SkyIsland: Aerial Docking Drone System

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CREATING THE NEXT®

ECE 4012 Team: SkyIsland
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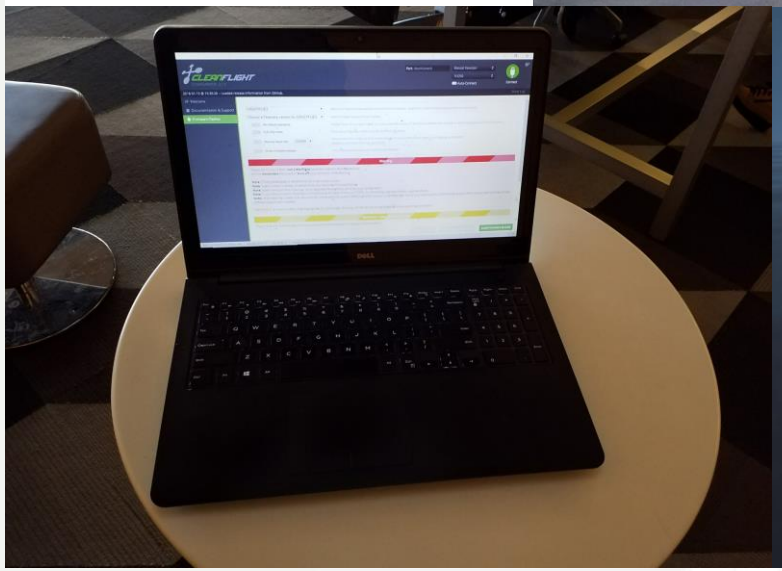
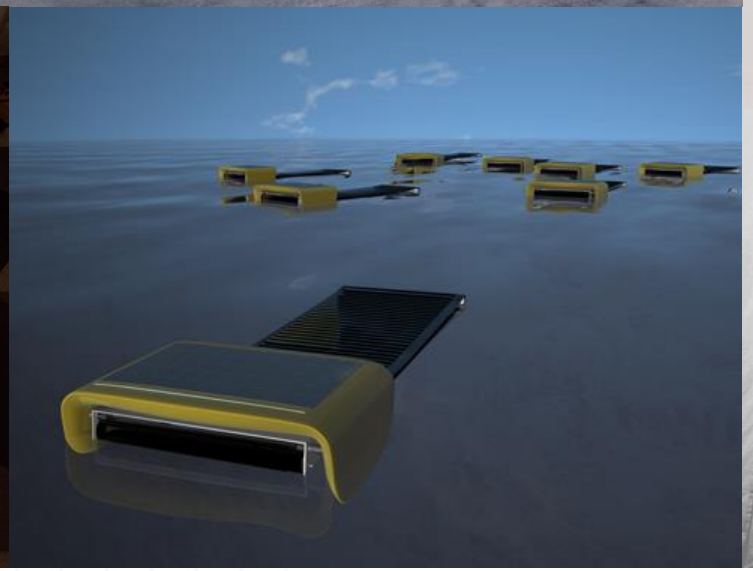
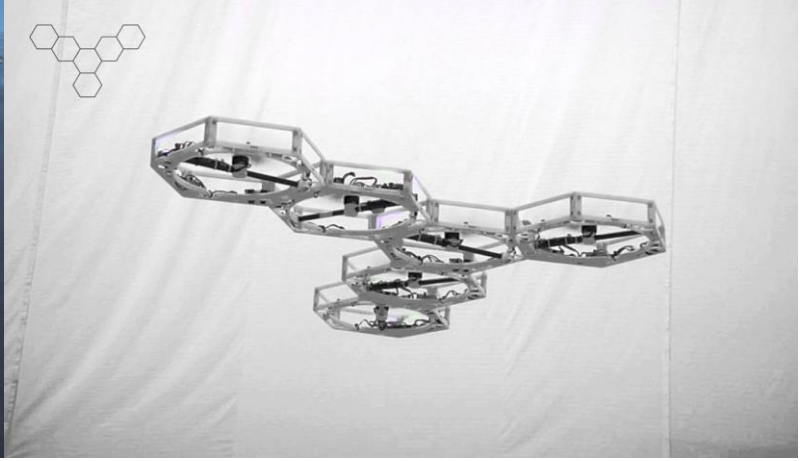
Background







Goals and Specifications

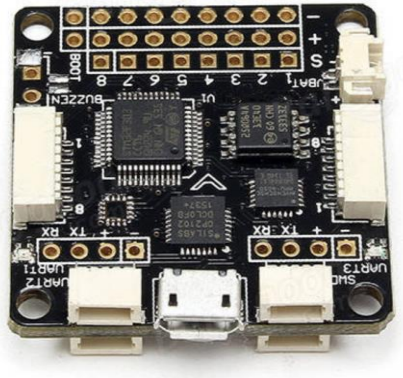
Hardware Feature	Specification
Position Sensor Detection Range	> 10m, >40º
Alignment Sensor Sensitivity	< 1cm
Minimum Re-polarization Magnetic Field	> 50kA/m
Drone-to-Drone Communication Sensor Distance	> 20m
Drone-to-Ground Communication Sensor Distance	~50m
Flight Time	5 minutes

Software Feature	Specification
Amount of Command Input	< 12
Bit Rate	125 kbs/s
Communication Latency	< 250ms
State Precision	±5cm, ±5º
Stability Correction Rate	> 100Hz

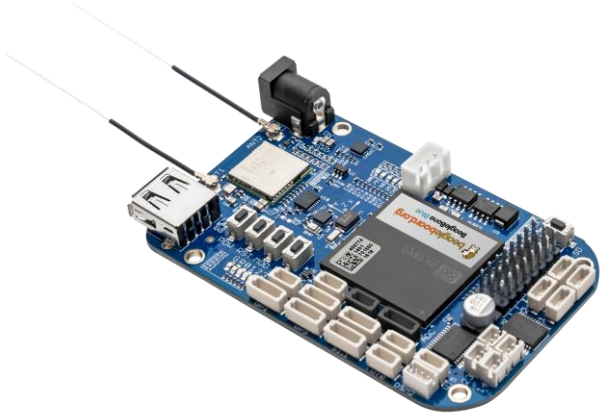
Drone and Microcontroller Features

Microcontroller Compared

	F3 Controller	BeagleBone Blue
Core	32-Bit ARM Cortex-M4	32-Bit ARM Cortex-A8
Maximum Frequency	72MHz	1GHz
Flash Memory	16 up to 512 kB	4 GB
RAM	16 kB	512 MB
Operating Voltage, VDD	1.8 V	6-18 V
Sensors	6-axis IMU	9-axis IMU, barometer



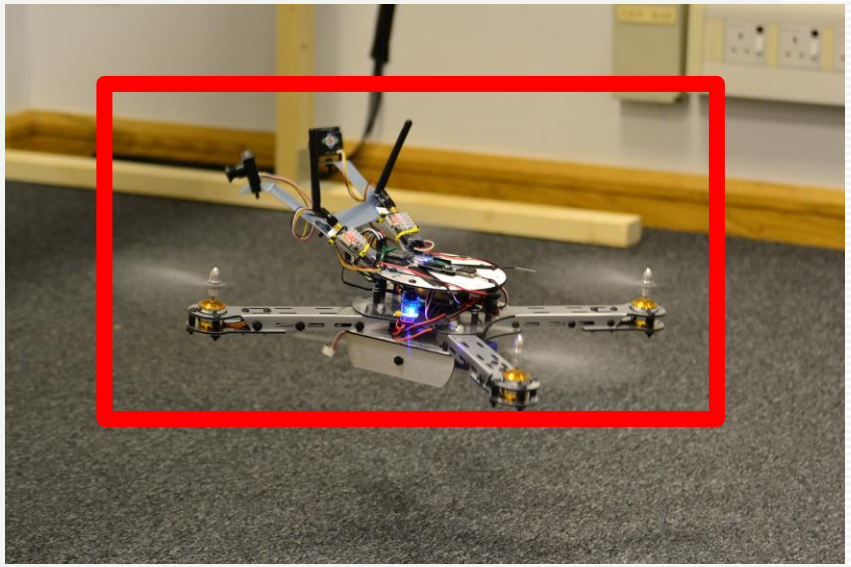
F3 Controller



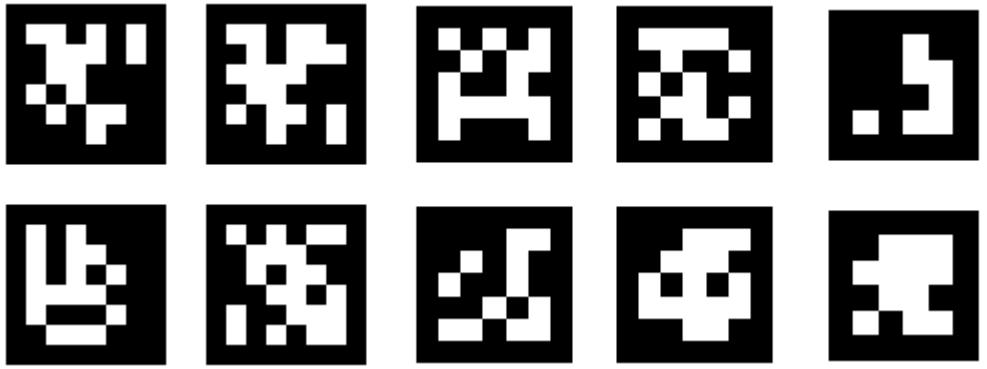
BeagleBone Blue Controller

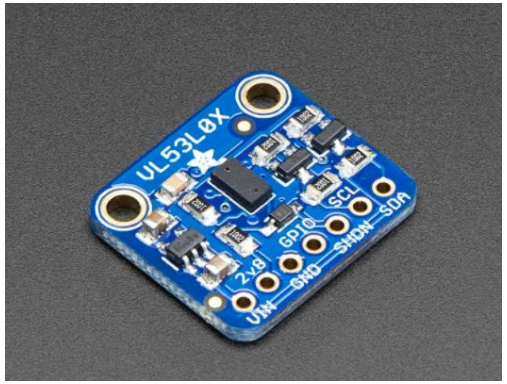
Docking and Positioning Sensors

Far Range Positioning:
Image Processing
and Machine Learning



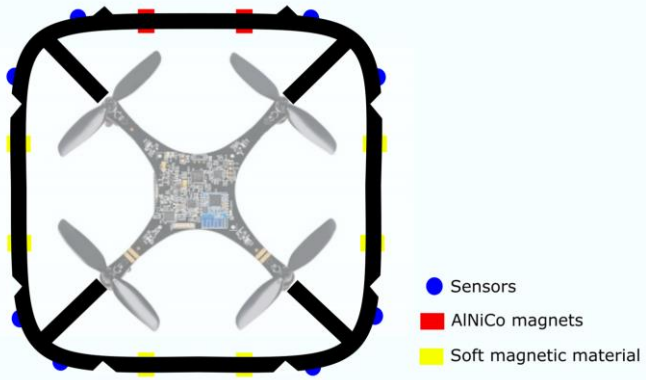
Close Range Positioning:
AprilTag
and Time of Flight Sensors

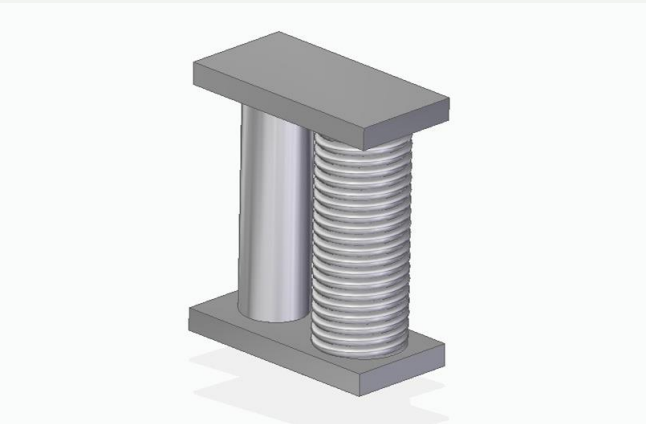




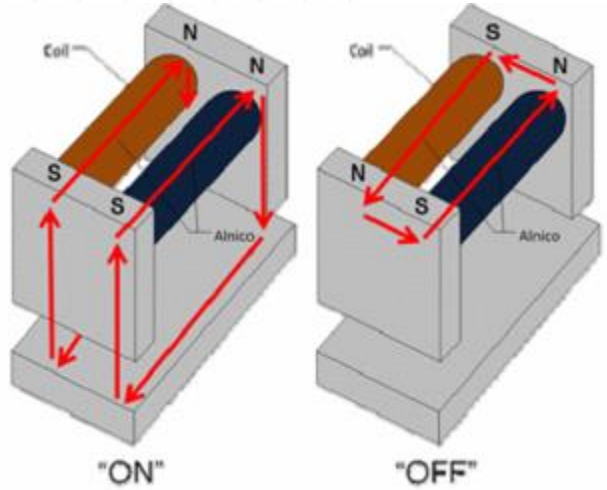
Docking Mechanism

Mechanical Structure

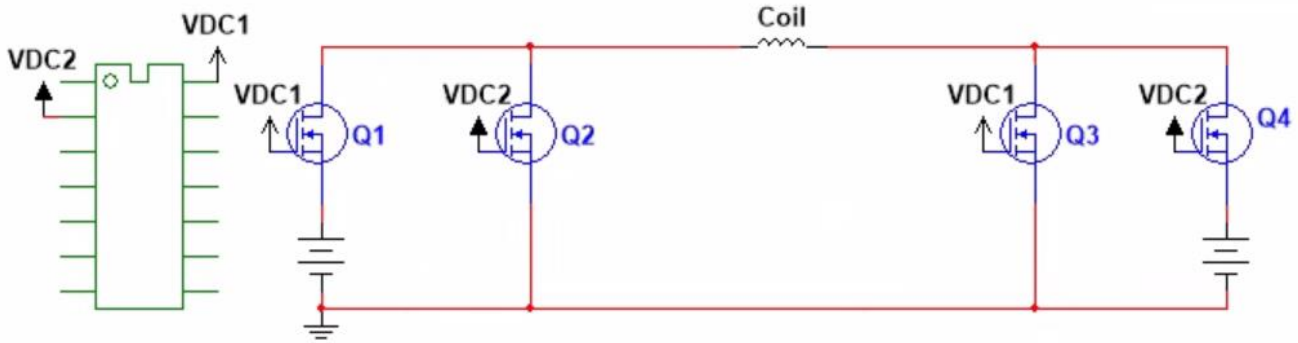




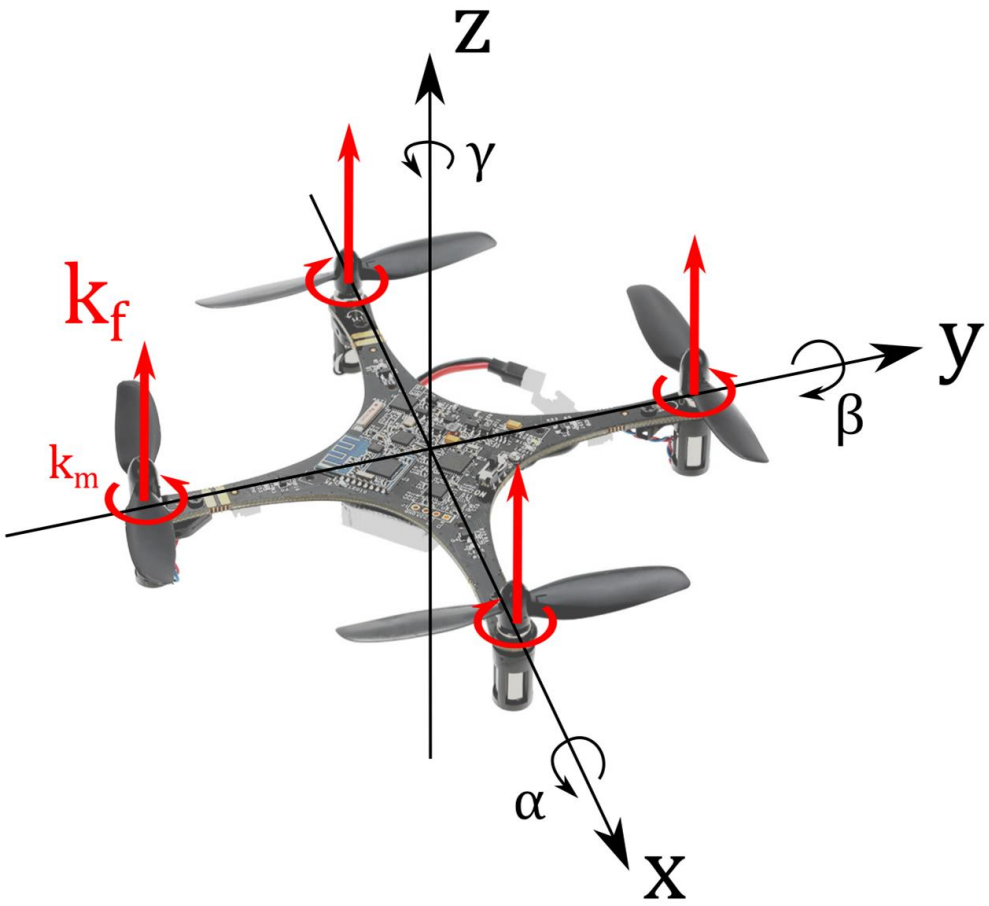
Physics



Control Circuit



Control System



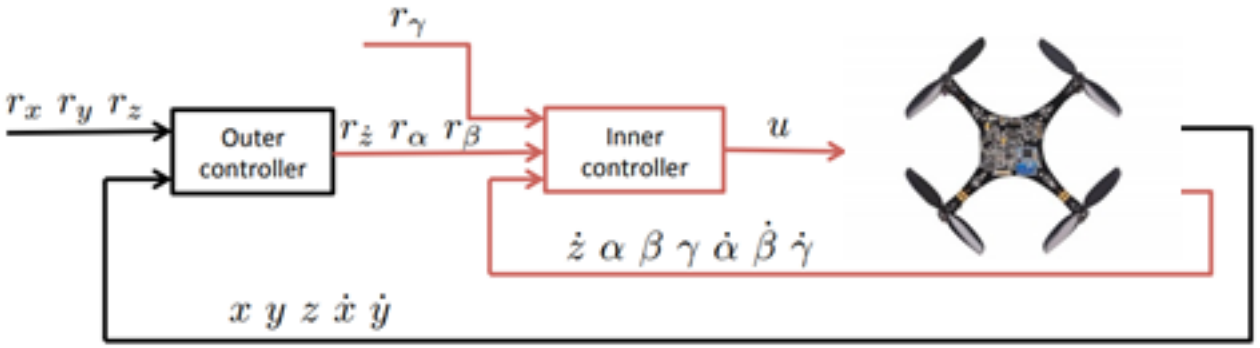
Matrix Model

$$\begin{pmatrix} F \\ M_\alpha \\ M_\beta \\ M_\gamma \end{pmatrix} = \begin{pmatrix} k_F & k_F & \dots & k_F \\ L_{1,\alpha} \cdot k_F & L_{2,\alpha} \cdot k_F & \dots & L_{n,\alpha} \cdot k_F \\ L_{1,\beta} \cdot k_F & L_{2,\beta} \cdot k_F & \dots & L_{n,\beta} \cdot k_F \\ L_{1,\gamma} \cdot k_m & L_{2,\gamma} \cdot k_m & \dots & L_{n,\gamma} \cdot k_m \end{pmatrix} \begin{pmatrix} u_1 \\ u_2 \\ \vdots \\ u_n \end{pmatrix}$$

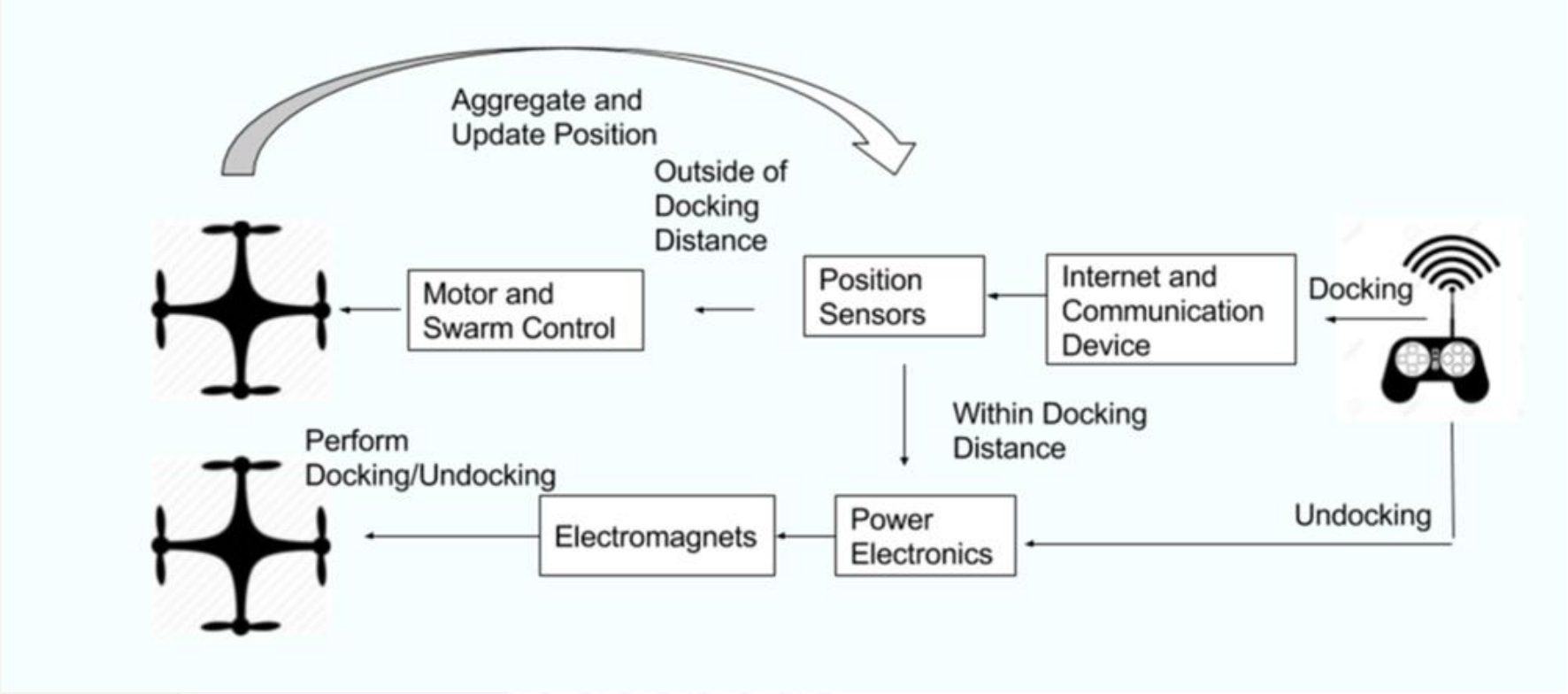
The Euler-Newton Equation

$$\begin{pmatrix} \ddot{\vec{x}} \\ \ddot{\vec{\alpha}} \end{pmatrix} = \begin{pmatrix} mI_3 & 0 \\ 0 & I_{cr} \end{pmatrix}^{-1} \left(\begin{pmatrix} \vec{F} \\ \vec{M} \end{pmatrix} + \begin{pmatrix} \vec{F}_{mag} \\ \vec{M}_{mag} \end{pmatrix} - \begin{pmatrix} 0 \\ \dot{\vec{\alpha}} \times I_{cr} \dot{\vec{\alpha}} \end{pmatrix} \right)$$

Cascade LQR Controller

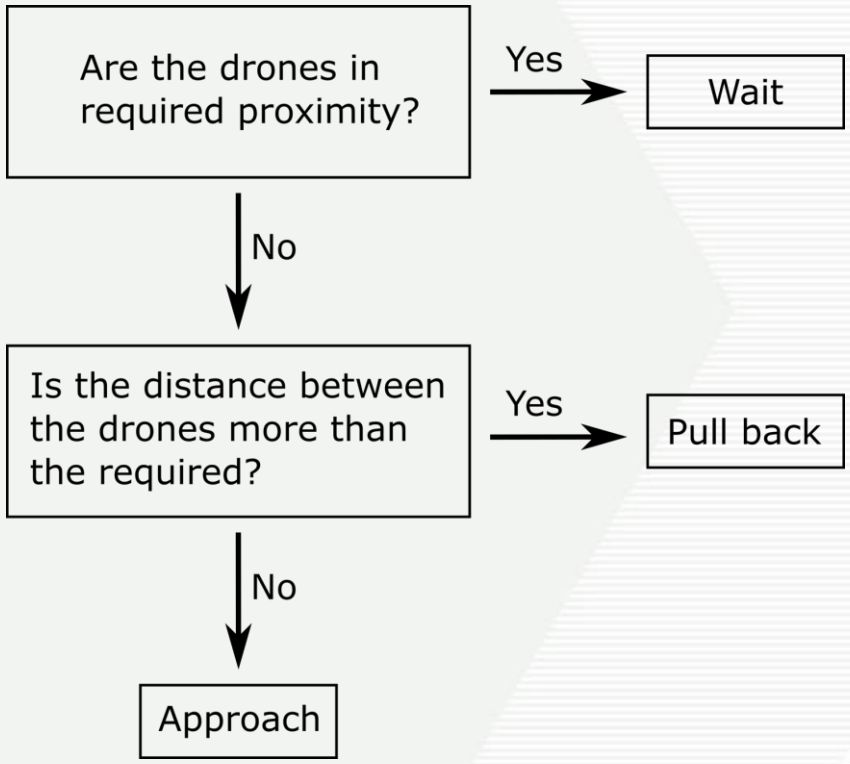


Communication

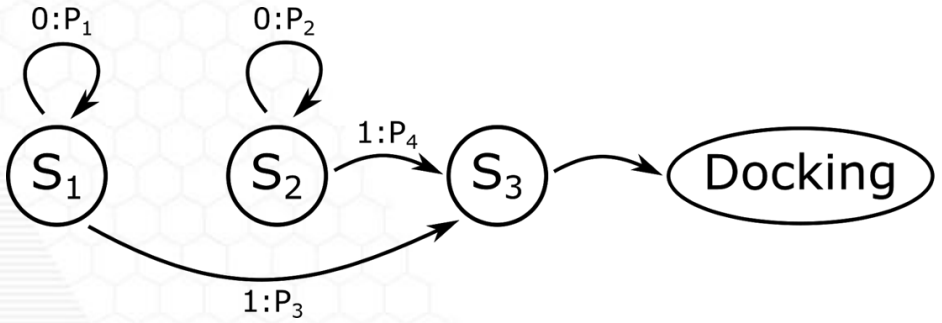


Swarm

Flowchart for Swarm Behavior



Probabilistic Finite State Machine (PFSM)



S_1: Approach
S_2: Pull back
S_3: Wait

Human Machine Interface (HMI)

Leading Industry Solution

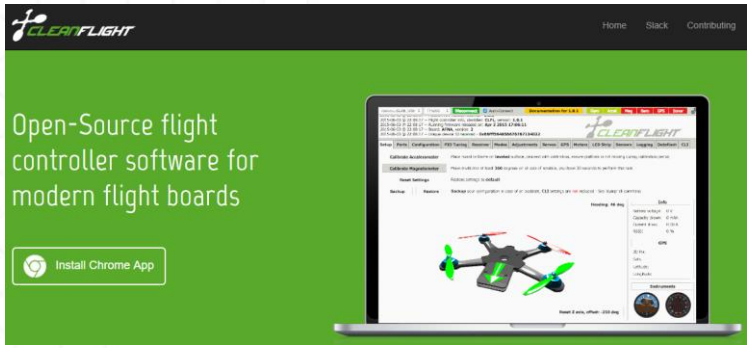
DJI Mavic Pro Controller:

- Two-Tier HMI
- Telemetry LCD
- Android/iOS App
- Proprietary Firmware

Proposed HMI Solution

Crazepony RadioLink:

- Multi-Tier HMI
- Configurable Controller
- CleanFlight Compatible
- Open Source Firmware



Components

Part	Vendor	Price per Unit	Requested Quantity	Cost
AlNiCo Magnet	Digi-Key	$2.63	8	$21.04
SunFounder FPV Racing Drone	Amazon	$210	2	$420
ToF Sensor (close range)	Adafruit	$13.95	4	$55.80
ToF Sensor (long range)	Amazon	$12.99	2	$25.98
Diode	Digi-Key	$0.57	10	$5.70
Supercapacitor	Digi-Key	$3.88	6	$23.28
MOSFET	Digi-Key	$0.70	20	$14
BeagleBone Blue Flight Controller	Digi-Key	$93.75	1	$93.75
Total Cost				$659.55

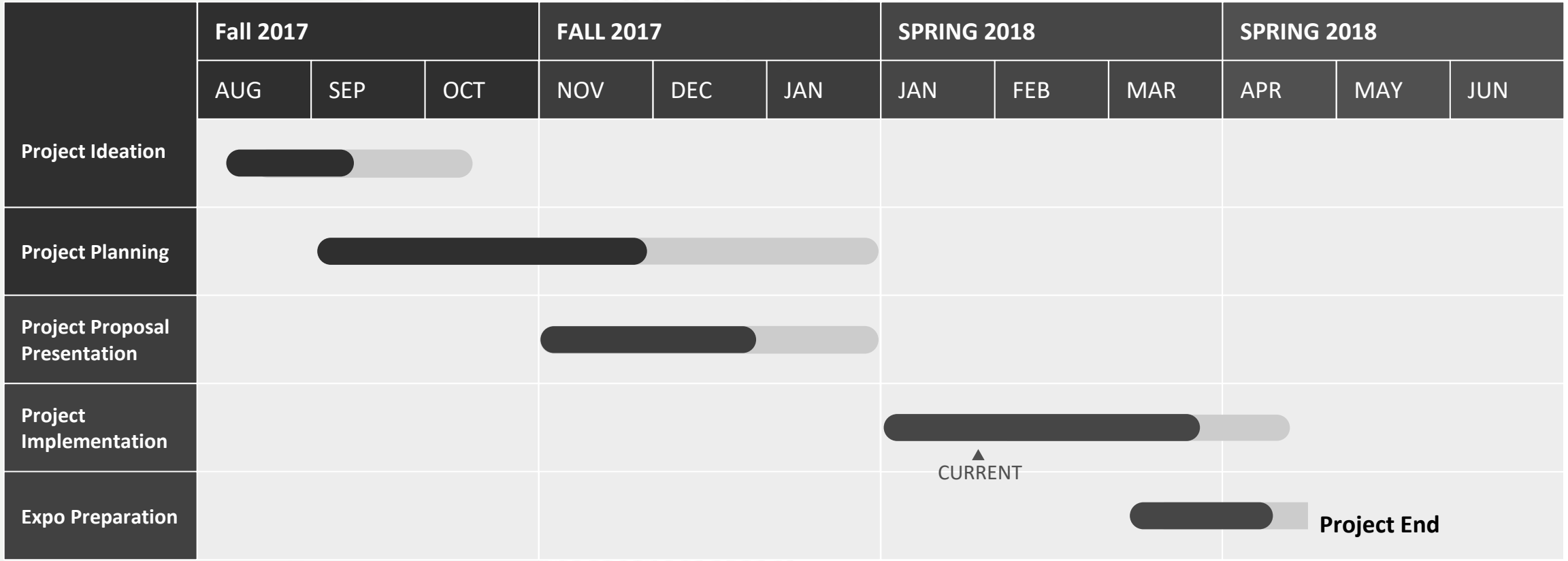
SunFounder FPV Racing Drone

Current Progress

Georgia Tech

Preliminary Implementation / Work in Progress

Revision / Improvements / Finalization



QUESTIONS?

Thanks for Listening!

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