime Number Generation	519.238 Seconds	468 Seconds
AOBench Size: 2048 x 2048	125.643 Seconds	187 Seconds
FLAC Audio Encoding WAV To FLAC	85.805 Seconds	104.01 Seconds
LAME MP3 Encoding WAV To MP3	124.952 Seconds	144.21 Seconds
Perl Pod2html	0.58082059 Seconds	0.7114 Seconds
Redis GET	491168.39 Requests/Second	568431 Requests/Second
PyBench Total For Average Test Times	5673 Milliseconds	7080 Milliseconds

Raspberry Pi 4B



Flight Control Unit





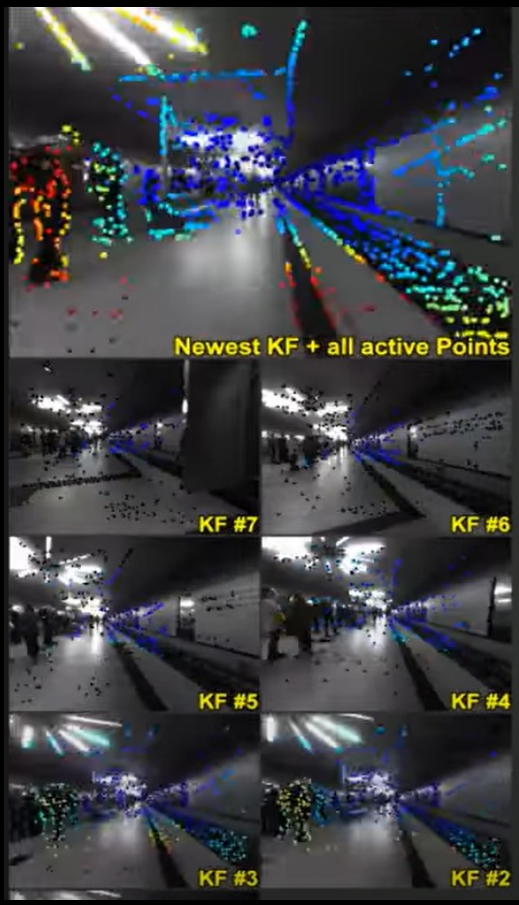
Camera

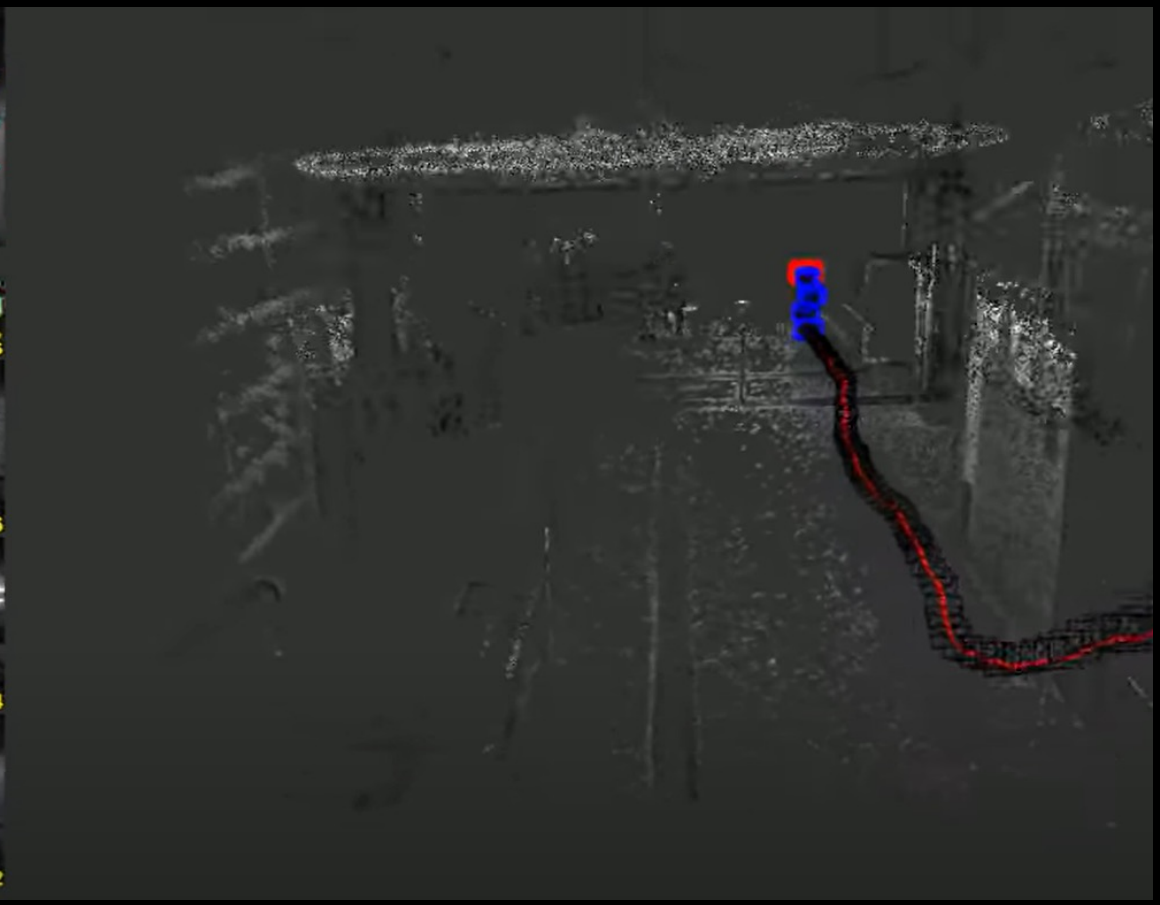
Mapping Software

	Frame Times (ms)		
Mapping Algorithm	**Mean**	**St.D.**	**CPU @20fps**
ORB Mono SLAM	29.81	5.67	187
LSD Mono SLAM	23.23	5.87	236
DSO Mono	9	-	-
SVO Mono	2.53	0.42	55

- We decided to use ORB-SLAM, and keep the others as backups in case ORB-SLAM does not run fast enough.

ORB-SLAM 3.0





Problems with 3D Mapping

```
[navigation_actor-6] process has died [pid 8521, exit code 127, cmd /home/tom/ca
tkin_ws/src/nm_dependencies/nm_navigation/devel/NavigationActor_x86_64_16.04 /rt
abmap/grid_map:=/map /cmd_vel/managed:=/motor_controller/command /cmd_vel:=/moto
r_controller/command_no_stamp __name:=navigation_actor __log:=/home/tom/.ros/log
/b2de0418-0818-11ea-bf64-08002711b324/navigation_actor-6.log].
log file: /home/tom/.ros/log/b2de0418-0818-11ea-bf64-08002711b324/navigation_act
or-6*.log
/home/tom/catkin_ws/src/nm_dependencies/nm_navigation/devel/ServerVitals_x86_64_
16.04: ◆x◆=◆V◆ ◆◆◆J◆pnO◆8◆◆◆◆+◆◆◆_◆&◆◆F◆/◆◆G◆agi
                                                    ā(G◆W◆L◆a◆5◆◆◆◆◆◆
-@◆◆◆MD◆Ϙ$◆◆q◆◆&◆◆◆◆◆◆h◆d◆/◆1u9◆◆8◆◆2+
process[ServerVitals-7]: started with pid [8522]
[ServerVitals-7] process has died [pid 8522, exit code 1, cmd /home/tom/catkin_w
s/src/nm_dependencies/nm_navigation/devel/ServerVitals_x86_64_16.04 /rtabmap/gri
d_map:=/map /cmd_vel/managed:=/motor_controller/command /cmd_vel:=/motor_control
ler/command_no_stamp __name:=ServerVitals __log:=/home/tom/.ros/log/b2de0418-081
8-11ea-bf64-08002711b324/ServerVitals-7.log].
log file: /home/tom/.ros/log/b2de0418-0818-11ea-bf64-08002711b324/ServerVitals-7
*.log
```

Computer Vision

TensorFlow

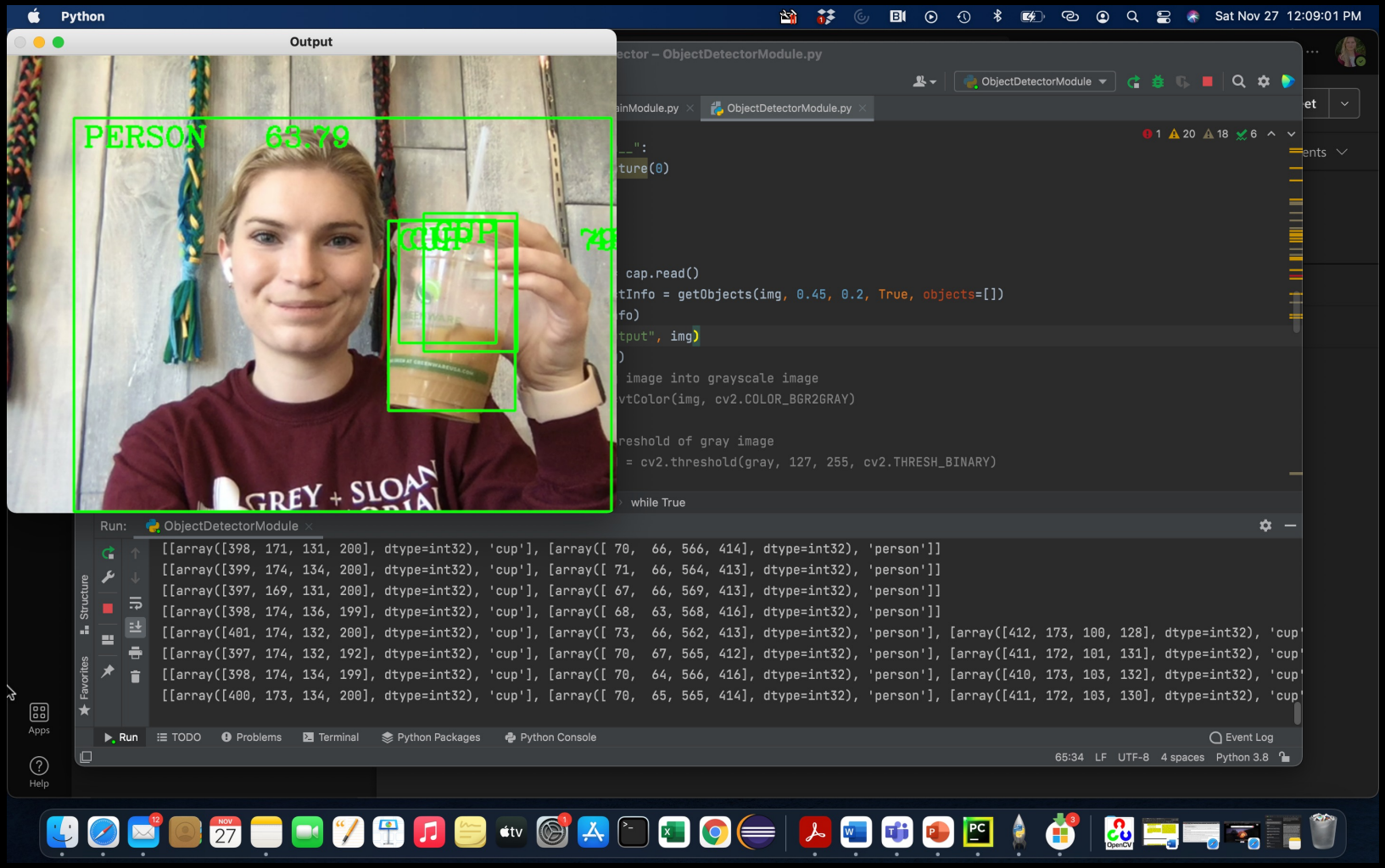
OpenCV

Computer Vision

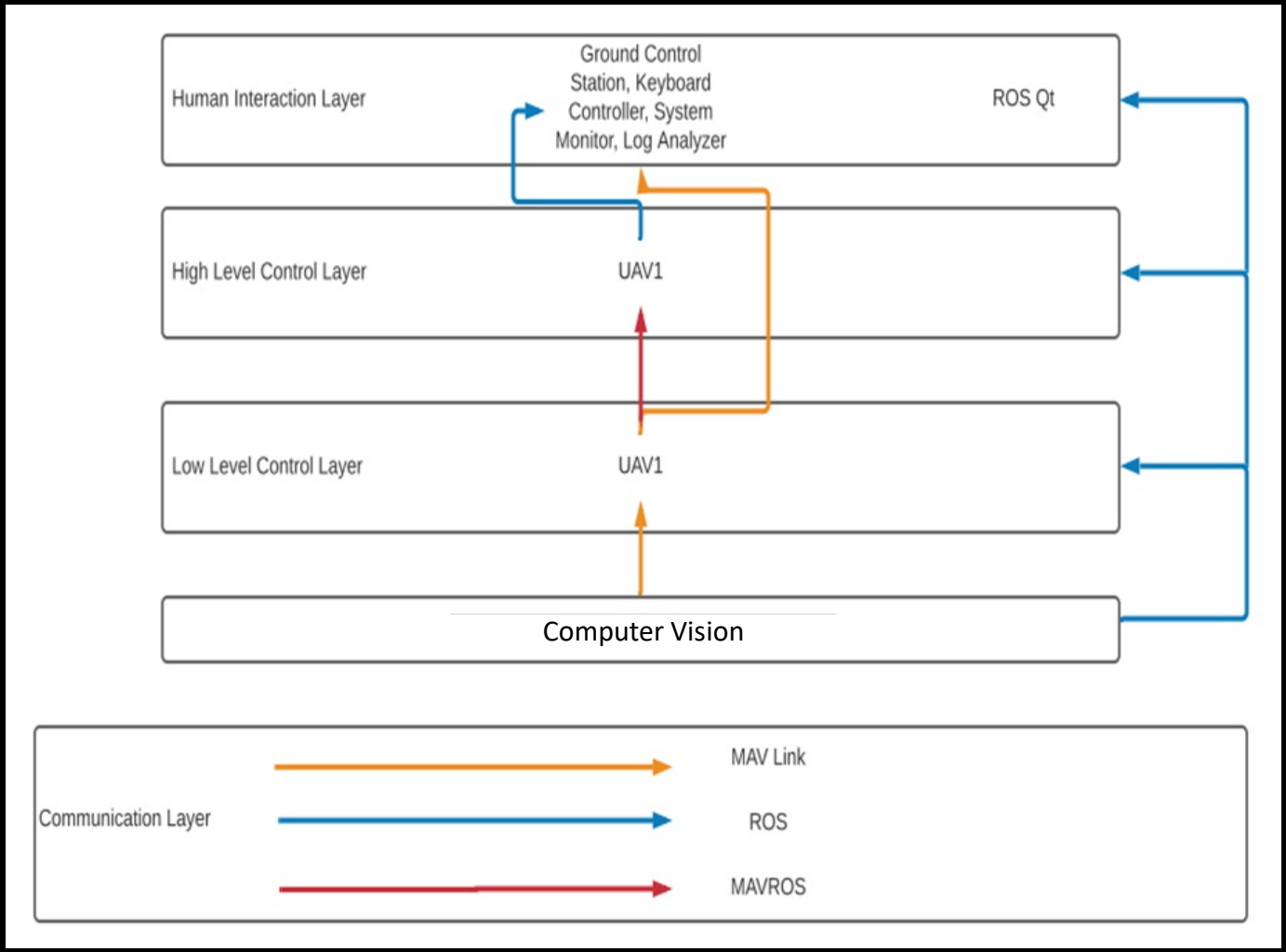
```python
import cv2
import numpy as np
from matplotlib import pyplot as plt


classNames = []
classFile = 'item.names'
with open(classFile, 'rt') as f:
    classNames = f.read().rstrip('\n').split('\n')

configPath = 'ssd_path.pbtxt'
weightsPath = 'inference_graph.pb'

net = cv2.dnn_DetectionModel(weightsPath, configPath)
net.setInputSize(320, 320)
net.setInputScale(1.0 / 127.5)
net.setInputMean((127.5, 127.5, 127.5))
net.setInputSwapRB(True)


def getObjects(img, thres, nms, draw=True, objects=[]):
    classIds, confs, bbox = net.detect(img, confThreshold=thres, nmsThreshc
    #print(classIds, bbox)
    if len(objects) == 0:
        objects = classNames
    objectInfo = []
    if len(classIds) != 0:
        for classId, confidence, box in zip(classIds.flatten(), confs.flatt
```

```python
while True:
    success, img = cap.read()
    results, objectInfo = getObjects(img, 0.45, 0.2, True, objects=['person'])
    # converting image into grayscale image
    gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)

    # setting threshold of gray image
    _, threshold = cv2.threshold(gray, 127, 255, cv2.THRESH_BINARY)

    # using a findContours() function
    contours, _ = cv2.findContours(
        threshold, cv2.RETR_TREE, cv2.CHAIN_APPROX_SIMPLE)

    i = 0

    # list for storing names of shapes
    for contour in contours:

        # here we are ignoring first counter because
        # findcontour function detects whole image as shape
        if i == 0:
            i = 1
            continue
        # cv2.approxPloyDP() function to approximate the shape
        approx = cv2.approxPolyDP(contour, 0.01 * cv2.arcLength(contour, True), True)
```

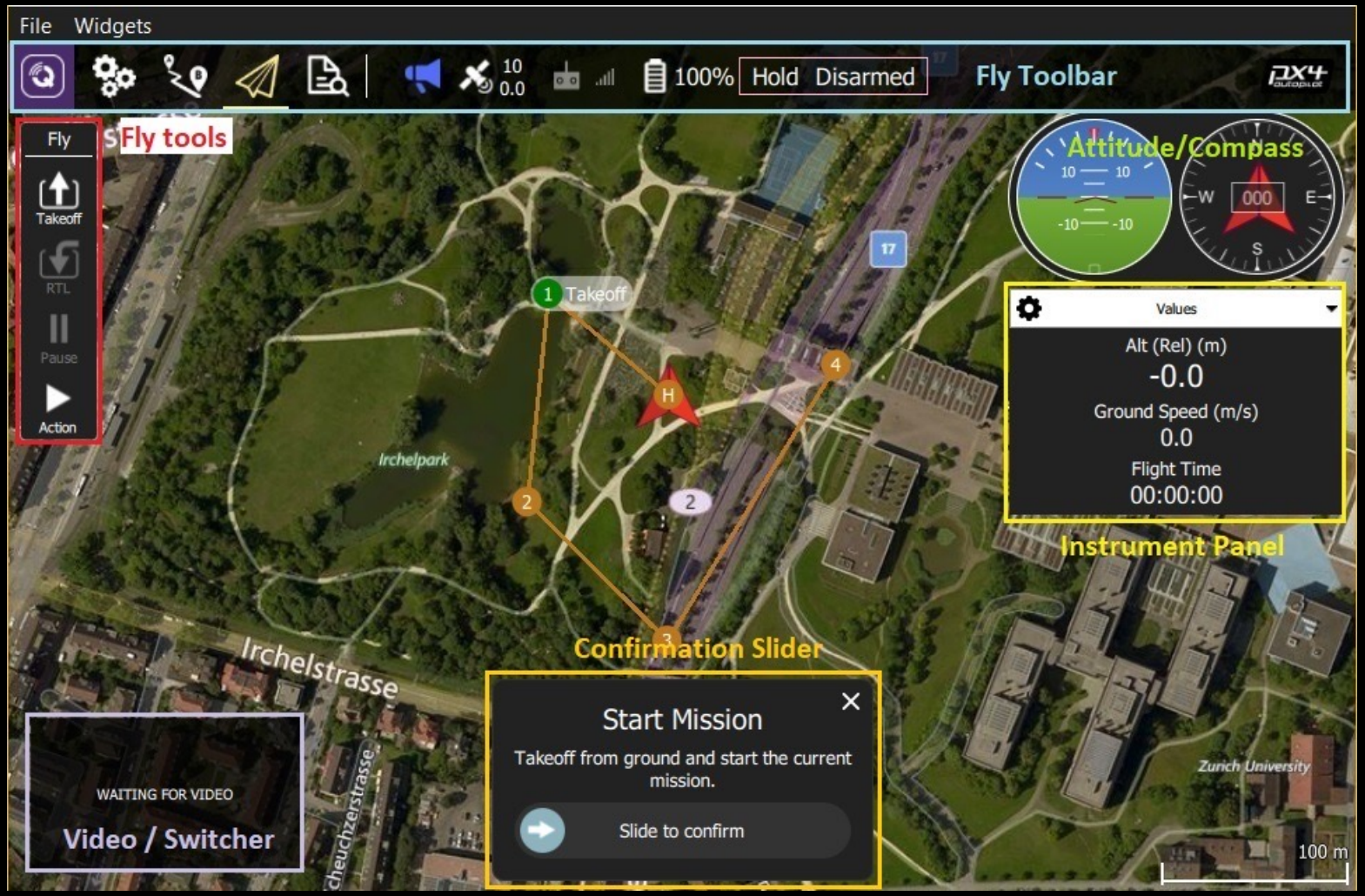
Computer Vision



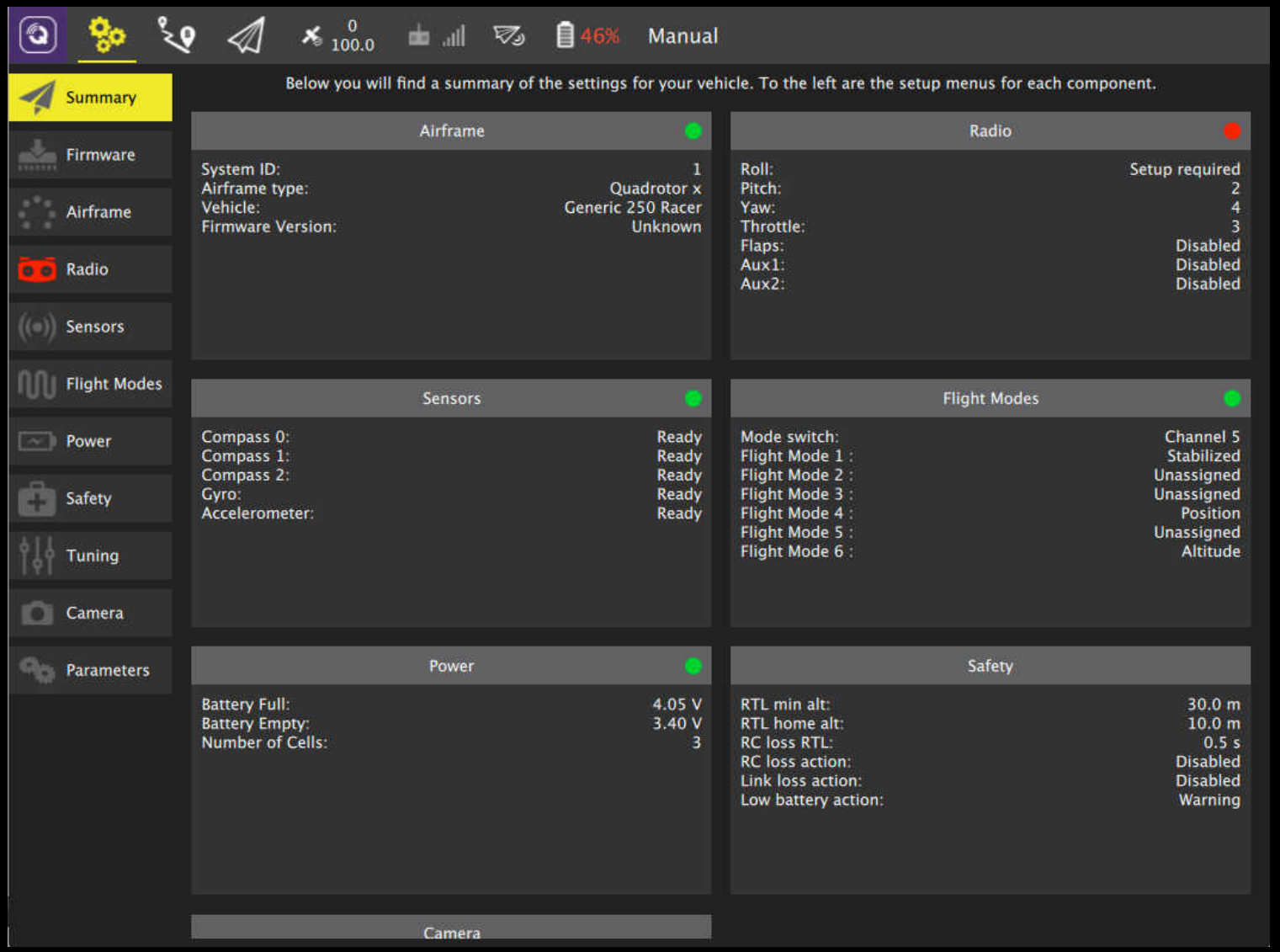
Software Flowchart



QGroundControl



QGroundControl



QGroundControl

100% Hold Disarmed

Vehicle Setup

- Summary
- Firmware
- Airframe
- Radio
- Sensors
- Flight Modes
- Power
- Safety
- Tuning
- Camera
- Parameters

Search: Clear

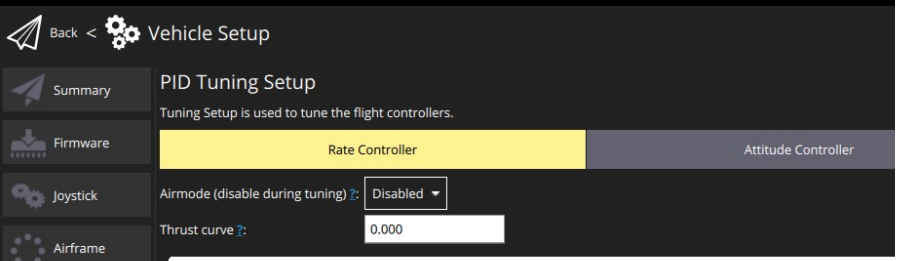
Component #: 1

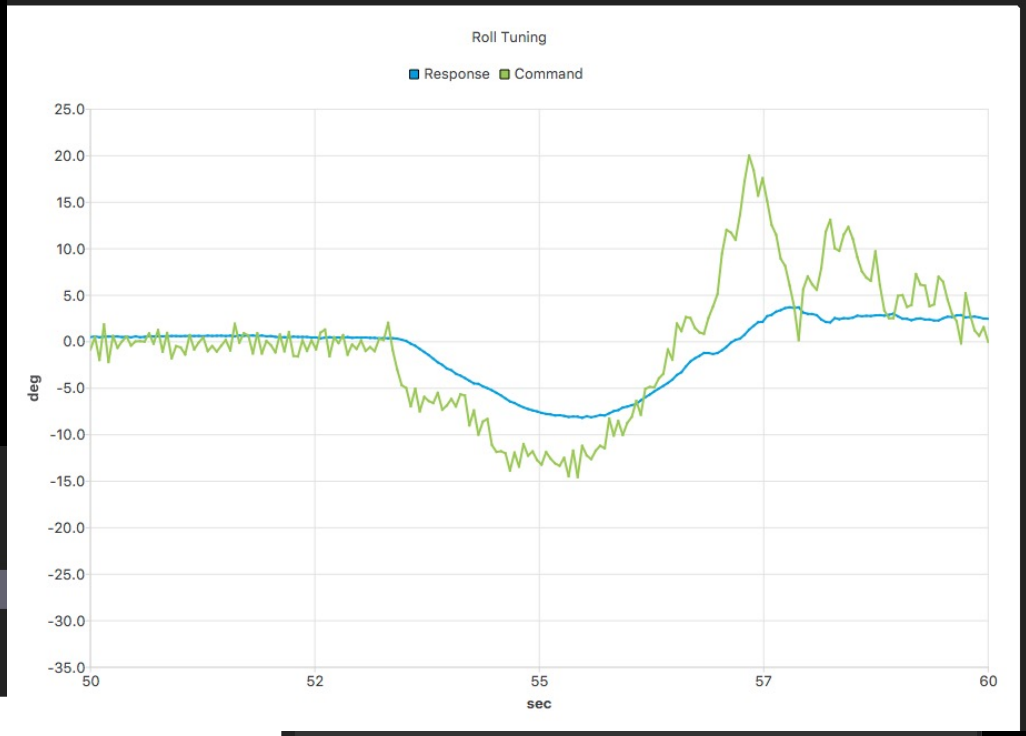
- *Default Group
- Battery Calibration
- Camera trigger
- Circuit Breaker
- Commander
- Data Link Loss
- EKF2
- FW Attitude Control
- FW L1 Control
- FW Launch detection
- FW TECS
- Follow target
- GPS Failure Navigation
- Geofence
- Land Detector

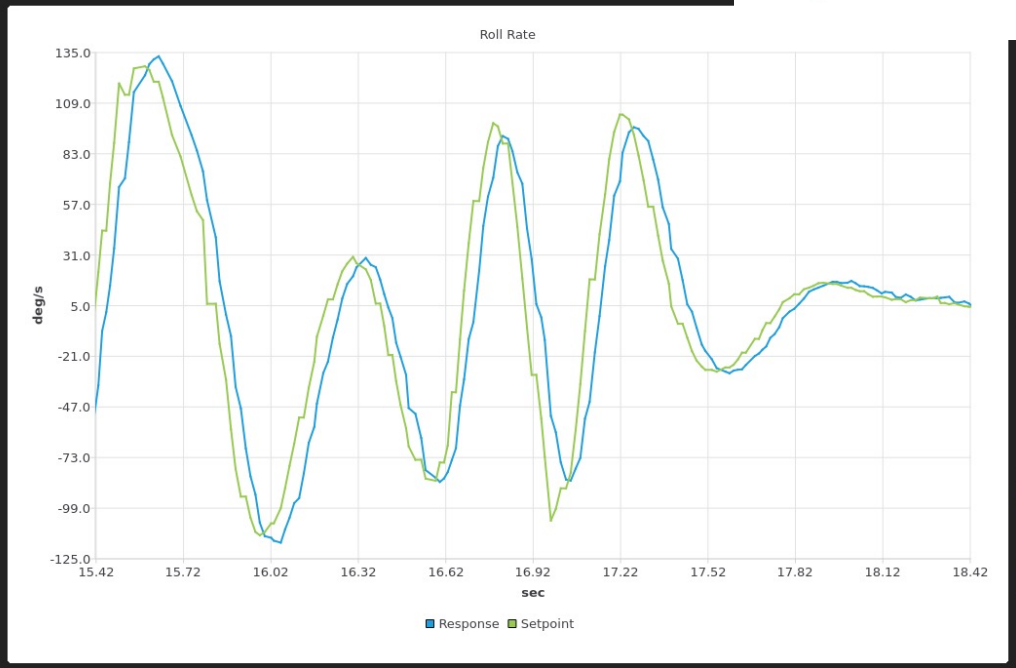
Tools

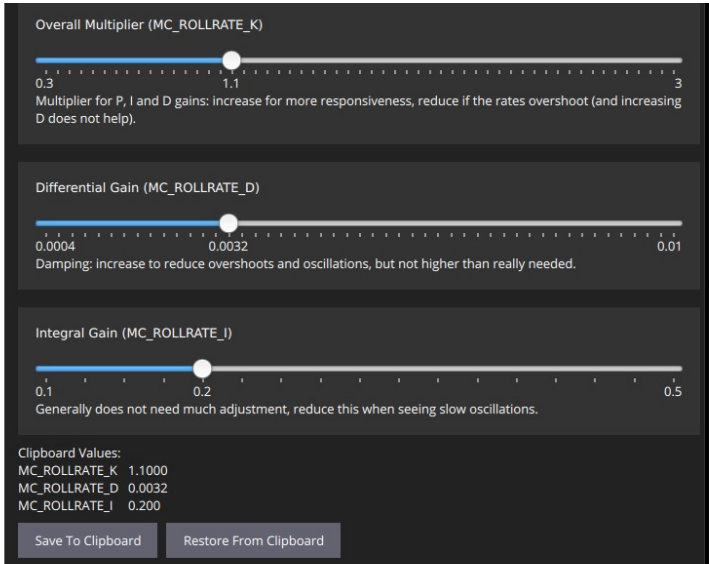
BAT_A_PER_V	15.39103031	Battery current per volt (A/V)
BAT_CAPACITY	-1 mA	Battery capacity
BAT_CNT_V_CURR	0.00080566	Scaling from ADC counts to volt on the ADC input (battery current)
BAT_CNT_V_VOLT	0.00080566	Scaling from ADC counts to volt on the ADC input (battery voltage)
BAT_CRIT_THR	7 %	Critical threshold
BAT_EMERGEN_THR	5 %	Emergency threshold
BAT_LOW_THR	15 %	Low threshold
BAT_N_CELLS	3S Battery	Number of cells
BAT_R_INTERNAL	-1.000 Ohms	Explicitly defines the per cell internal resistance
BAT_SOURCE	Power Module	Battery monitoring source
BAT_V_CHARGED	4.05 V	Full cell voltage (5C load)
BAT_V_DIV	10.17793941	Battery voltage divider (V divider)
BAT_V_EMPTY	3.40 V	Empty cell voltage (5C load)
BAT_V_LOAD_DROP	0.30 V	Voltage drop per cell on full throttle
BAT_V_OFFS_CURR	0.00000000	Offset in volt as seen by the ADC input of the current sensor

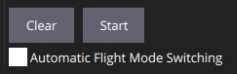
QGround Control



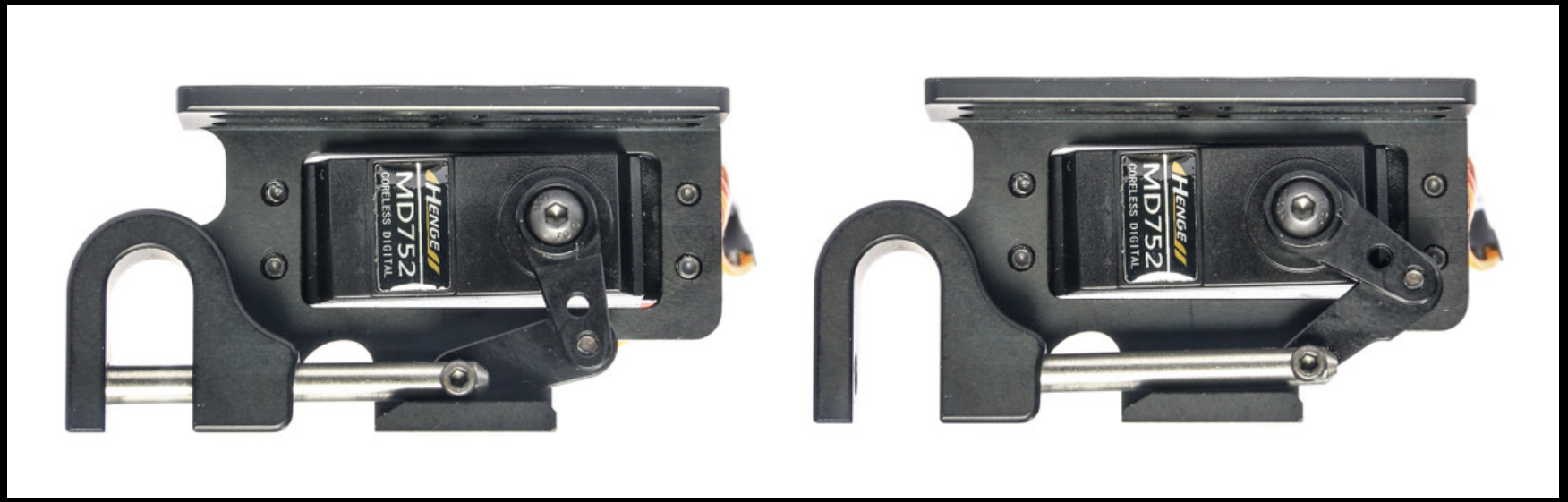








Package Release Mechanism



Sensors

Camera

Barometer

GPS

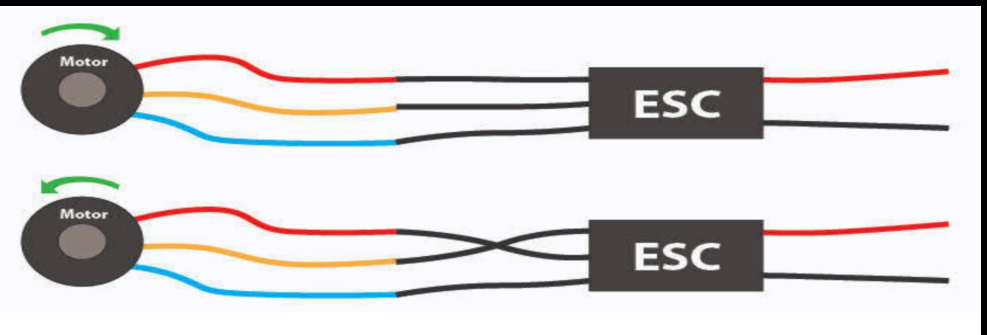
3-axis Gyroscope

Accelerometer

Compass

Electric Speed Controller

- Electric Speed Controller
  - Translator from the ’pilot’ to the motor by giving specific voltage/current based on input from ‘user’
  - Options we had to choose from
    - 4 in 1 packages or individual
      - Individual is most cost effective because if one breaks only one must be replaced
    - BEC vs no BEC
      - Battery Elimination Circuit: provides control of power to other components
      - Not necessary for our drone project, but was included in the kit purchased as a cost-effective decision



PX4 vs Ardupilot

	PX4	Ardupilot
Coding Language	C++	C++
Majority Hardware Capabilities	Yes	Yes
Majority Software Capabilities	Yes	Yes
Release Date	2009	2012

ARDUPILOT
Versatile, Trusted, Open

PX4 autopilot

Administration Content

Constraints

Economic
- Covid-19
- Self-funded

Environmental
- Batteries
- Litter the environment

Legal
- Open airfield
- Not on UCF grounds

Health and Safety
- LiPo batteries
- PCBs and wires

Manufacturability
- Fusion360 to make the STL files to 3D printing

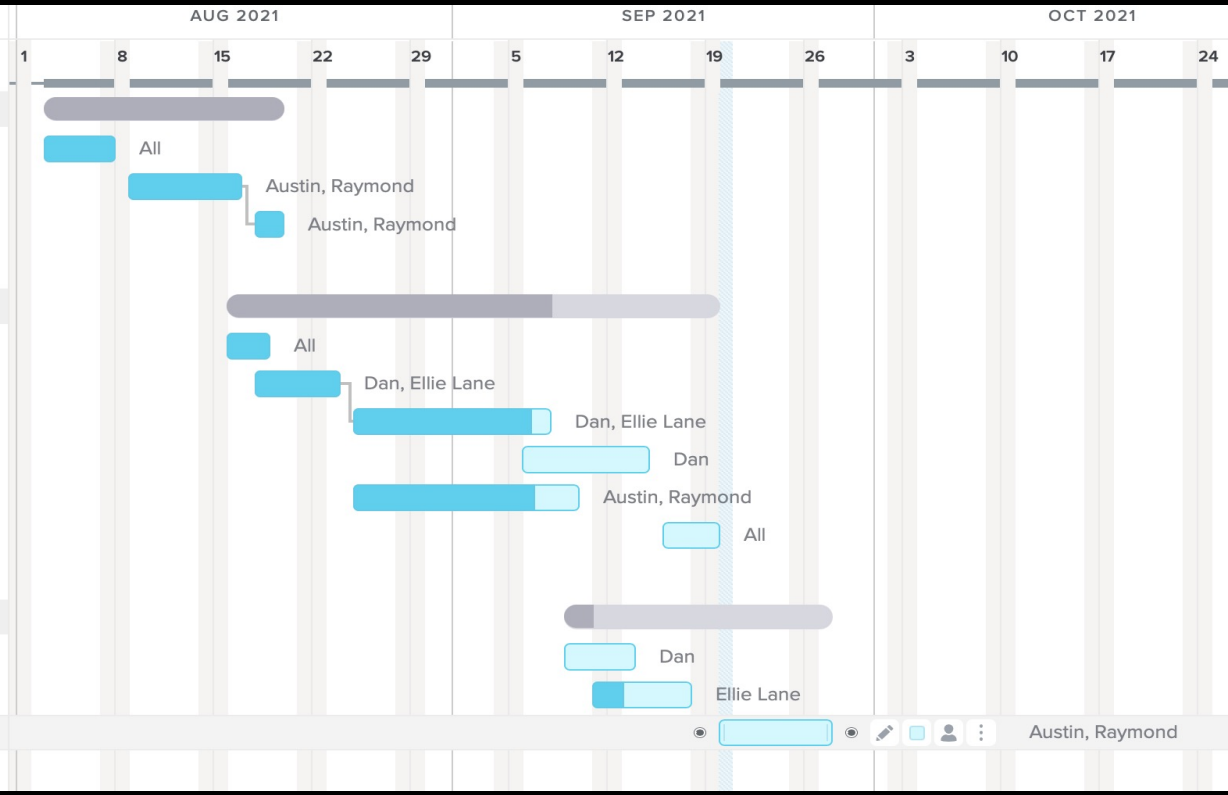
Ethical
- Our project should only positively affect the businesses we are getting supplies from and businesses that will be helped by our drones' success

Budget

Frame	2	
Brushless Motors	8	
ESC	4	
Propellers	8	$125.72
Navio 2 - Flight Controller	1	$246
Raspberry Pi 4b	1	$75
Battery	2	$92.84
PCB	3	$133
Electronic Components	6	$6.99
Ultrasonic sensors	6	$10.59
Transmitter	1	$29.81
Antenna Mount	1	$7.33
Vibration Dampeners	24	$6.38
Camera	1	$13.10
Total		$746.76

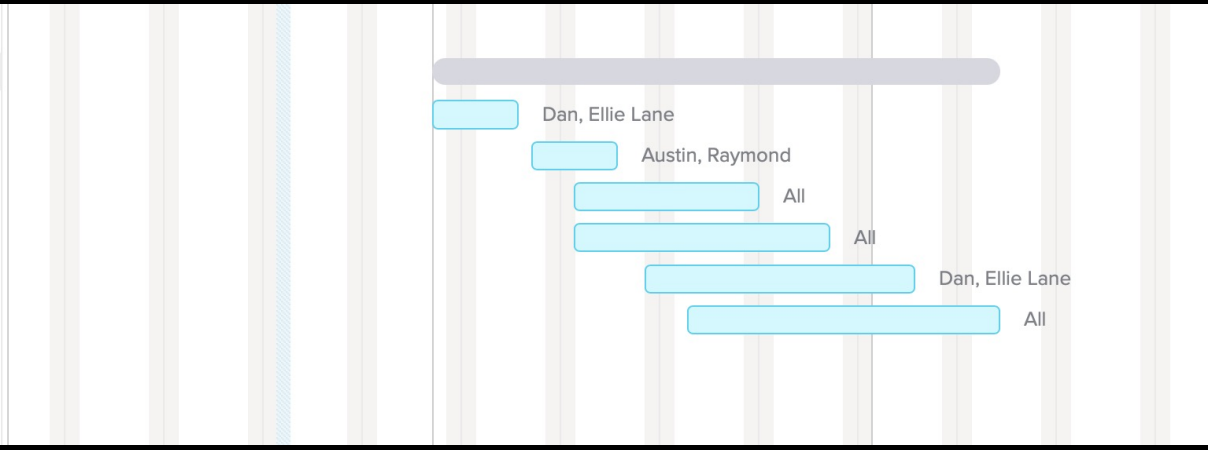
Gaant Chart

	Assigned	Progress
D.E.A.R.		30%
▾ Ordered Parts		100%
Purchased first round	All	100%
Design PCB	Austin, Raymond	100%
Purchased PCB	Austin, Raymond	100%
▾ Build		66%
Assemble Frame, motors and p...	All	100%
Configure Raspberry Pi	Dan, Ellie Lane	100%
Configure Navio onto Rasp.	Dan, Ellie Lane	90%
Connect to frame	Dan	0%
Test electrical components	Austin, Raymond	80%
Hover Test	All	0%
▾ Develop		11%
Create mapping alg. files	Dan	0%
Create computer vision files	Ellie Lane	30%
Adjust components for balance	Austin, Raymond	0%



Gaant Chart Cont.

▼ Test		0%
Test using simulation	Dan, Ellie Lane	0%
Test electrical components	Austin, Raymond	0%
Take off test	All	0%
Path test	All	0%
Object detection Test	Dan, Ellie Lane	0%
Full path test	All	0%



Challenges

- Hardware
  - Components Available
  - Manufactures
  - Shipping Time
- Software
  - Setting up development environment
  - Communication between development computer and flight controller
  - Navigating the options
- Overall Challenge
  - Self-Funded

Improvements

- Hardware
  - Incorporating Shell
  - Improving Motor Power/Lift off ratio
  - Improving Receiver/Transceiver
- Software
  - Reducing Latency
  - Seamless Linux set-up
- Overall Improvements
  - More funding

Thank you!

Q&A

UCF