Midway Design Review

Team Otto

November 25, 2014

The Team

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Our System

Otto - The Personal Videographer

- Quadcopter for recording individual action sports
- Autonomous flight
- FollowMe (Tracking)

Evaluator Concerns

- Societal impact
- No collision avoidance or drone-drone communication
- What is different about Otto?

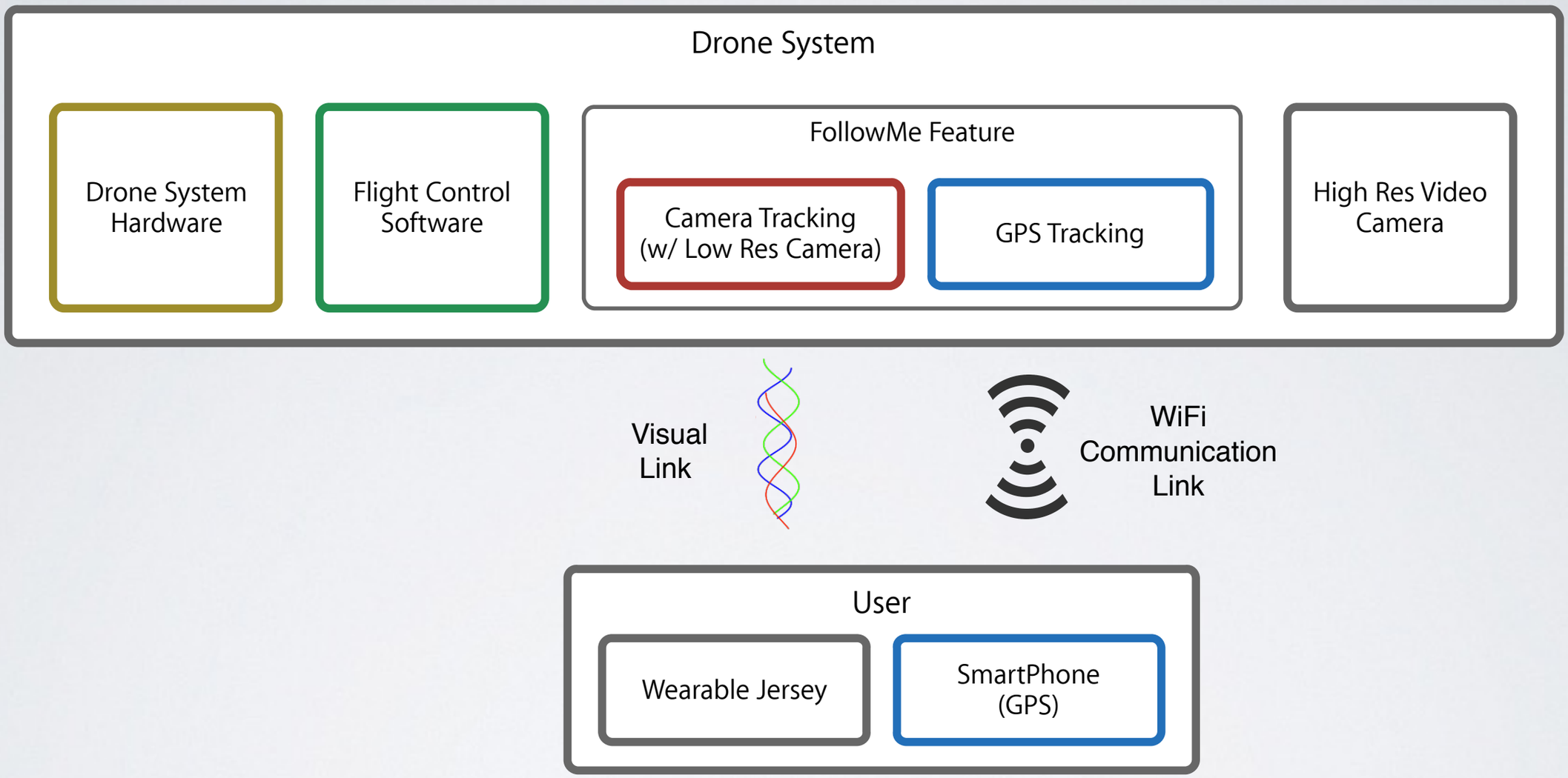
System Requirements

1. **Track user through a fusion of two sensors: GPS and camera**
2. **Collect GPS location of user with WiFi connection to user device**
3. **Collect finer location data of user through camera tracking**
4. Carry out user takeoff and landing commands
5. Maintain a user-defined drone/user separation distance
6. Allow user to start and stop video recording
7. Video recording is high-definition (720p or better)
8. **Must maintain visual lock on user for duration of recording**
9. Must take preliminary measures upon reaching critical battery level
10. **Safety lock in hardware and software**

System Specifications

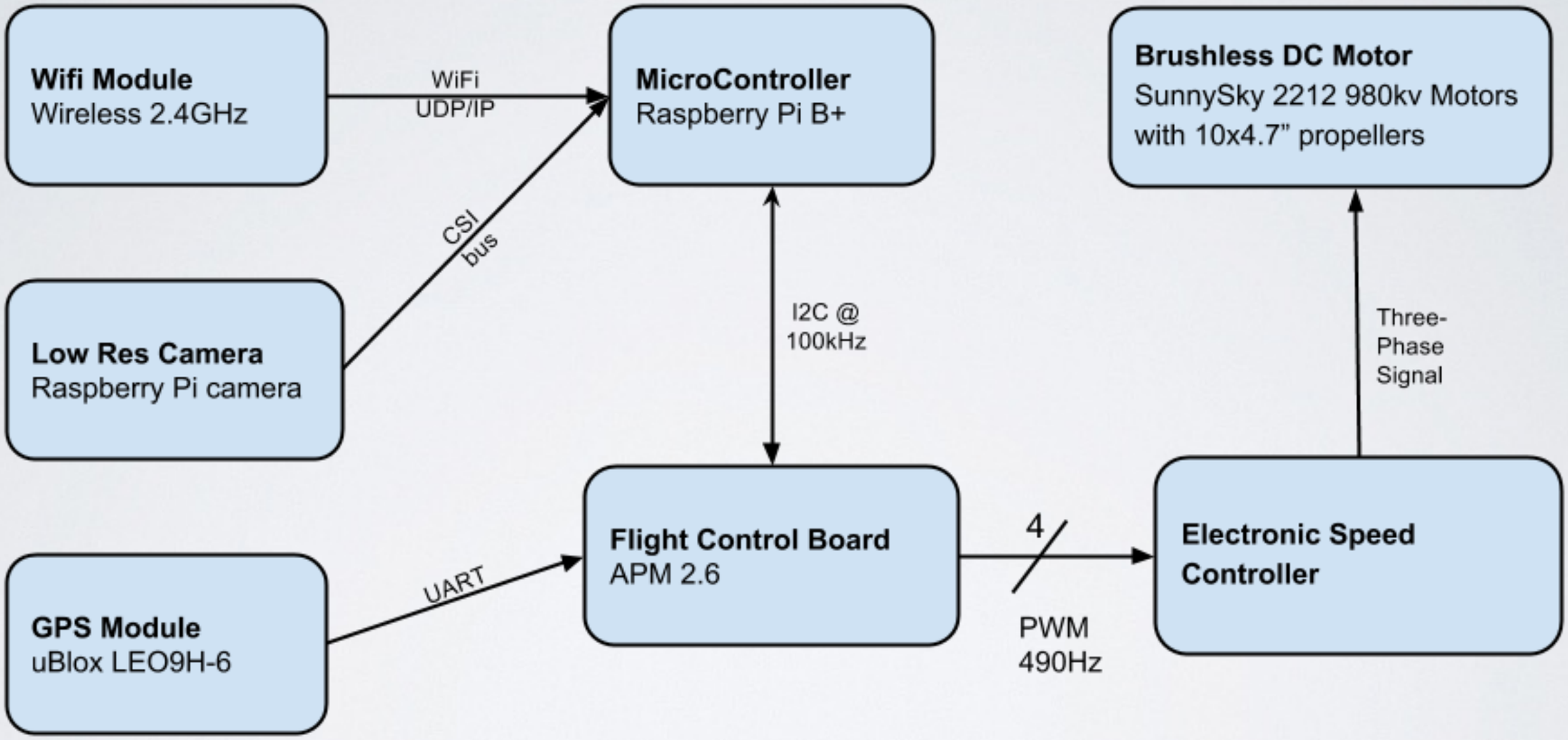
1. **Maximum drone/user separation: 30 meters**
2. Minimum drone/user separation: 5 meters
3. Average flight time: 10 minutes
4. **Max velocity of drone: 30 mph**
5. **Max angular velocity of 1.8 rad/sec (103°/sec)**
6. **All-up mass must be less than 1.5 kg**
7. **Must lift at least 1.5 kg at 50% throttle**

Otto Block Diagram

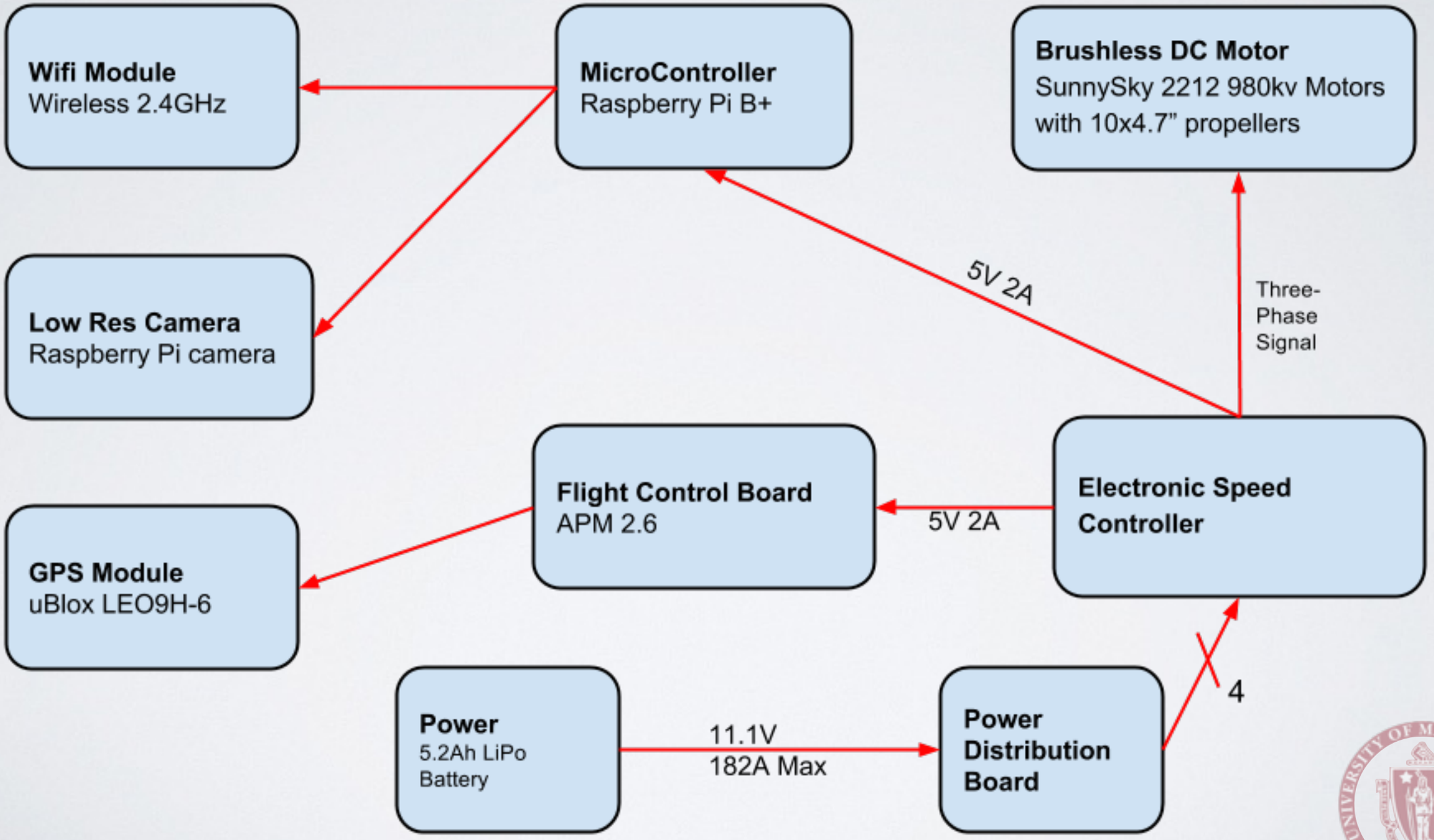


Andrew Seth Noah Albion

Drone System Hardware - Data



Drone System Hardware - Power



Drone System Hardware

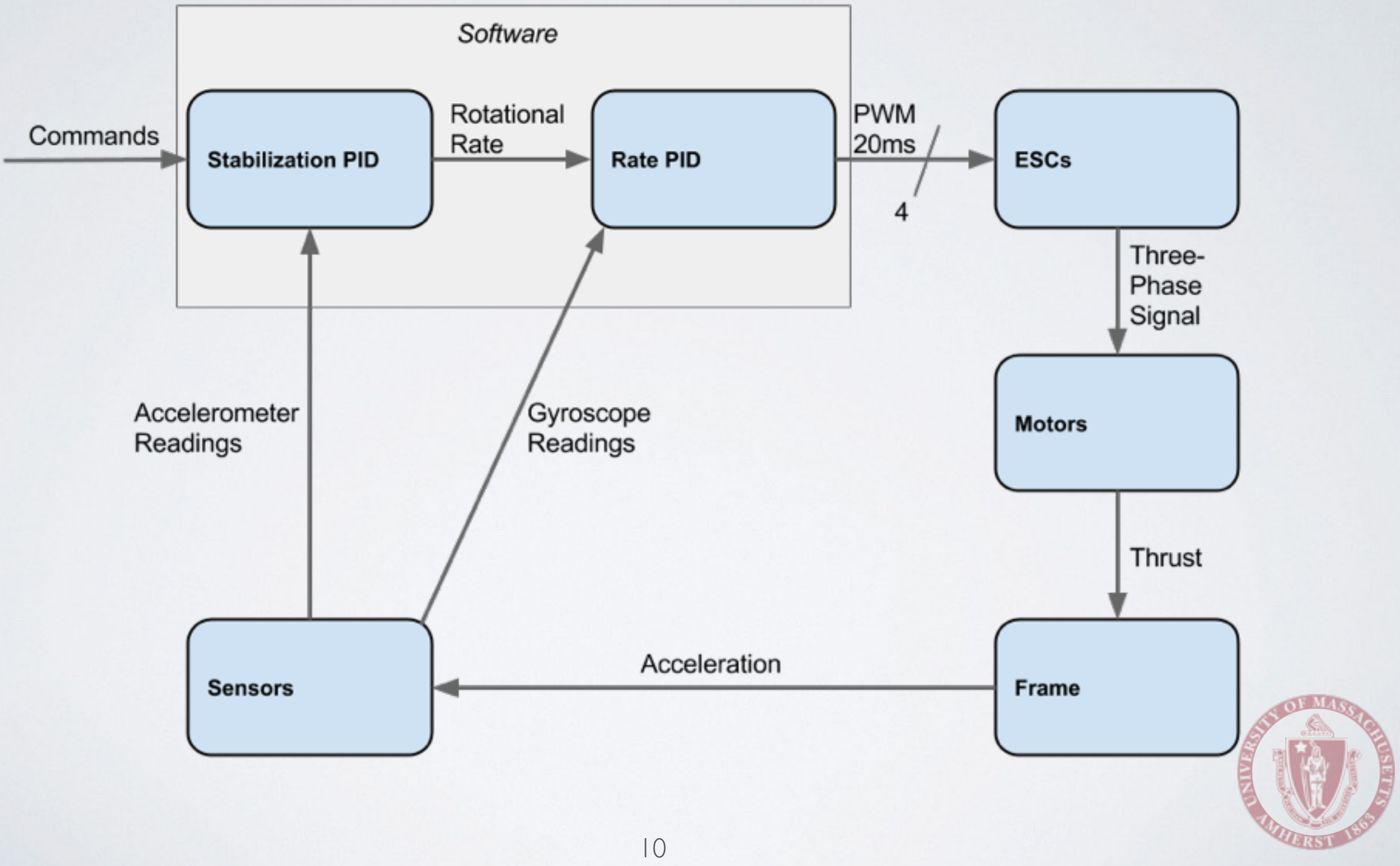
Requirements

- Power system with 11.1V for 10 minutes
- Must lift at least 1.5 kg at 50% throttle
- Interface all devices together

Accomplished

- All of the above in prototype form

Flight Control Software



Flight Control Software

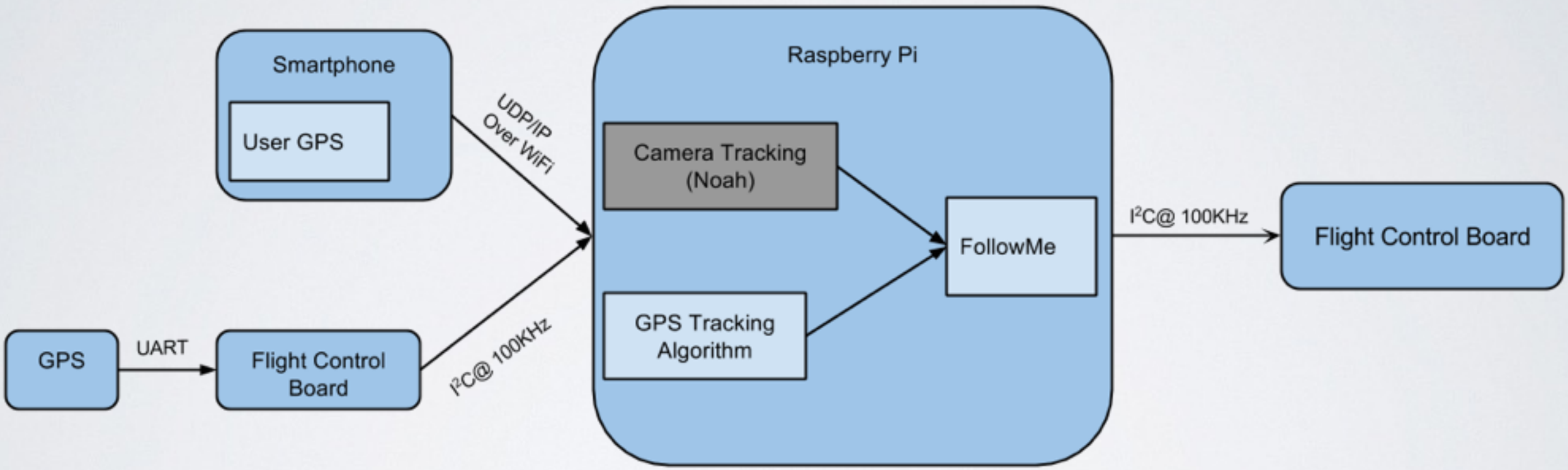
Requirements

- Read sensor data
- Feed flight control algorithm
- Send speed updates to ESCs

Accomplished

- Demonstrated ability to accurately read accelerometers and gyroscopes
- Implemented PID algorithm to make fast decisions on motor updates
- Successful test flights via manual RC control

GPS Tracking



GPS Tracking

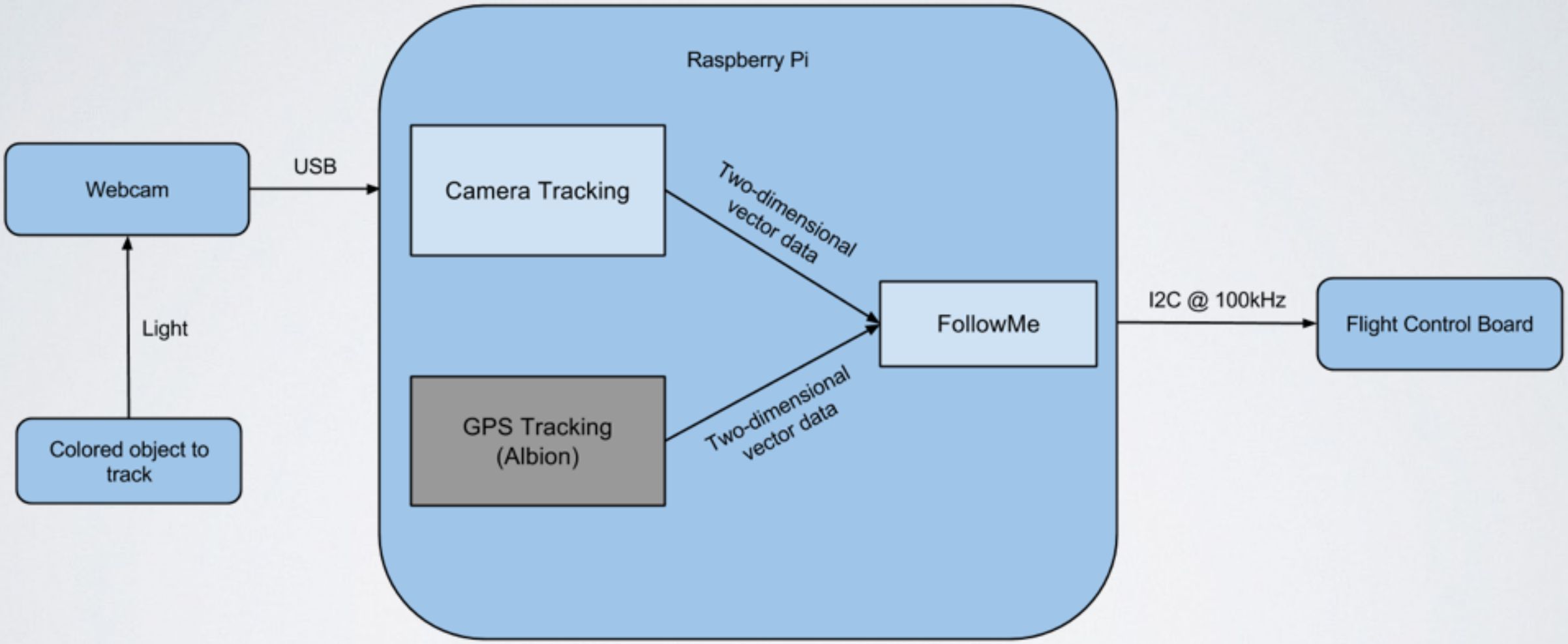
Requirements

- GPS+WiFi module on drone and user's smartphone
- WiFi running @ 2.4Ghz
- Maximum of 30 meter separation between the two WiFi modules

Accomplished

- Establish WiFi and I2C link
- Exchange coordinates between WiFi+I2C Link @ 2Hz
- Output separation between drone and user on smartphone

Camera Tracking



Camera Tracking

Requirements

- Use low-resolution video camera
- Perform color-based object tracking
- Send commands to flight control software

Accomplished

- Color-based object tracking on Raspberry Pi
- Executes at 7.5 fps
- Detects when object is moving out of frame
- Sends yaw commands to servo to keep object in frame

FollowMe Requirements

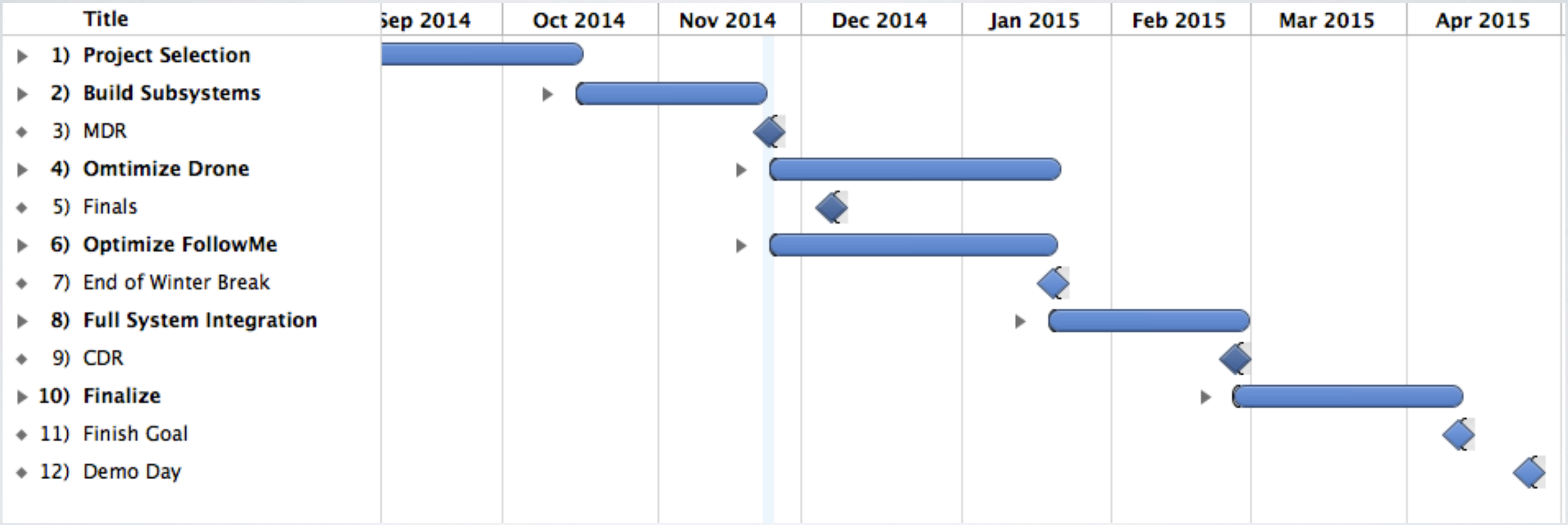
1. Synthesize GPS tracking and camera tracking inputs
2. Perform weighted average of inputs based on each system's confidence metric
3. Output commands to flight control board over I2C
4. Visually lock onto user upon takeoff
5. Maintain visual lock on user for duration of recording

CDR Deliverables

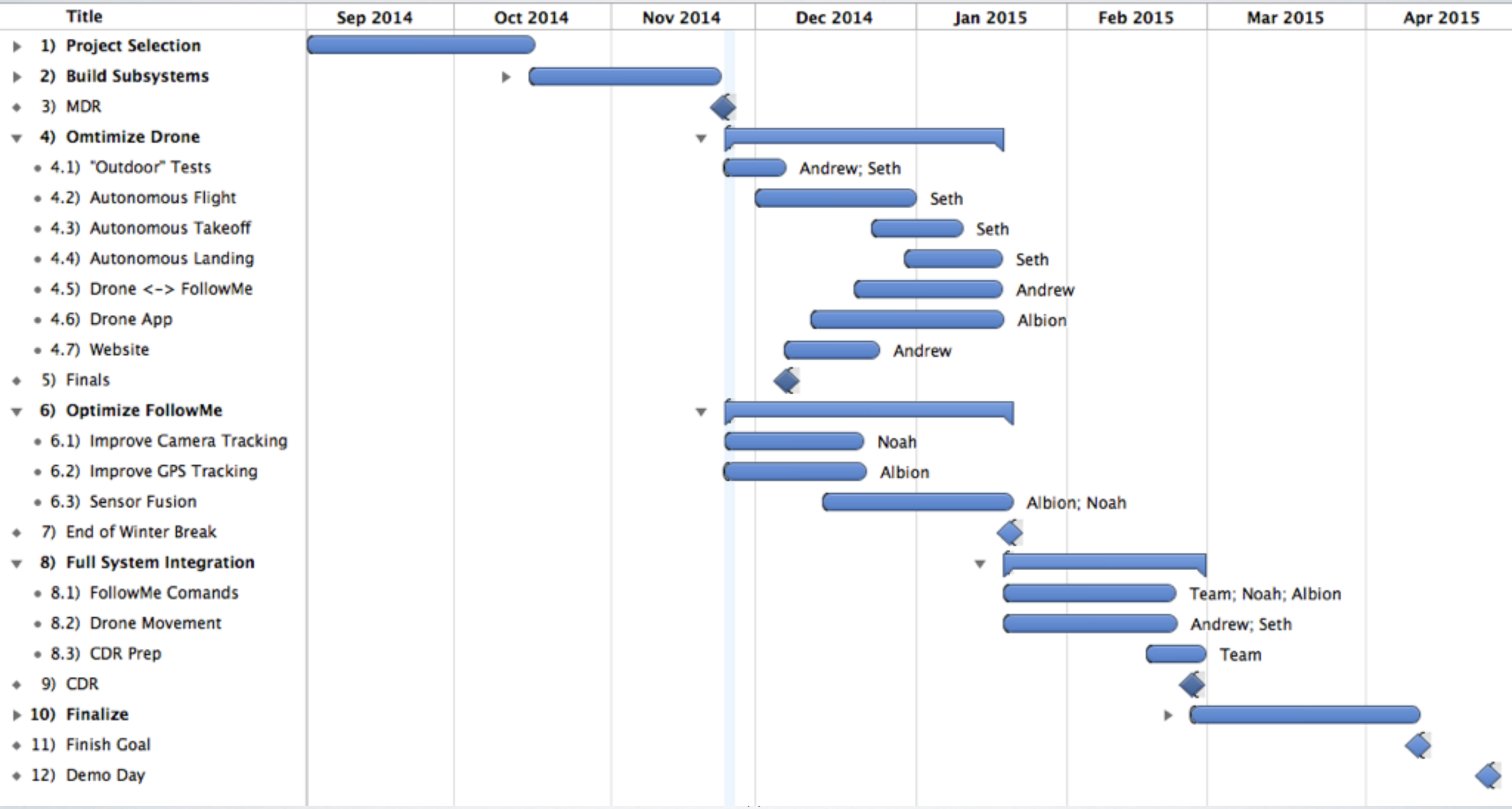
Functional prototype

- Autonomous flight
- FollowMe Feature
- Record user

Timeline


Title
Sep 2014
Oct 2014
Nov 2014
Dec 2014
Jan 2015
Feb 2015
Mar 2015
Apr 2015
1) Project Selection
2) Build Subsystems
3) MDR
4) Omtimize Drone
5) Finals
6) Optimize FollowMe
7) End of Winter Break
8) Full System Integration
9) CDR
10) Finalize
11) Finish Goal
12) Demo Day

Timeline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1) Project Selection
2) Build Subsystems
3) MDR
4) Omtimize Drone
4.1) "Outdoor" Tests
4.2) Autonomous Flight
4.3) Autonomous Takeoff
4.4) Autonomous Landing
4.5) Drone <-> FollowMe
4.6) Drone App
4.7) Website
5) Finals
6) Optimize FollowMe
6.1) Improve Camera Tracking
6.2) Improve GPS Tracking
6.3) Sensor Fusion
7) End of Winter Break
8) Full System Integration
8.1) FollowMe Comands
8.2) Drone Movement
8.3) CDR Prep
9) CDR
10) Finalize
11) Finish Goal
12) Demo Day
Andrew; Seth
Seth
Seth
Seth
Andrew
Albion
Andrew
Noah
Albion
Albion; Noah
Team; Noah; Albion
Andrew; Seth
Team

Demonstration

- ☑ Build Drone
- ☑ Flight Algorithm
- ☑ GPS Tracking
- ☑ Camera Tracking

Thank you.

Questions?

Backup Slides

Societal Impact

Positive	Negative
Ability to have a unique aerial 3rd person view of yourself	Could capture other people in recordings (without their knowledge of who the drone belongs to)
Ability to be followed by a quadcopter which could execute task for you	“Bad guys” could use this technology to follow people (could be discreet; could use GPS from phone)
Image processing on our system enables excellent tracking of user	Technology could be used to locate and track certain people (who do not want to be located)
This product will open our eyes to the many possibilities of what drones can do	“Bad guys” could use our platform for invasion of privacy, or even physical attacks
Technology could be leveraged in other areas such as medical, military, etc.	Could be used maliciously in a military or medical context

Stretch Goals

- Live video feed
- Camera tracking, no wearable jersey required
- Stabilize camera with a gimbal
- Obstacle avoidance
- Backwards recording

Collision Avoidance

- **Infrared Receivers**
  - Not a great option
  - Earth's surface receives IR energy from the sun
    - Unreliable due to operating environment

- **Ultrasonic sensors**
  - Maxbotix Sonar Range Finder
  - Range: 0 - 21ft
  - Price: 25 each
  - http://www.pololu.com/product/726/resources

Drone-Drone Communication

- Not considering the multi-user for our prototype

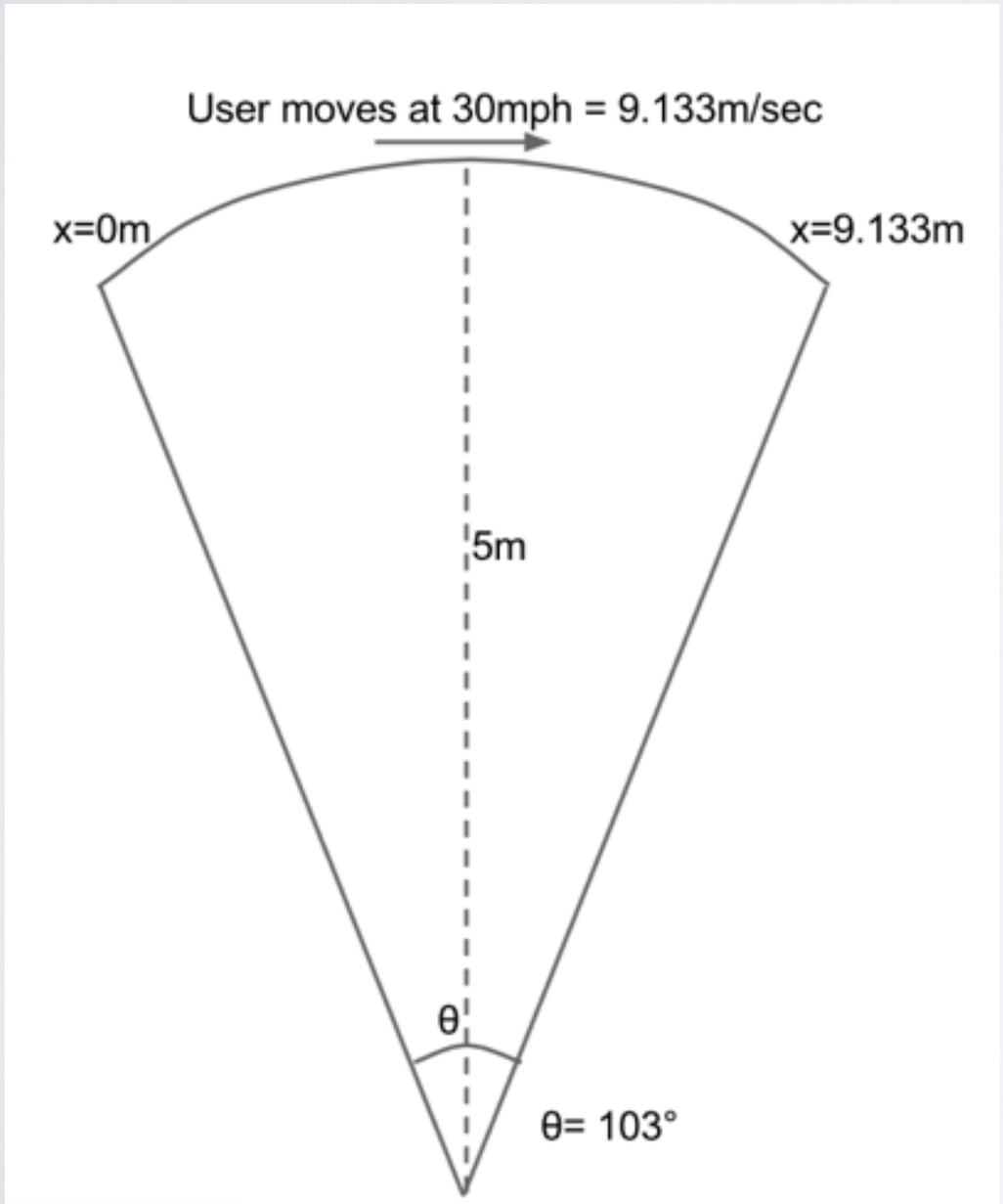
Power

- Battery - 5200mAh lipo
- 35C = 35*5.2A = 182A of Const. Current
- Max burst current = 70C = 364A

- Battery Voltage: 11.1 < V < 12.3

- BEC on ESC output 5V @ 2A max per ESC

Angular Velocity



θ= length of subtended arc / radius

θ= 1.8 rad == 103°

ω = θ/t == 1.8 rad/sec

Drone Hardware

Battery		
Load:	10.77	C
Voltage:	11.06	V
Rated Voltage:	11.10	V
Flight Time:	5.6	min
Mixed Flight Time:	11.4	min
Hover Flight Time:	15.7	min
Weight:	390	g
	13.8	oz

Motor @ Optimum Efficiency		
Current:	5.38	A
Voltage:	11.44	V
Revolutions*:	10231	rpm
electric Power:	61.6	W
mech. Power:	54.5	W
Efficiency:	88.5	%

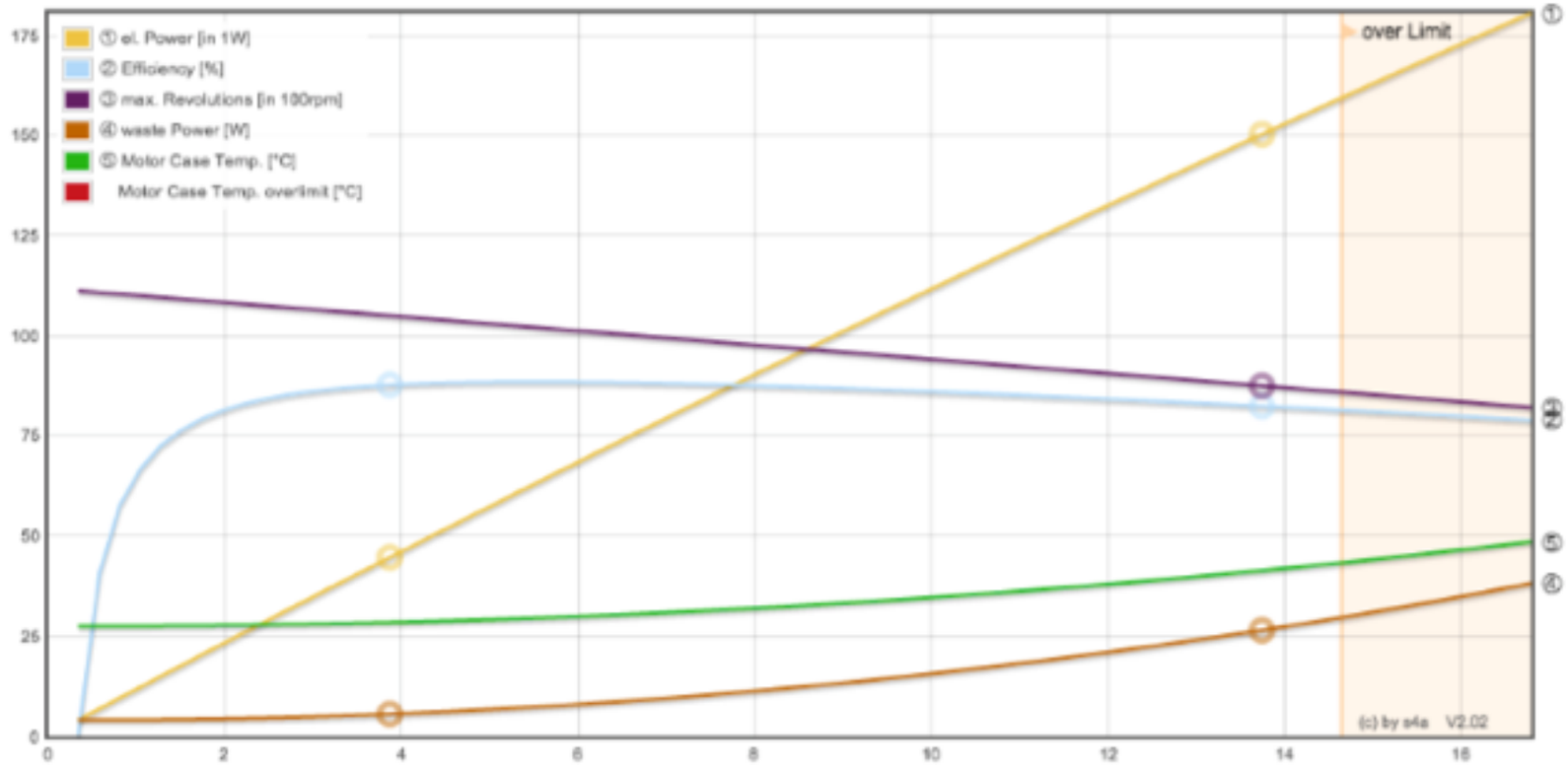
Motor @ Maximum		
Current:	14.00	A
Voltage:	10.92	V
Revolutions*:	8704	rpm
electric Power:	152.9	W
mech. Power:	125.6	W
Efficiency:	82.1	%
est. Temperature:	42	°C
	108	°F

Motor @ Hover		
Current:	4.24	A
Voltage:	11.51	V
Throttle (linear):	47	%
electric Power:	48.8	W
mech. Power:	42.9	W
Efficiency:	88.1	%
est. Temperature:	29	°C
	84	°F
specific Thrust:	7.69	g/W
	0.27	oz/W

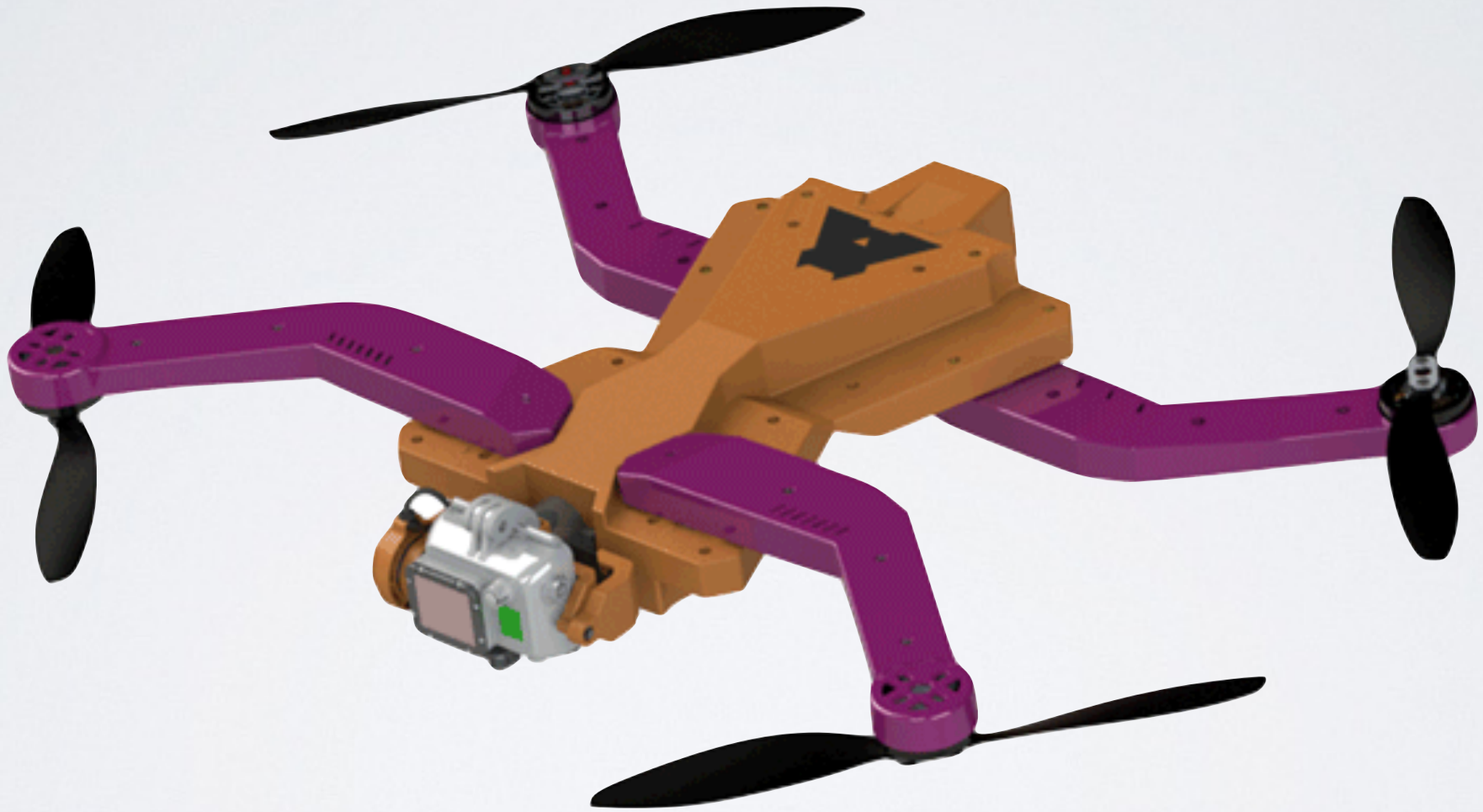
Total Drive		
Drive Weight:	785	g
	27.7	oz
Current @ Hover:	16.94	A
P(in) @ Hover:	199.3	W
P(out) @ Hover:	171.7	W
Efficiency @ Hover:	86.2	%
Current @ max:	56.01	A
P(in) @ max:	659.0	W
P(out) @ max:	502.5	W
Efficiency @ max:	76.2	%

Multicopter		
All-up Weight:	1500	g
	52.9	oz
add. Payload:	844	g
	29.8	oz
max Tilt:	50	°
max. Speed:	48	km/h
	29.8	mph

Motor Characteristics



Current Solution: AirDog



Current Solution: Hexo+

HEXO+

Current Solution: Iris+

Camera: GoPro Hero (2014)

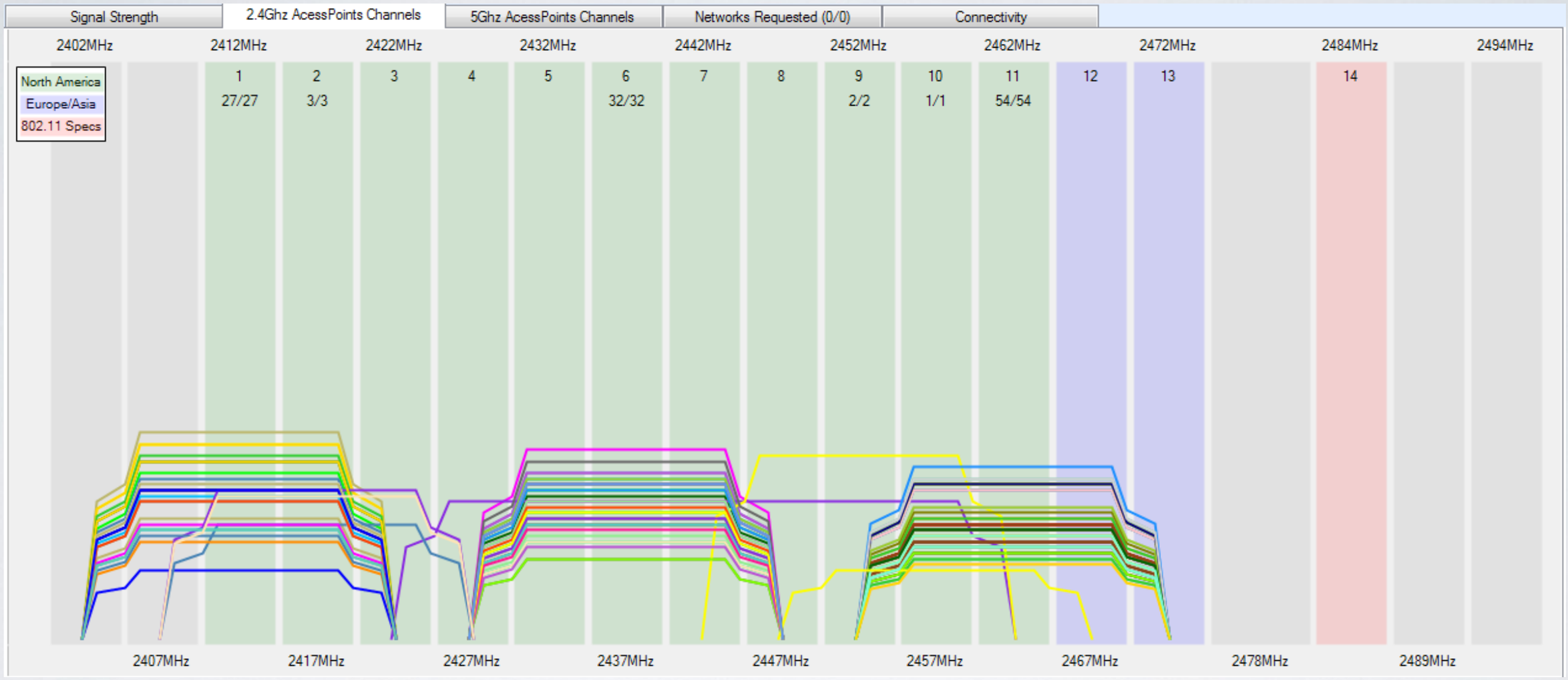
Design Alternatives

1. Use long-range bluetooth instead of WiFi
2. Use a wearable device in place of a phone for tracking
3. Physical tether
4. Use a planned flight path in place of the FollowMe feature
5. Use a single camera for both tracking and recording

Noah Portnoy
SDP 15 - Team Otto
10/7/14

Wi-Fi Signal Strength in the Quad, using Acrylic Wi-Fi Free

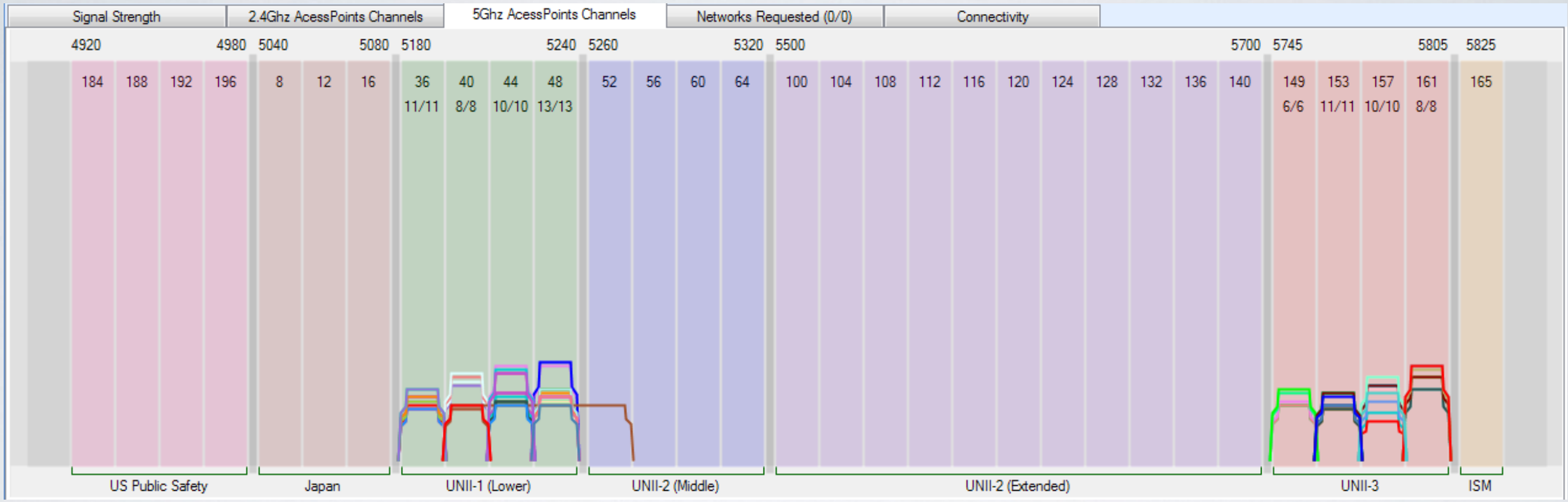
2.4 GHz Spectrum



Color indicates a unique broadcast. Band height indicates signal strength (RSSI) in dBm.

129 unique broadcasts in the 2.4 GHz spectrum (65.8% of total broadcasts)
Max RSSI for all broadcasts: -64 dBm
Min RSSI for all broadcasts: -88 dBm

5 GHz Spectrum



Color indicates a unique broadcast. Band height indicates signal strength (RSSI) in dBm.

65 unique broadcasts in the 5 GHz spectrum (33.2% of total broadcasts)
Max RSSI for all broadcasts: -75 dBm
Min RSSI for all broadcasts: -90 dBm

Drone Weight & Payload

Item	Price	Weight (g)	Notes
DRQ250 "Mini-D" w/ 6" prop arms	85	155	Has a dirty / clean design and location for camera. The design is supposed to help with stable & clean shot
Motors - SunnySky x2204s	100	100	Tested to provide 214g of thrust @ 50% per motor with HQ 6030 probs below
4x Props	8	20	6030 Carbon Composite Props (reccomended by frame)
ESC	32	80	Work with motors above, B-12A Ice Blue series SimonK-(RapidESC)
Flight Control	65	10	OpenPilot CC3D Flight Controller
Battery	40	310	30C 4000mAh 3S 11.1V LiPo Battery; should allow for 15-20 min (ideal)
GoPro	130	150	actualy about 76g (Hero)
GPS Module	79	2	
GPS Antenna GLONASS 9 M	79	10	Antenna for GPS / GLONASS; SMA connector; reccomended by ublox neo m8 series GPS Module
uController w/ WiFi (approx)	75	20	
WiFi Module	—	—	
Extraneous Parts	50	100	
TOTAL PRICE	743		
TOTAL WEIGHT	957		
Required Thrust / Motor	287.1		Achieved at about %60 thrust

Current Financial Standing

Item	Unit Cost	Quantity	Shipping	Total
APM 2.6 & GPS Module	$239.98	1	$25.00	$264.98
DJI FlameWheel Frame	$32.00	1	$0.00	$32.00
SunnySky 2212 980kv motor	$19.39	4	$0.00	$77.56
F-20A Fire Red series	$8.00	4	$4.00	$36.00
10 x 4.7 CF Props (8)	$30.98	1	$16.61	$47.59
Luminer 5200mAh Battery	$49.99	1	$11.78	$61.77
Raspbery Pi B+	$38.39	1	$0.00	$38.39
XT60 Lipo Pigtail 12AWG	$8.99	1	$3.50	$12.49
3.5mm Gold Bullet Connector	$4.37	1	$0.00	$4.37
Raspberry PI 5MP Camera	$26.51	1	$0.00	$26.51
Landing Gear	$17.99	1	$3.68	$21.67
SD Card	$17.88	1	$0.00	$17.88
10 x 4.7 CF Props (8)	$30.98	1	$0.00	$30.98
I2C Cables	$14.95	1	$7.15	$22.10
				$0.00
TOTAL				**$694.29**