MediDrone

Group 28

Team Members :

Varadha Anandakumar *(Mechanical Engineering)*

Lior Barak *(Aerospace Engineering)*

Ryan Grant *(Electrical Engineering)*

Joey Hodson *(Electrical Engineering)*

Seth Horowitz *(Electrical Engineering)*

Seba Villalobos *(Computer Engineering)*

Project Advisors :

Dr. Samuel Richie

Dr. Lei Wei

Goals & Motivations

- Development of a quadcopter that delivers temperature sensitive medicines and/or medical devices from a launch point to the specified destination. Aims to optimize medical transport to benefit both businesses and users.

- Current technology allows for air transport via quadcopter drone of many non-medical goods such as food. This technology has also proven well in commercial industries such as agriculture where autonomous labor operates over vast areas of land.

- MediDrone aims to expand the state of the art of payload carrying quadcopters toward medical payload utility.

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Objectives

- Optimize Aerial Delivery of Medical Supplies
- Autonomous Delivery
  - GPS navigation
  - Precision landing
  - Propeller power distribution
  - Collision avoidance
  - All terrain delivery
- Structure
  - Insulated container securely attached
  - Quadcopter design capable of carrying substantial loads
- Cheap and fast
- Hospital and natural disaster relief

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Specifications

- Flight
  - Carry a payload of 3 pounds
  - Range of 1 mile
  - Maintain distance of at least 5 feet from any object
- Loading and Takeoff
  - System startup should take no more than 30 seconds with a self test
  - Manual loading of payload should be possible in less than 1 minute
- Landing and Unloading
  - Land within 5 feet of the target mat
  - Unloading box with supplies should be possible in less than 1 minute

- These are the main specifications, more can be found within our Senior Design Paper

Work Distribution

Name	Flight / Software	Power	Payload	Landing	Drone Frame
Varadha Anandakumar		X			X
Lior Barak					X
Ryan Grant			X	X	
Joey Hodson	X			X	
Seth Horowitz			X		
Seba Villalobos	X	X			

Seth: Chapie Partnership

Agreement between MediDrone SD Team and Chapie

Medi-Drone X Chapie

Implementation of Chapie Plus

Can contain the "vaccine", Safe for transport, Will keep product contained & at temp

Requires a payload containing "box"

Implementation of Chapie Pro

Can serve as the payload entirely

Design mounting for Chapie Pro beneath drone

Benefit for Medi-Drone:

Use of Chapie, already optimized for high thermal conditions & keeping a delicate product resistant to those conditions

High Thermal Conditions referring to outside temperature during drone flight, similar to conditions of a summer day at the beach

Lightweight payload, no extras required

Benefit for Chapie:

Research & Test : Testing for alternate and medical utility

Process/Package Engineered: Further than the current iterations exploring all utilities

Proprietary Technology: Designed for use with "Chapie Payload" mounting to drone

Chapie "Sponsored" Medi-drone

Content Creation: deliver unharmed ChapStick to the pool or beach of your choosing

Requests from Chapie:

Chapie Pro and Chapie Plus units for testing

Current Research on Chapie Products range of utility (Will sign an NDA)

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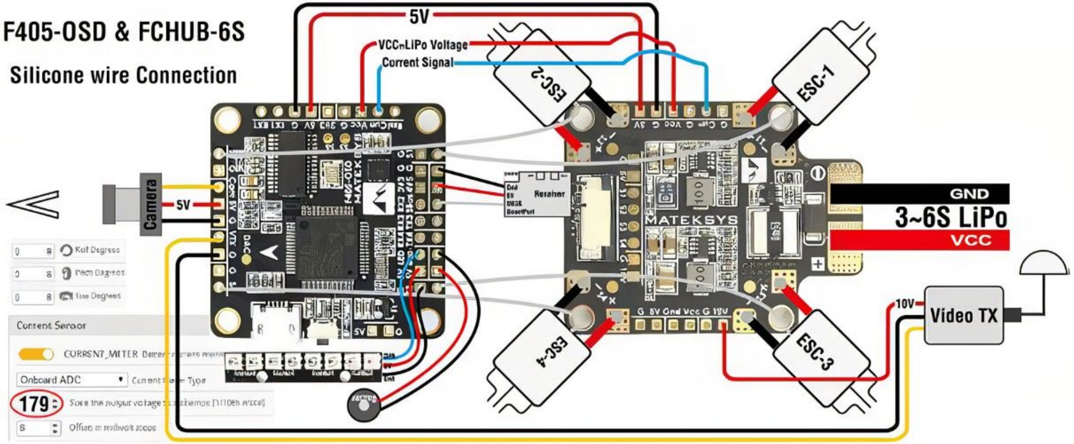
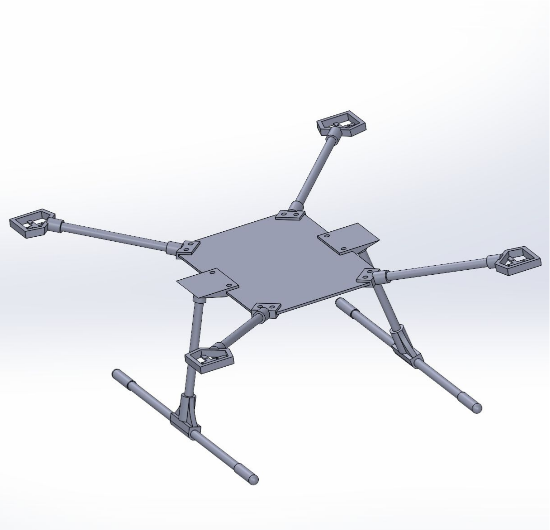
Seth: Power Supply

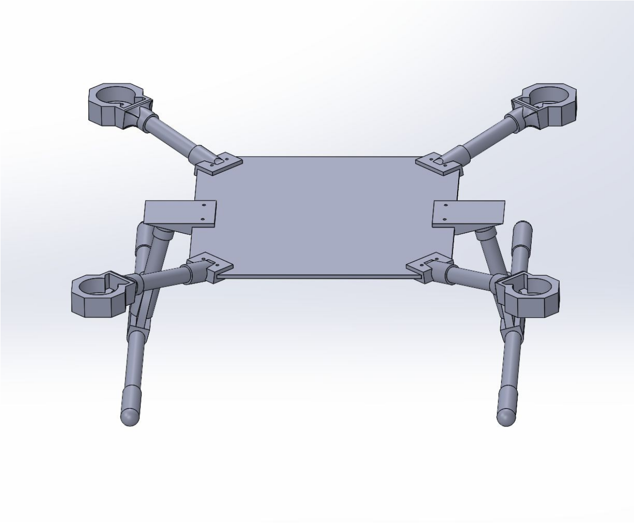


Drone designs

- Initial design
- Large to account for the payload and battery weight



- Current Design
- Adjusted to account for the smaller payload and finance problems



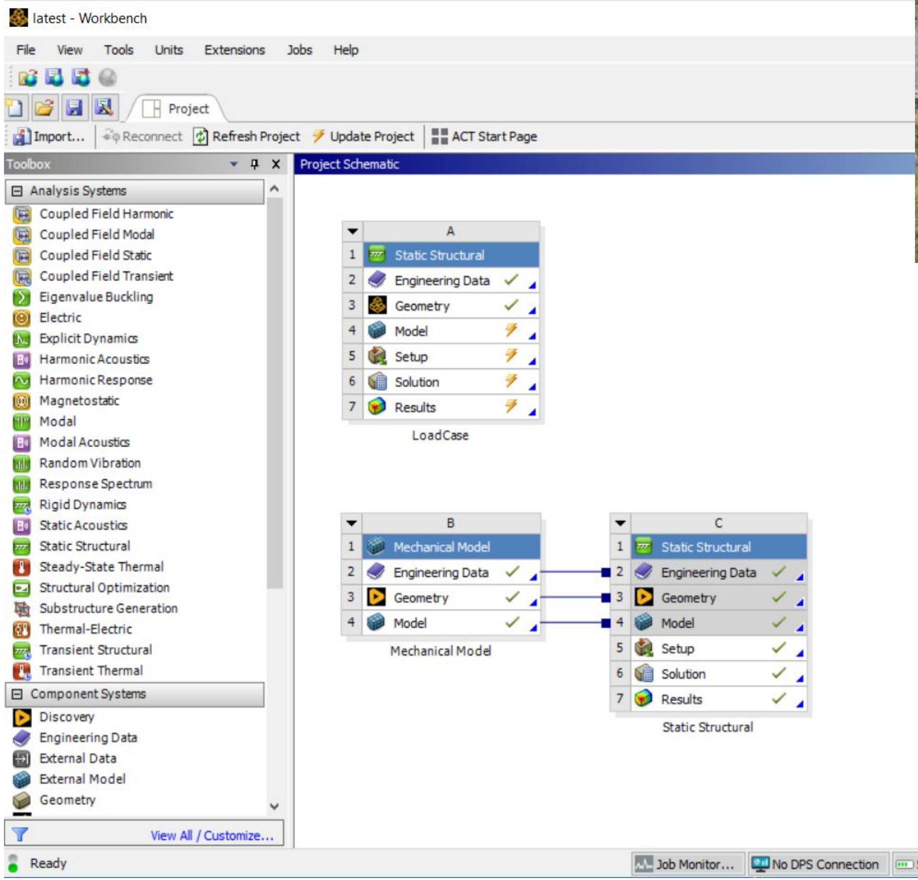
Analysis Software

ANSYS vs. Solidworks

ANSYS student license

Structural and Fluid analysis

Workbench



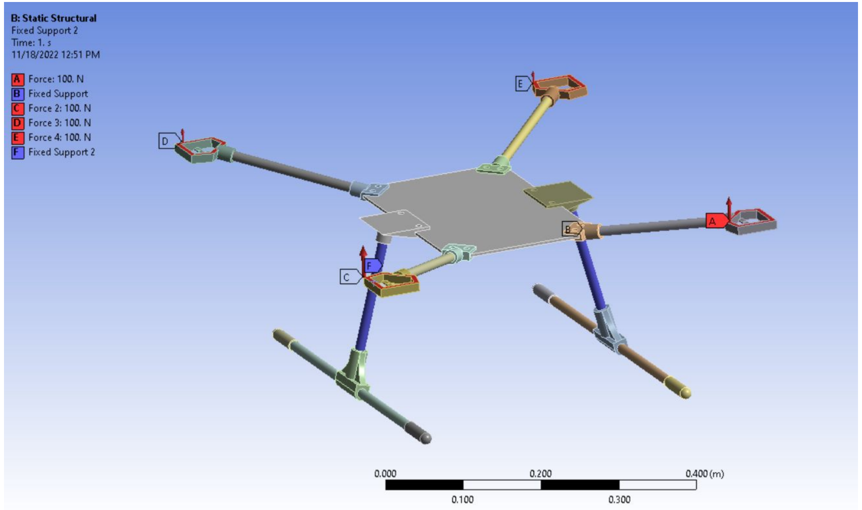
First Draft Structural Analysis

Static Structural Analysis on first draft frame.

- Loads applied: 100N vertical on each motor mount
- Fixed supports in the landing gear

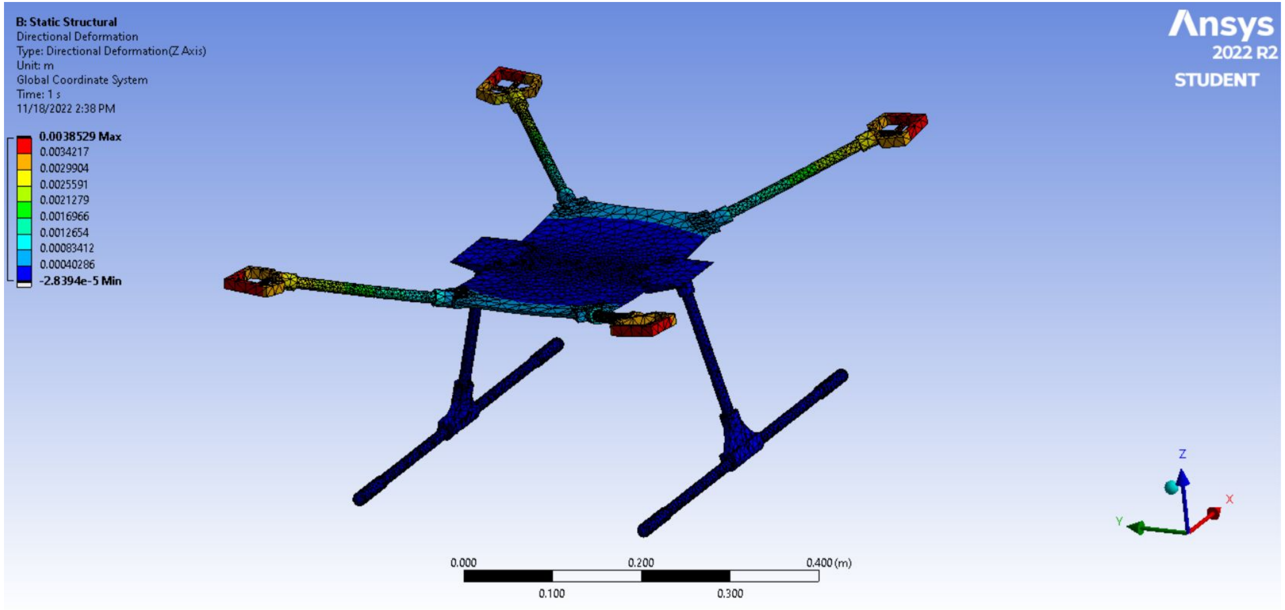
Goals

- Identify bending/buckling



Static Structural Analysis Colormap

- Deformation is concentrated on the motor mounts as expected
- Maximum deformation is on the order of 4mm



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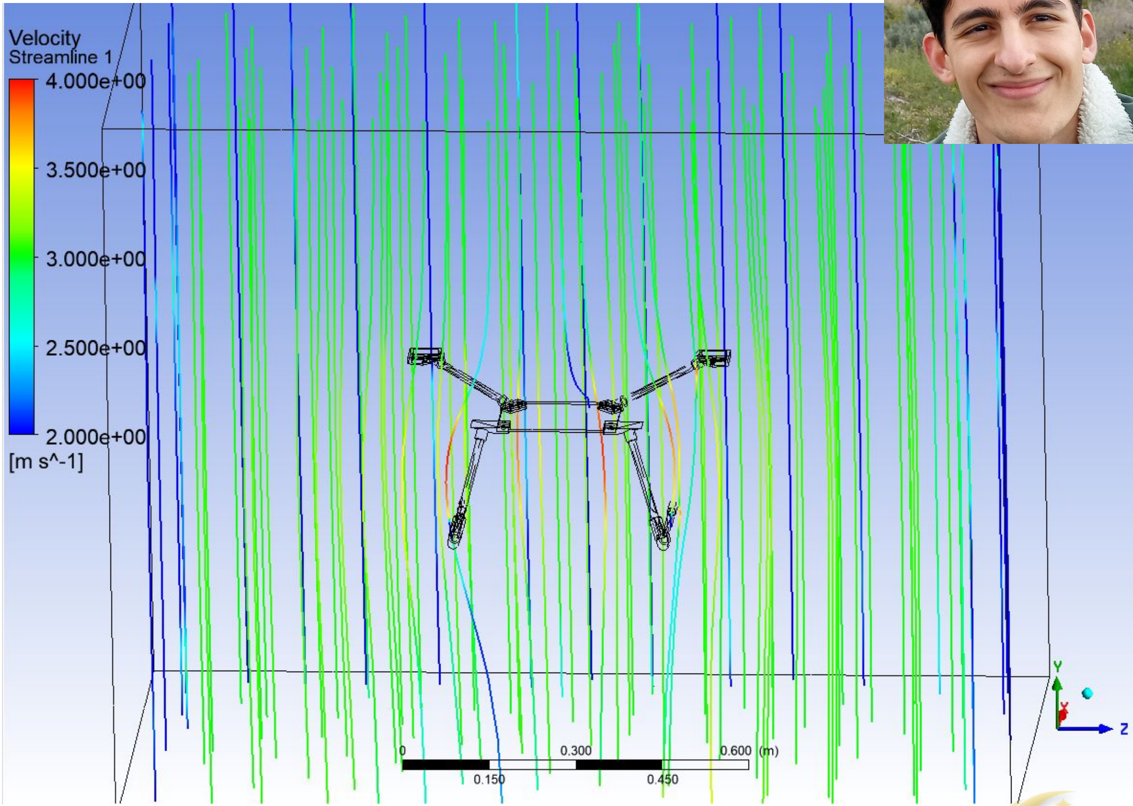
Fluid Analysis

- High velocity concentrations along the sides of the platform
- Low velocity at the top of the platform
- Very high pressure concentration at the top of the platform



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Hardware Network Overview

- Controller Area Network (CAN)
  - Protocol is highly robust and can well withstand noise as it's based upon a differential signal pair (used within motorized vehicles frequently)
    - Can resist EM interferences from four (noisy) brushless motors
    - Two-wire protocol
  - Scalable
    - Hardware remains very similar from node to node. The controller, CAN encoder/decoder, and CAN transceiver are found on every node. Only difference is what each node functions as (e.g. one node may control motor while another node is sensing)
    - This also allows for mechanical scalability (placing boards in distinct/intricate places)
  - Each node may read or write (no master)
    - CAN-FD (Fast Data extended protocol) supports substantial data rates
- Outside of CAN
  - Power Distribution, Battery Management System

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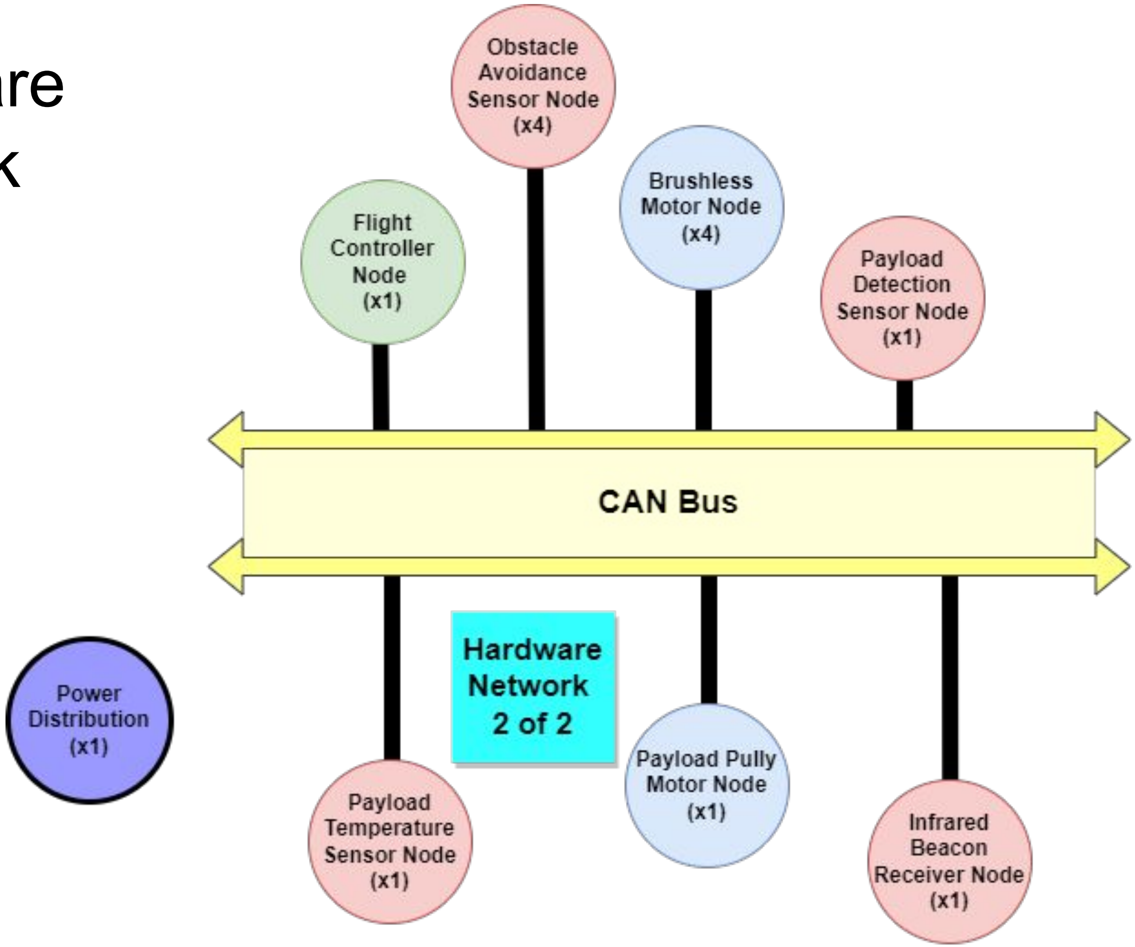
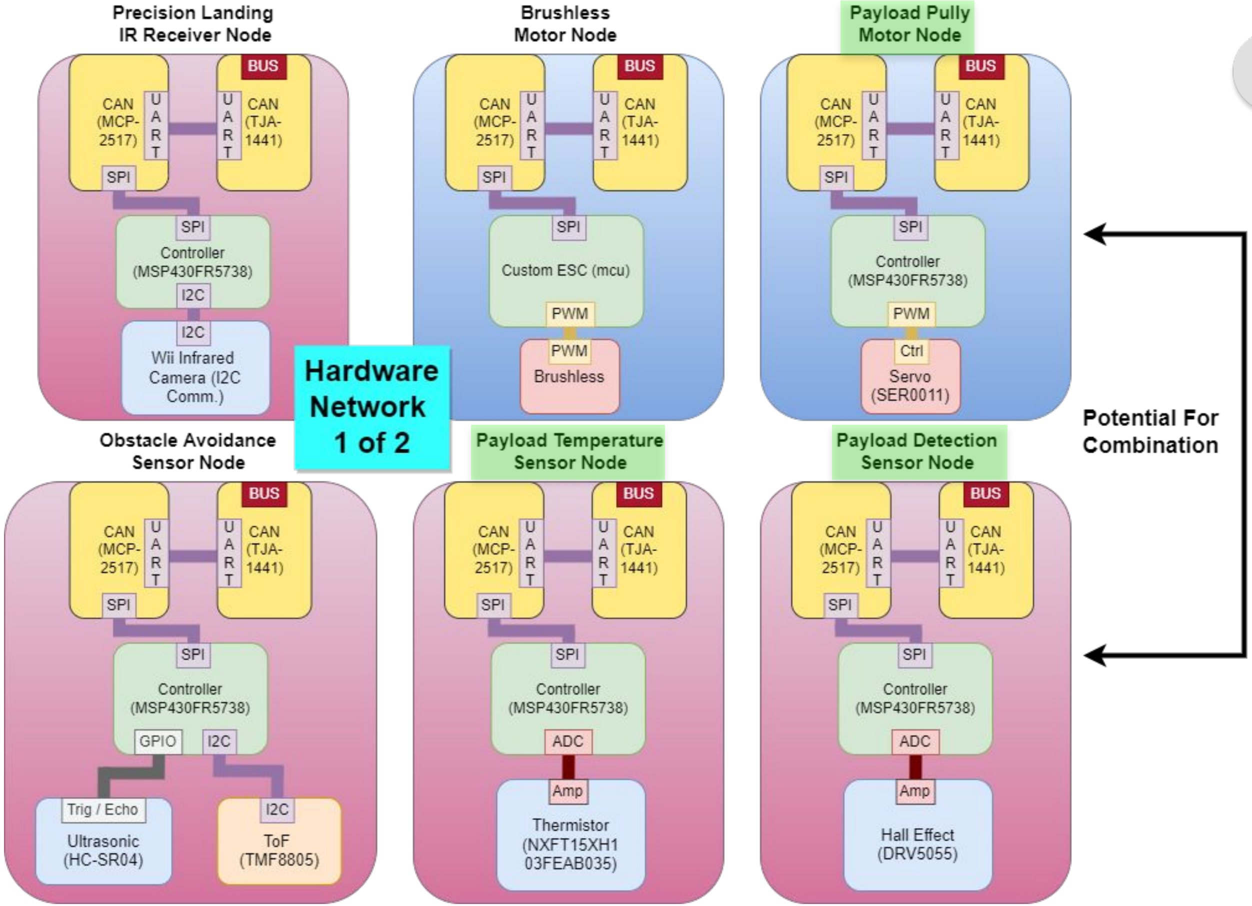
Hardware Network



Hardware Network



Stretch Goal Indication

Obstacle Avoidance Overview

- Four boards in total (one per side of drone)
- Boards embed two distance detection sensors
  - Time-of-Flight (TMF8805)
  - Ultrasonic (HC-SR04 breakout board)
- The two sensors in conjunction instill a greater fault tolerance to negative system and/or environmental impacts
  - Time-of-Flight has greater range/speed (& less weight) yet is less tolerant to noise from ambient sunlight
  - If communication deteriorates or fails from one sensor to the controller, the complement can still provide proximity readings
- Status: Five boards have been built (one spare) and i2c communication to ToF sensor has been established

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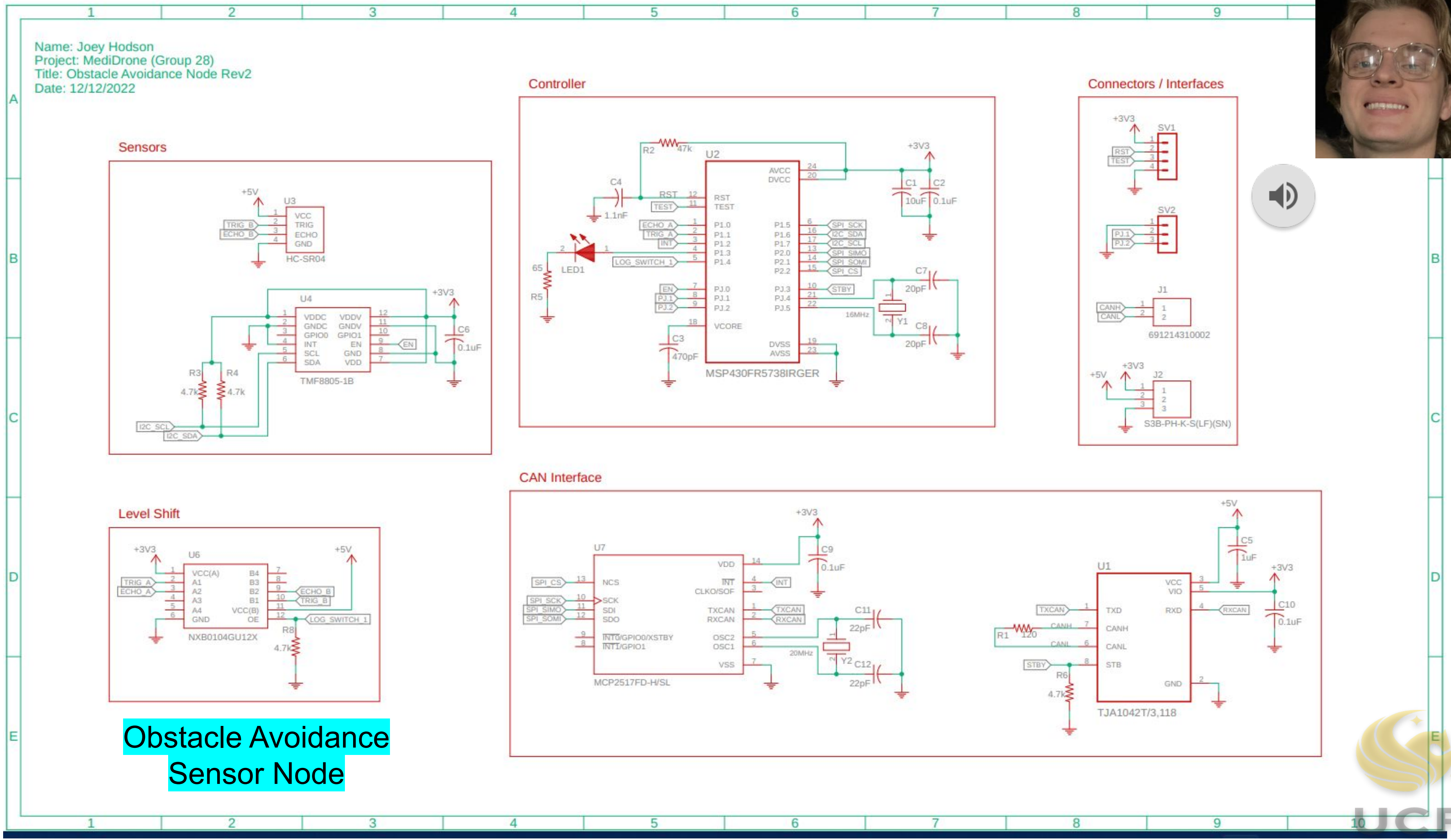
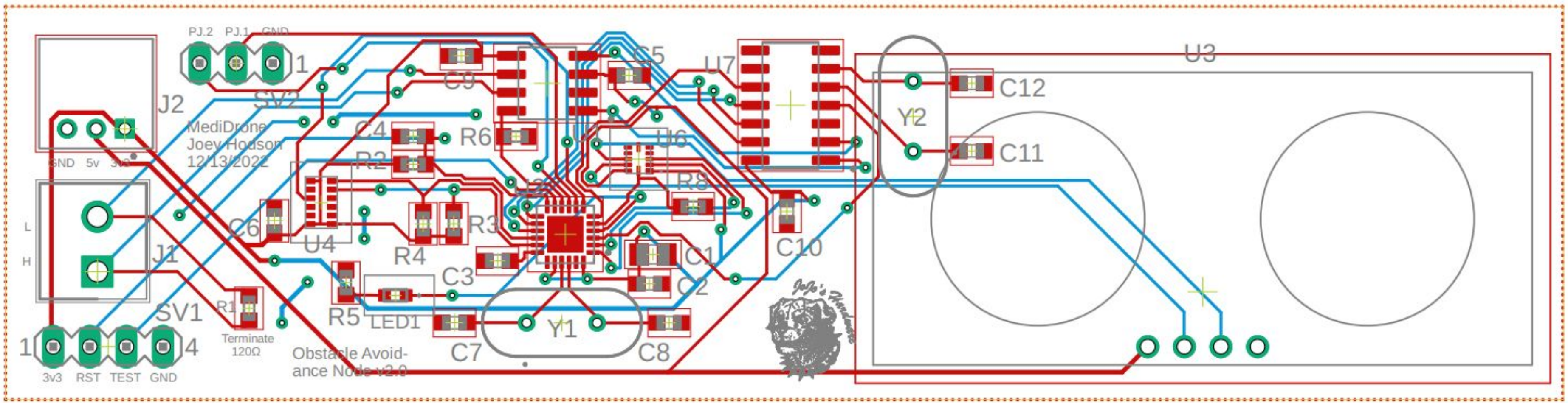


Obstacle Avoidance Sensor Node

Obstacle Avoidance Board Layout



ICs :

U1 : CAN Transceiver (**TJA1441**) [middle/center]

U2 : Microcontroller (**MSP430FR5738**) [middle/center]

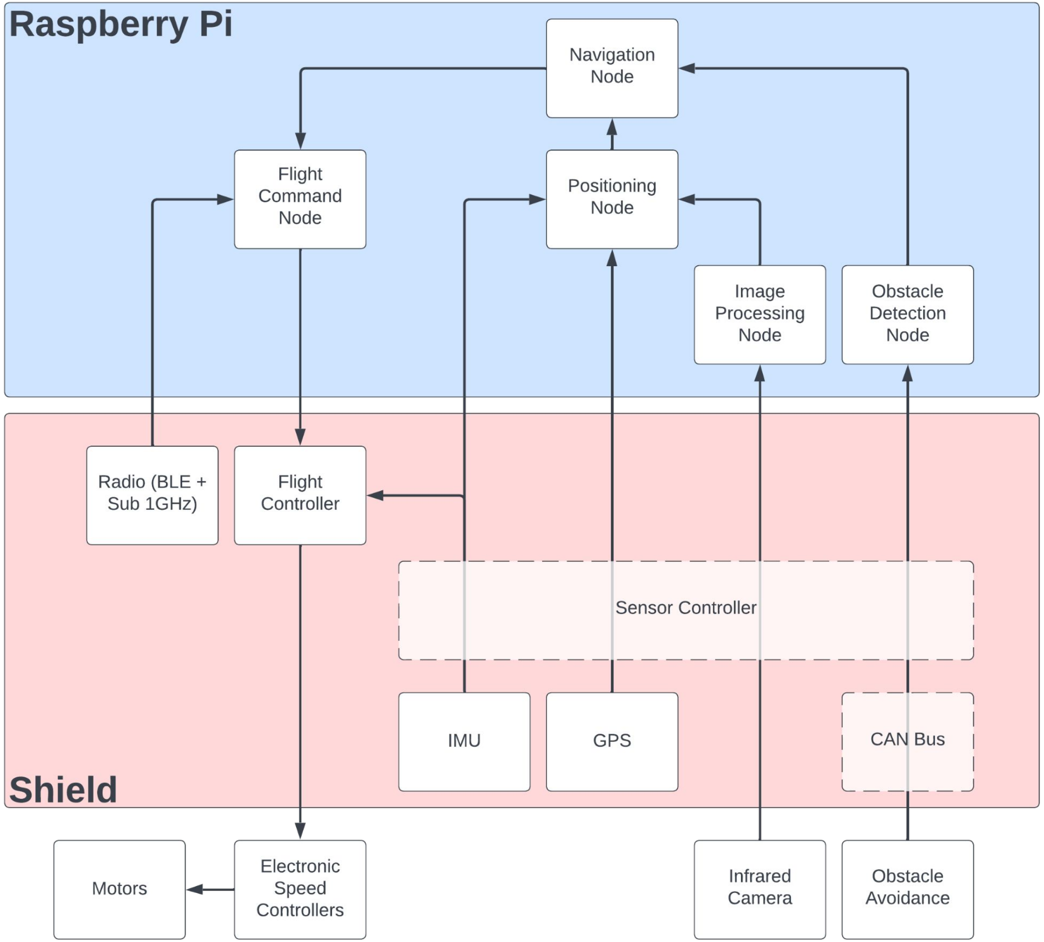
U3 : Ultrasonic Breakout (**HC-SR04**) [right]

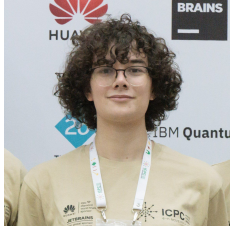
U4 : Time-of-Flight (**TMF8805**) [left/center]

U6 : Logic Shifter (**NXB0104**) [middle/center]

U7 : CAN Encoder / Decoder (**MCP2517**) [right/up]

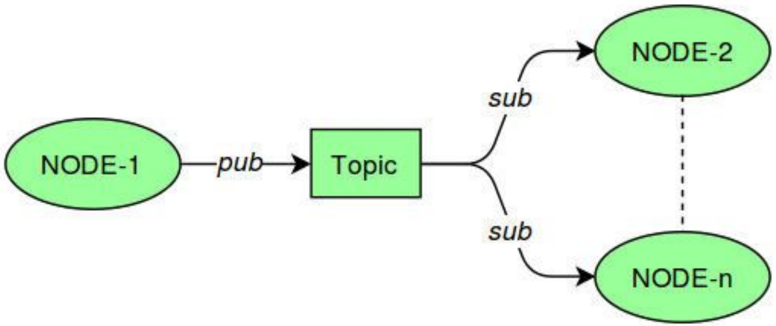
System Block Diagram

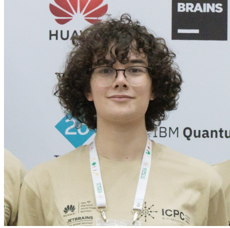




Software Operating Systems

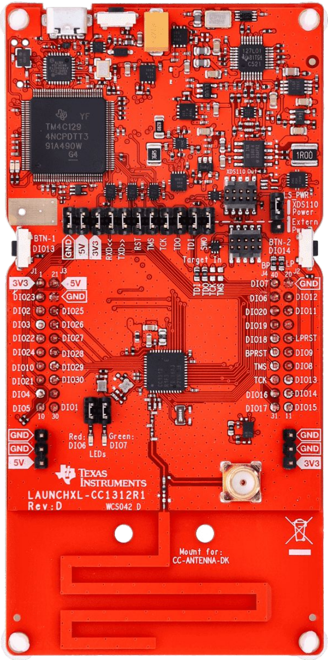
- Robot Operating System 2: ROS2
  - Runs on Linux computer (Raspberry Pi)
  - Core is written in C/C++
  - Our nodes are written in Rust
  - Each node is an independent program
  - Publisher/Subscriber model
- TI Real-Time Operating System: TIRTOS
  - Runs on MCUs
  - Written in C
  - Tasks and interrupts with priorities
  - Important to maintain radio connections and input/output

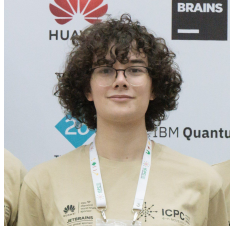




Radio Communications

- Bluetooth LE 5.2 for short range 2.4 GHz (400m range)
- Communicate with target to sync on pulse modulation
- TI 15.4 Stack for long range sub-1GHz (20 km range)
- Communicate with base station for safety
  - QGroundControl
- TI CC1312R MCU supports both



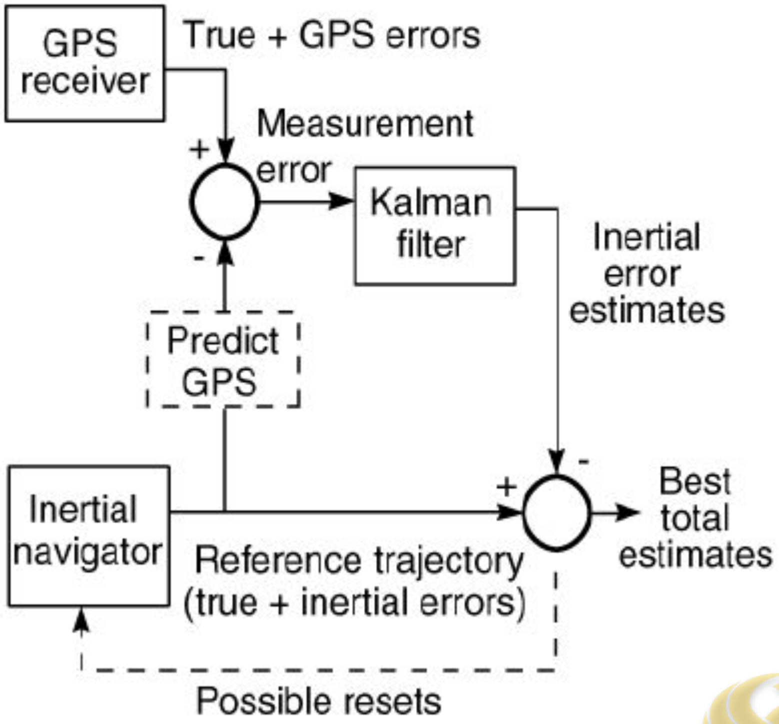


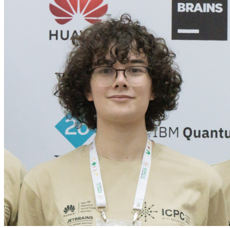
Kalman Filter Positioning

Using only GPS for positioning causes errors on small adjustments, doesn't update fast enough

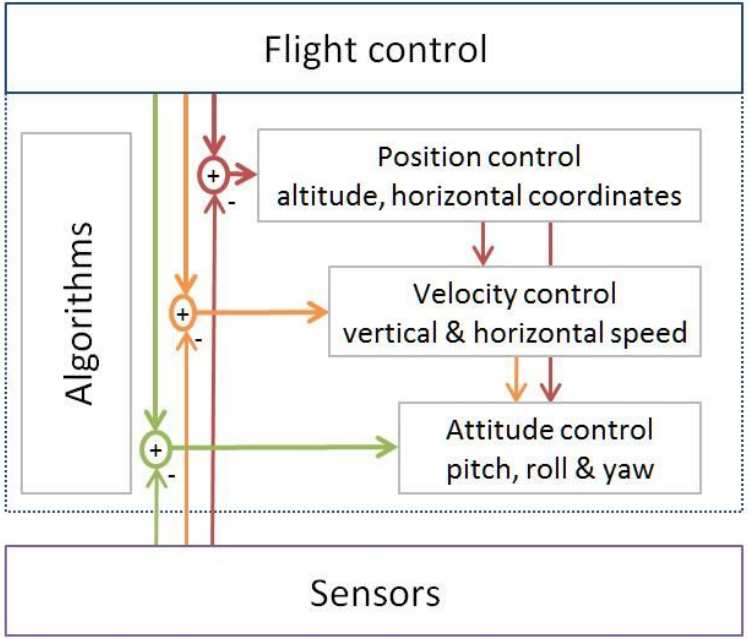
Using only IMU for positioning causes drift errors

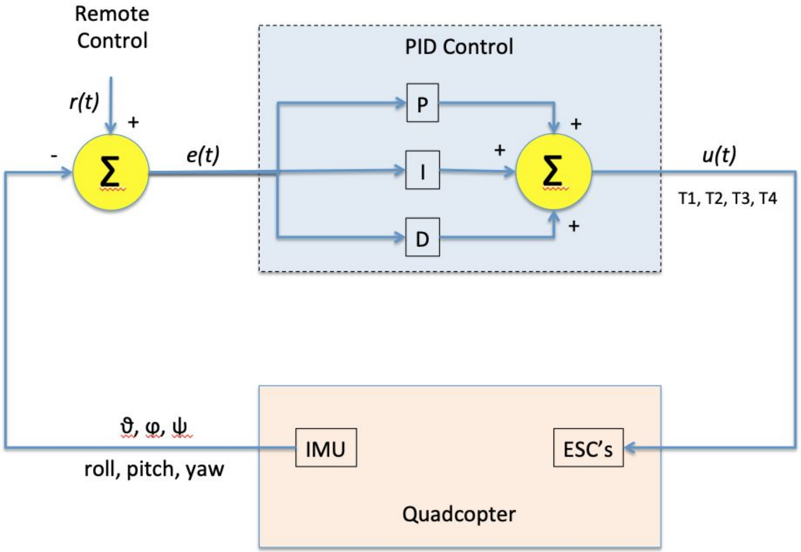
Combine both to get the most accurate real time position using a Kalman Filter





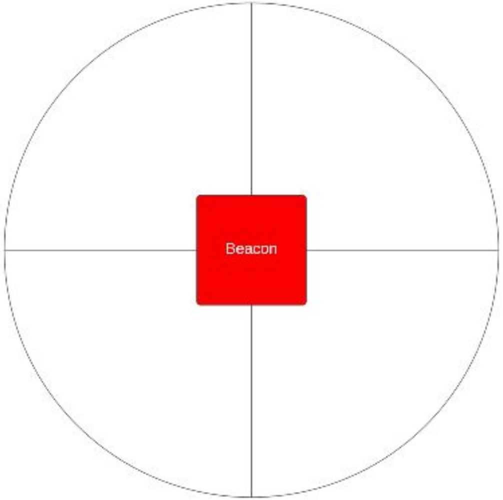
Flight Control Algorithms

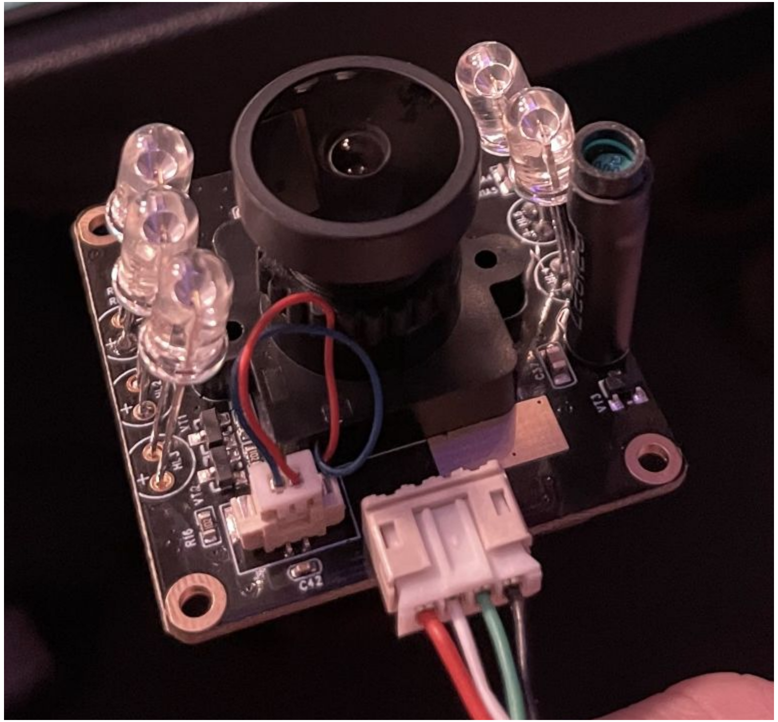




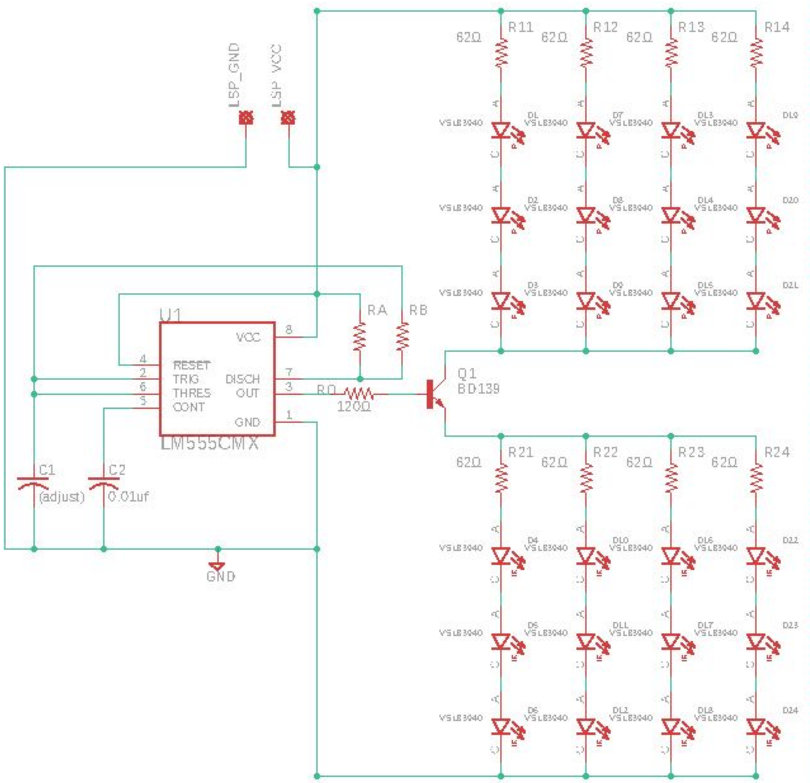
Autonomous Landing Using Infrared Beacon

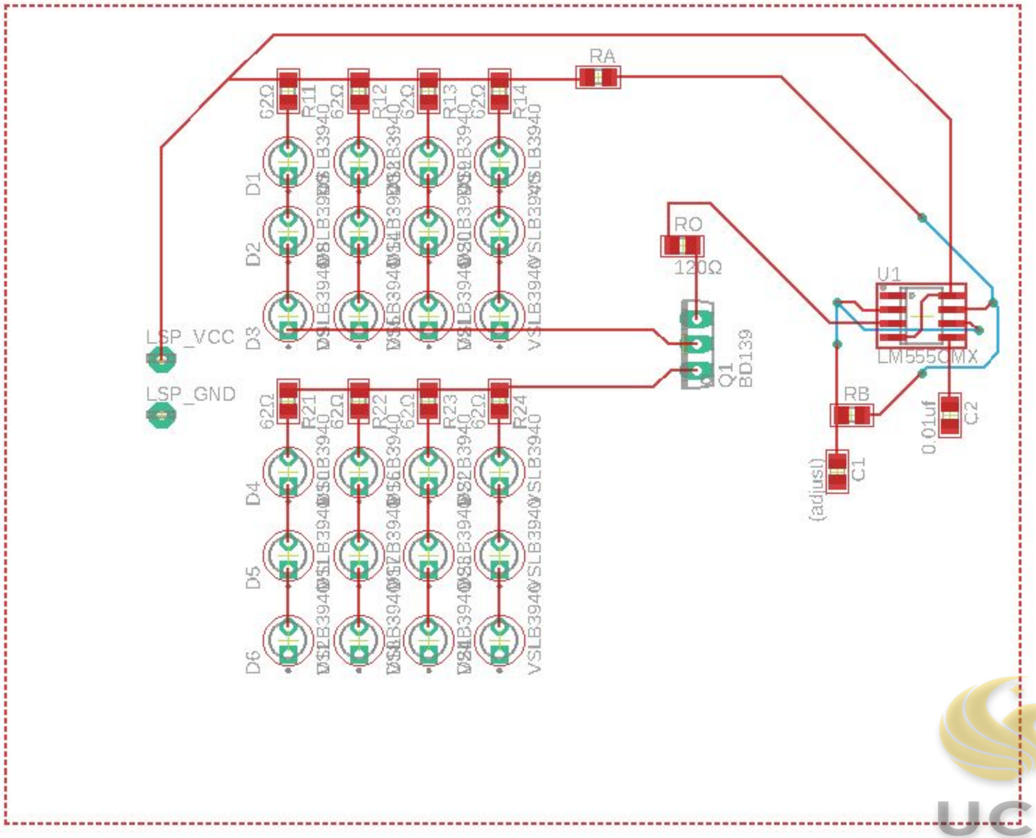
- Single-Beacon System
- Ideal Optimal Distance
  - Goal (Before Testing): 10-20 meters





IR-Beacon Layout



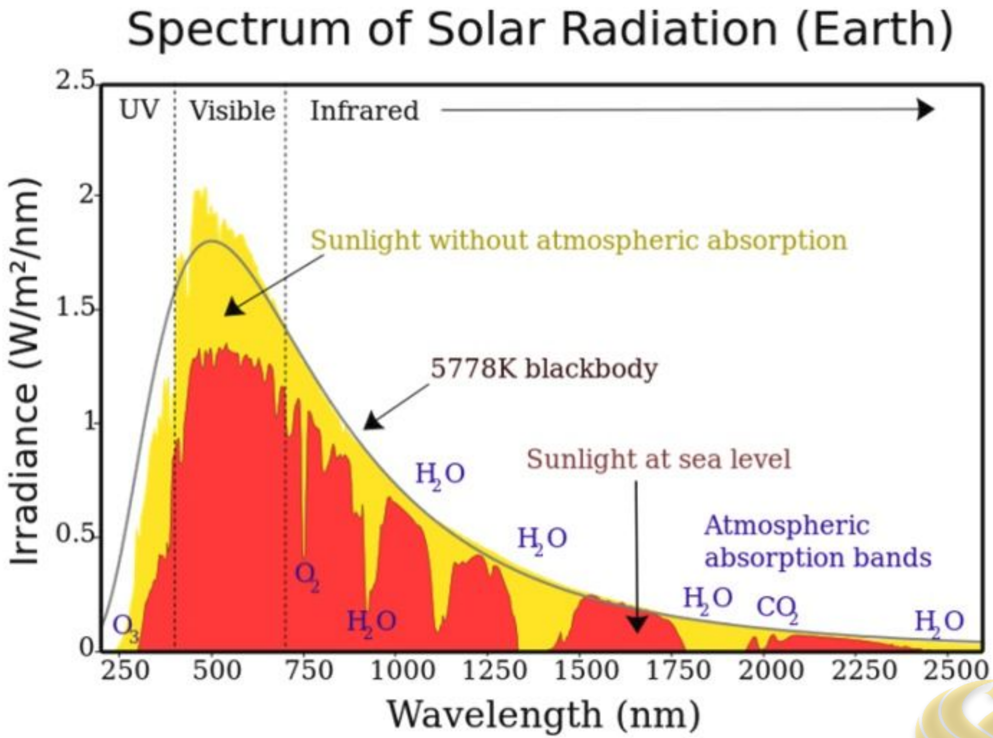


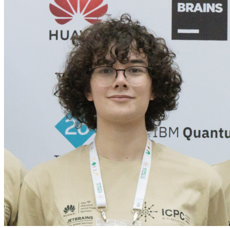
Detecting IR Beacon Outside

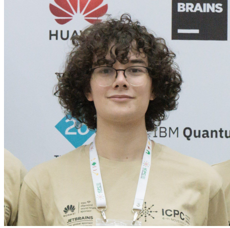
Sunlight has a significant infrared component

Finding the brightest IR point could be reflected sunlight, instead of the IR beacon

Solve this using pulse modulation on the IR beacon







Pulse Modulation Algorithm

Toggle the IR beacon on and off at a preset frequency, T = period

Find positions in the image that toggle at the same frequency as the beacon

Positions that match more than some threshold are averaged together

```
procedure ProcessFrame(f, frames, states, counts, threshhold, T)
    Enqueue(frames, f)
    while Time(Front(frames)) + T/2 < Time(f) do
        Dequeue(frames)
    end while
    f' ← Front(frames)                         ▷ Frame with opposite beacon state
    positions ← ∅
    for each position (x, y) do
        if f[x, y] ≠ f'[x, y] then
            s ← 1
        else
            s ← 0
        end if
        counts[x, y] ← counts[x, y] + s − Front(states[x, y])
        Dequeue(states[x, y])                  ▷ Update buffer of previous states
        Enqueue(states[x, y], s)
        if counts[x, y] ≥ threshhold then
            Insert(positions, (x, y))
        end if
    end for
    return Average(positions)
```

Administration Content

Drone Pros/Cons

Pros:

- Increased delivery speed
- More efficient than ground transport
- Reduced human error
- Completely electric
- Cheaper

Cons:

- Short range
- Limited payload capacity
- Single delivery per trip

Budget

We were able to use some components from prior Senior Design projects so our actual total is $251.29

Part	# of parts	Price per part	Total price
Motor	4	$65.00	$260.00
Propeller	4	$5.22	$20.88
ESC	4	$28.11	$112.44
Carbon Fiber Rod(4'')	4	$5.95	$23.80
Battery	2	$63.75	$127.50
MDF Wood(2' x 4')	1	$13.99	$13.99
3D-printer Filament(PLA - 1KG)	1	$21.00	$21.00
			$579.61

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Financing (impact on specifications)

Limitation	Impact
Overall Size	Drone design scaled down to accommodate for material cut.
Frame Design	Number of rotors has been decreased
Payload	Weight of payload decreased to 3lb
Range	Distance decreased to 1 mile

Spring Milestone Chart

Class Deadlines	Due date and progress	Project schedule	Due date and progress
CDR Final Submission	Due 02/02/2023 Completed	Research	Due 12/06/2022 Completed
Project Summary Submission	Due 02/17/2023 In progress	Design Prototype	Due 12/06/2022 Completed
Middle Term Demo	Due 03/20/2023 In progress	Design Completed	Due 02/20/2023 In progress
Conference paper and Committee Form	Due 03/31/2023 In progress	1st Build	Due 03/10/2023 In progress
Project Showcase 8 minute video submission	Due 04/15/2023 In progress	Electronics	Due 03/15/2023 In progress
Final Presentation submission	Due 04/16/2023 In progress	Test & Adjust	Due 04/12/2023 In progress
Final Documentation Due	Due 04/25/2023 In progress	Final project complete	Due 04/16/2023 In progress

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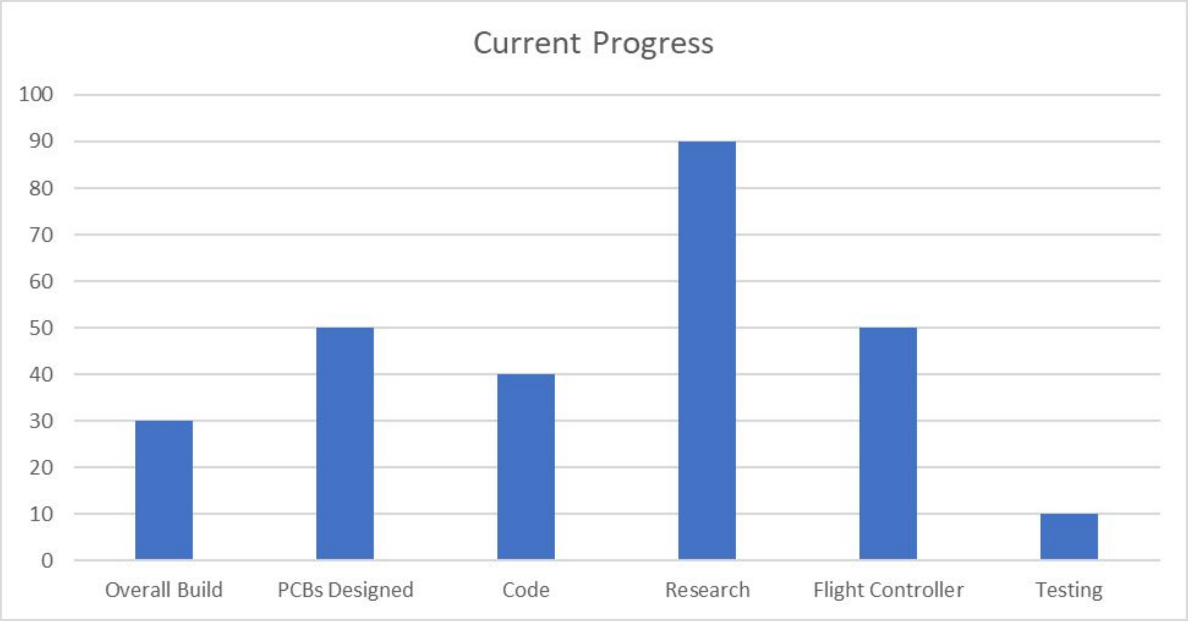
Current Progress

- Overall Build: 30%
- PCBs designed:50%
- Code:40%
- Research:90%
- Flight Controller:50%
- Testing: 10%



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Future Progress

- Hardware Progress
  - Drone chassis/skeleton assembled
  - Electronics
- Software Progress
  - Flight Path
  - Sensors
  - Completed Code

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Questions & Comments?