Bluetooth-Localized Drones

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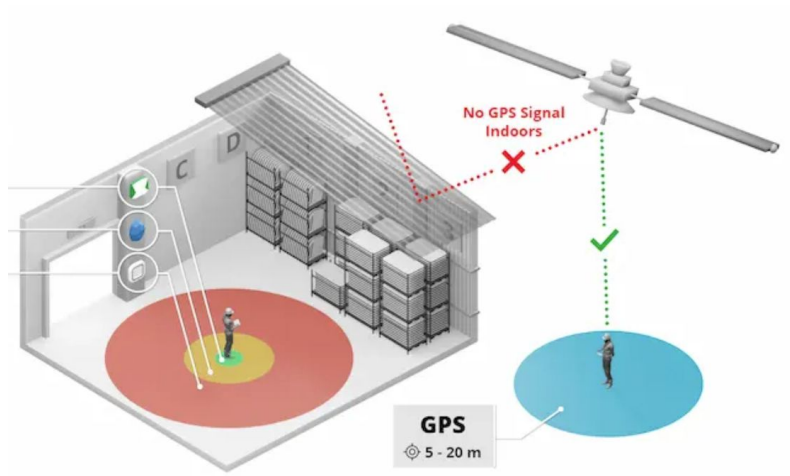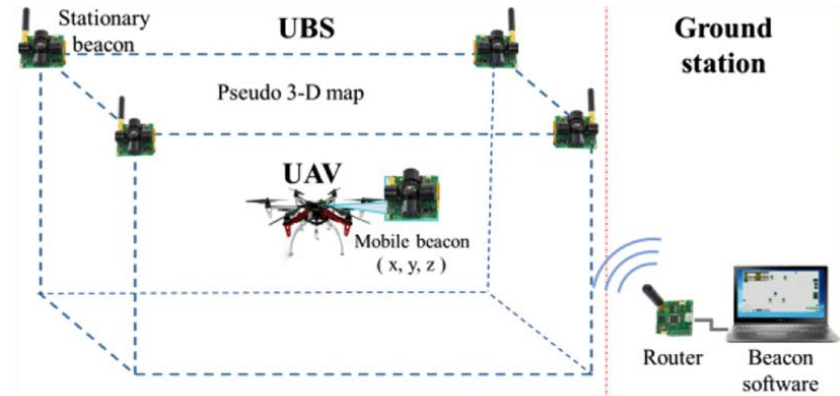
Contents

Motivation: Limitations of GPS Indoors

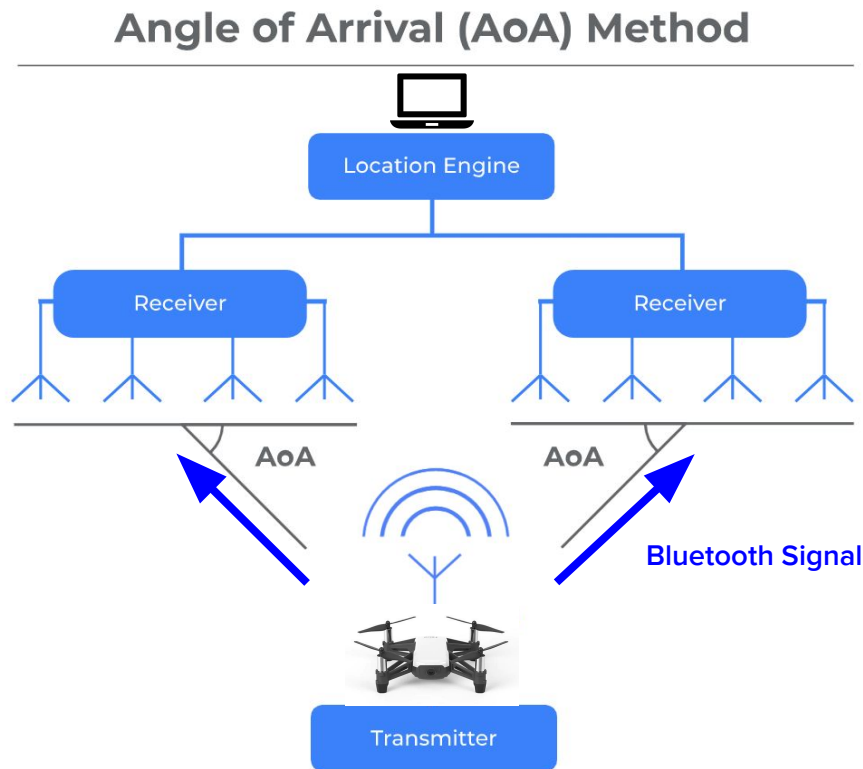- Indoor drones **can't use GPS** for localization due to weak signal

- Therefore: Indoor Positioning System usually implemented using **ultrasonic beacons placed around a room**

Motivation: Localization using Bluetooth

- **Bluetooth Low Energy (BLE)** can be used to locate signal origins using **Angle of Arrival (AOA)**

- **Question:** Can BLE technology be used for **localization of drones?**

Angle of Arrival (AoA) Method

Location Engine

Receiver

Receiver

AoA

AoA

Bluetooth Signal

Transmitter

Accuracy of Positioning Technologies

Drone Positioning Accuracy (Radius of Target)	
GPS	1 - 400 centimeters
Ultrasonic Beacons	1 - 100 centimeters
Bluetooth Low Energy (BLE) AOA	1 - 50 centimeters

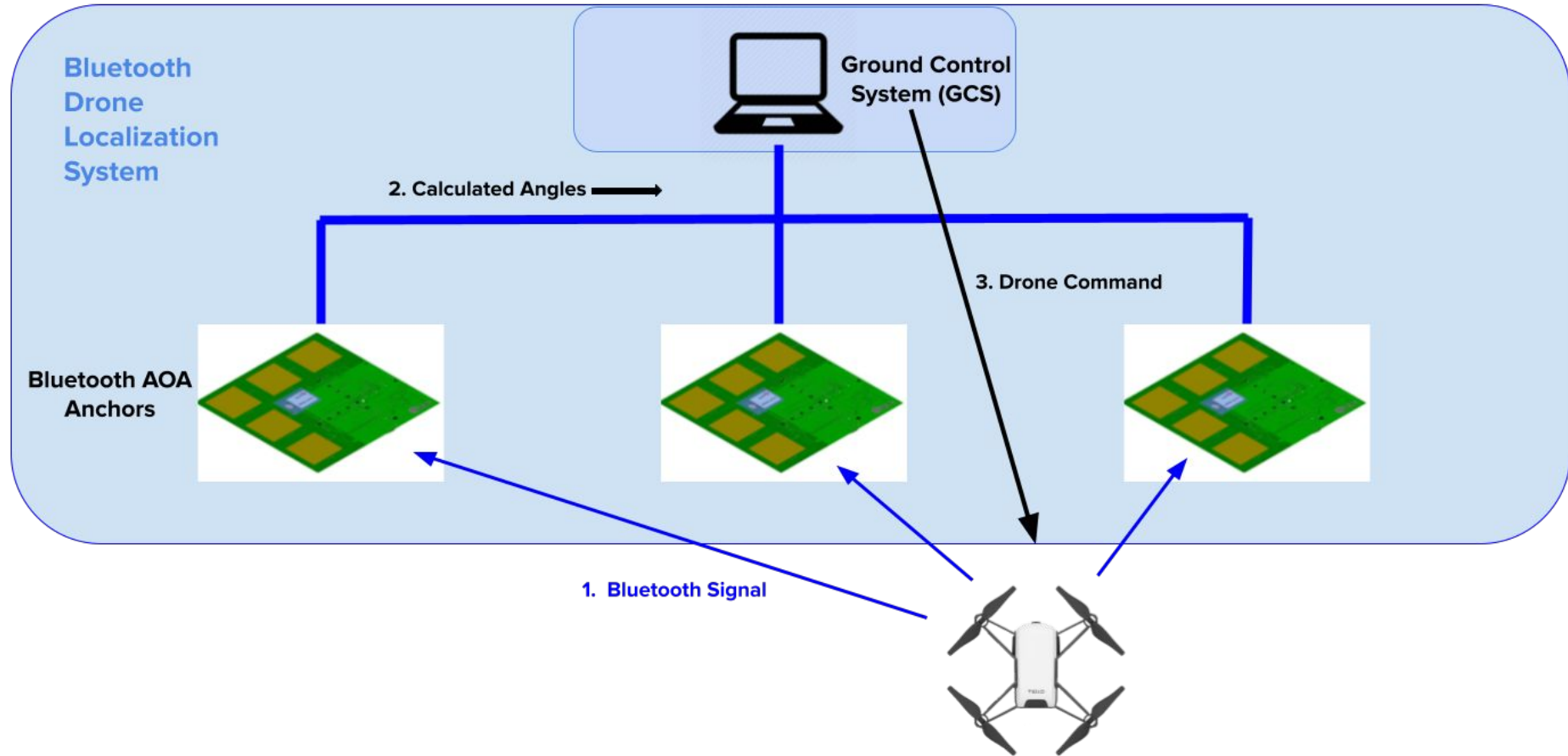# Project Goal: Using Bluetooth for Drone Localization

Develop a scalable **drone localization infrastructure** that utilizes **BLE AOA technology** to locate indoor drones
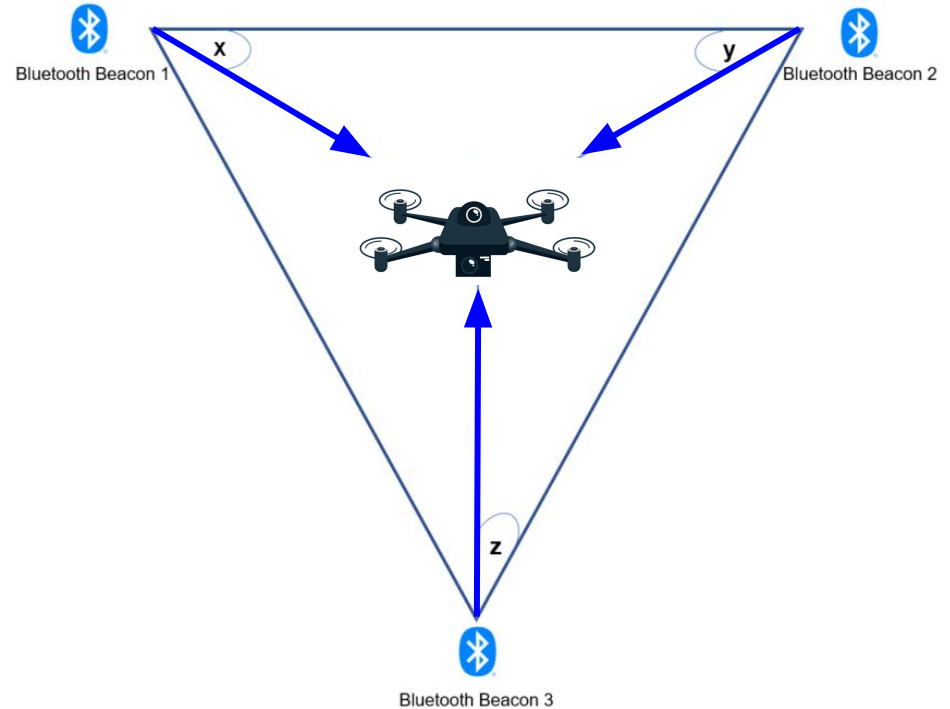
Project Requirements

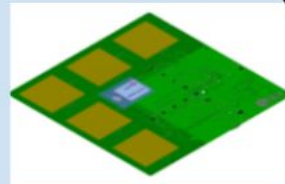| Requirement	Metric
Successful Drone-User Communication	GCS acknowledges drone's Bluetooth signal
Drone Flight Capabilities	Drone responds to directional commands
Drone Localization Accuracy	Drone detected within 20 cm of actual location
Improper Command Rejection	Drone rejects out-of-bounds and colliding commands

System Overview

Bluetooth Drone Localization System

Ground Control System (GCS)

2. Calculated Angles →

3. Drone Command

Bluetooth AOA Anchors

1. Bluetooth Signal

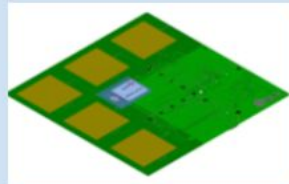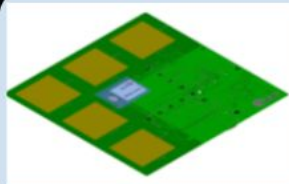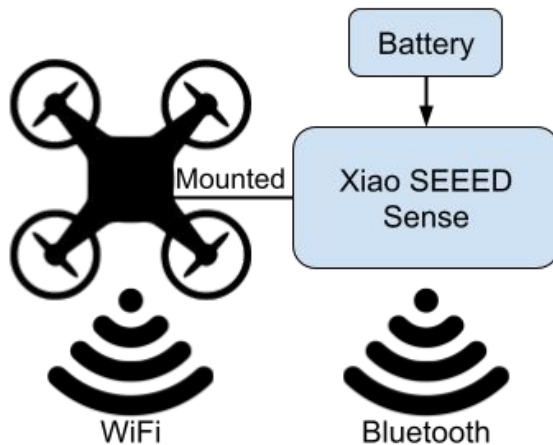# Technical Design

System Overview

Drone + Bluetooth System

- Previously attempted to build a custom drone
- Now prebuilt drone with bluetooth module attached

DJI Tello

Battery

Mounted

Xiao SEEED
Sense

WiFi

Bluetooth

Flight Control Firmware

- Fully handled by Tello SDK
- Tello drone is blind to its location

Drone ←— Command —— GCS WiFi ←—— Control System Algorithm

Drone ↕ Mounted Seeed

Seeed —— Location Broadcast —→ GCS Bluetooth Anchor —→ Control System Algorithm
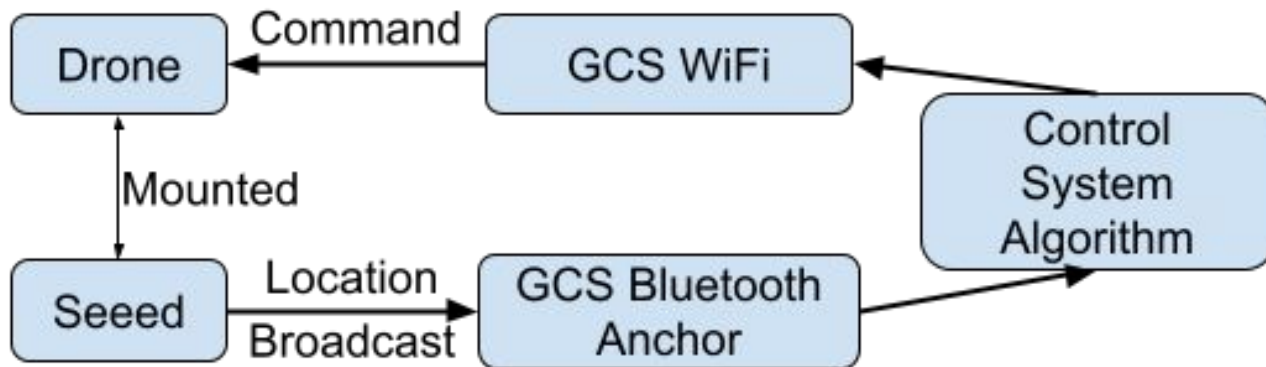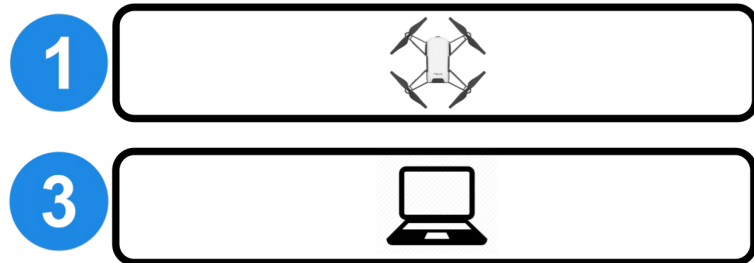
The Components of our Design

Microcontroller: Seeed Studio XIAO nRF52840 (Sense)

- Tiny BLE development board
  - Bluetooth 5.0 connectivity

- Is used to transmit signals for localization
  - Advertises presence through transmitting Eddystone Signals
    - Eddystone: method of broadcasting device data from a beacon (such as URLs, battery status, etc.)
    - Beacon: transmits signals which can help indicate the location of a device
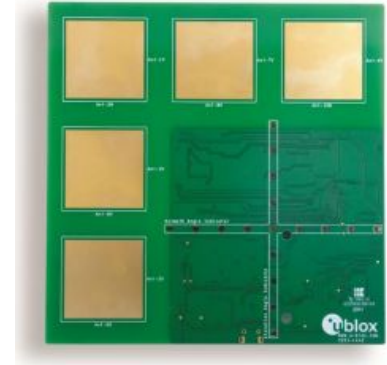
The Components of our Design
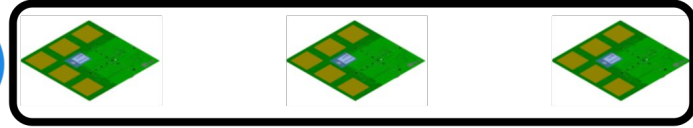
U-Blox BLE AOA board (Anchor)

- A board consists of an antenna array: detects the angle or direction of an object transmitting a bluetooth signal
  - uBlox localization software on board

- Angles are calculated in two dimensions and are delivered directly through a USB port
  - Angle polling

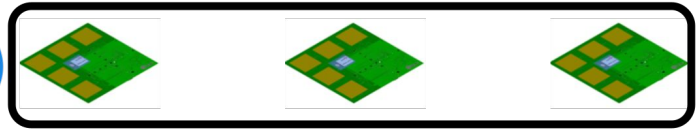u-blox C209 application board (tag)
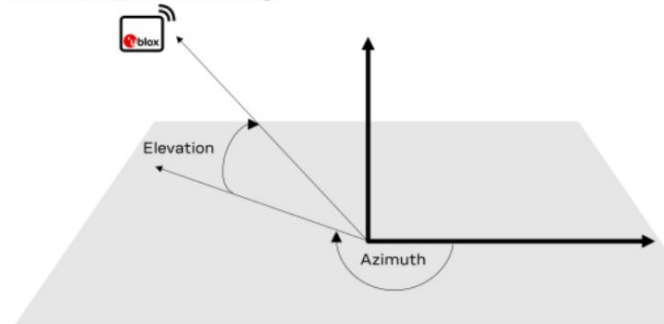
Elevation

Azimuth

Figure 5: Azimuth and elevation angles

Mohammad - 14

Drone Location Calculations

Triangulation: method to calculate the location of an object using angles, distances and trigonometry

- Input: (Azimuth 1 , Azimuth 2, Elevation)
- Output: (X, Y, Z) -> Cartesian Coordinates of Drone
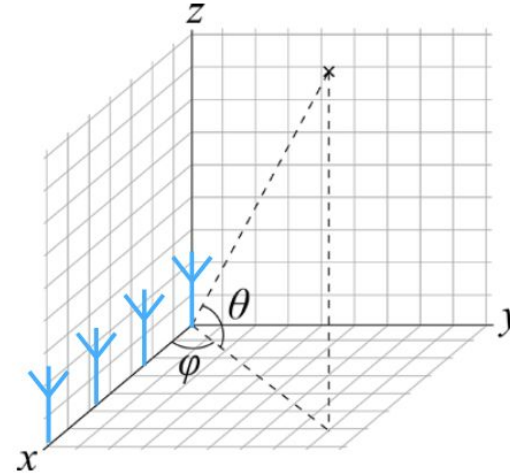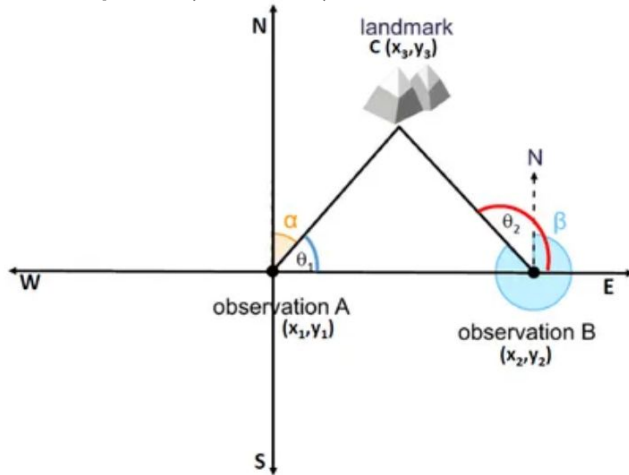
Interacting with drone: Control Interface

- ● PyQT5 GUI:

  - ○ Send control signals

  - ○ Display drone locations

  - ○ All control types available

Drone Control Interface

DroneID

ARM

DISARM

LIFTOFF

LAND

FWD/BACK

LEFT/RIGHT

CLIMB/DSND

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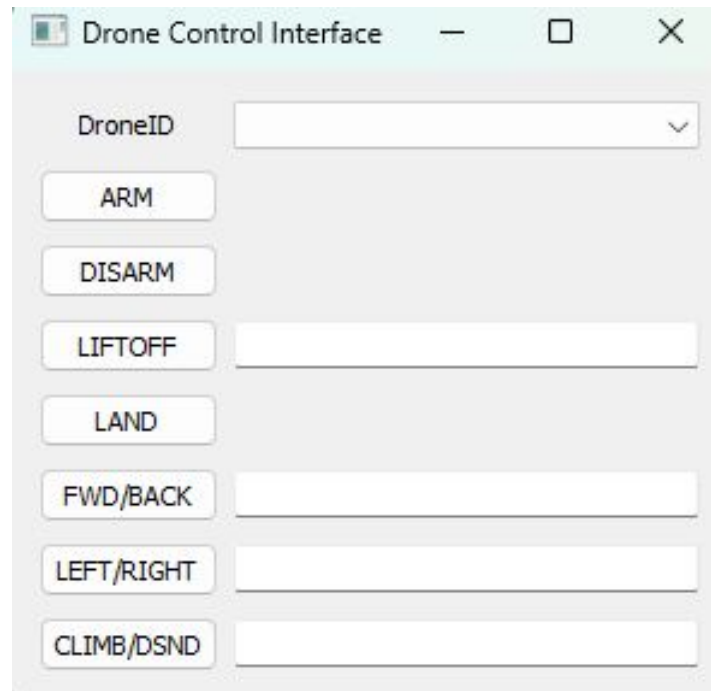
Technical Design (Controls)

Drone Movement Control
- Uses built in commands for movement
- Loops until drone within 20cm radius
- Keeps final location contained in 20cm radius

Location Refinement
- Multiple location values (after triangulation) averaged throughout time

+ THROTTLE

- THROTTLE

-PITCH

+ PITCH

+ ROLL

- ROLL

Progress Updates

- Major change: Drone system now based on DJI Tello instead of Seeed

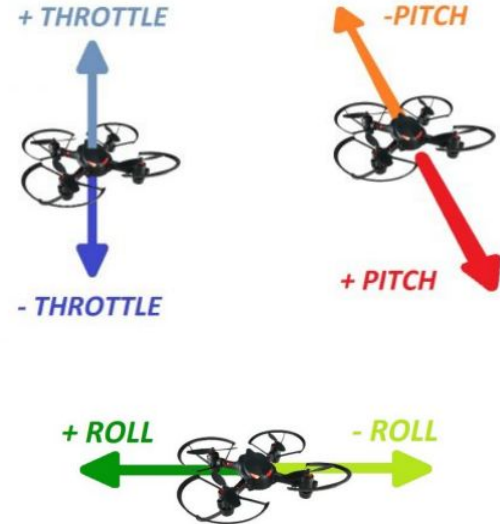| Task description	Start date	Finish date	Progress	11/7/2022	December 2022 12/1/2022	January 2023 1/1/2023	February 2023 2/1/2023	March 2023 3/1/2023	April 2023 4/1/2023
Milestone 1 - Hardware Procurement	Nov 14, 2022	Nov 25, 2022	100%	= = =					
Milestone 1.5 (Demo)	Nov 21, 2022	Dec 2, 2022	100%	=	= =				
Milestone 2 - Seeed BLE Connection & Localization	Nov 26, 2022	Dec 23, 2022	97%		= = = = =				
Localization of BLE modules using AOA Arrays	Nov 26, 2022	Dec 23, 2022	90%		= = = = =				
Milestone 3 - Single Drone System	Dec 23, 2022	Apr 10, 2023	54%		= = = = = = = = = =				
Communication between drone, AOA array and GCS	Dec 23, 2022	Feb 1, 2023	90%		= = = = = = =				
DJI Tello System	Mar 9, 2023	Mar 19, 2023	30%					=	
AOA accuracy of drone location is within 20cm	Mar 20, 2023	Apr 10, 2023	0%						
Milestone 4 - Multiple Drone System	Feb 1, 2023	April 10, 2023	0%						
Complete working system with 2 drones	Feb 1, 2023	March 15, 2023	0%						
Overflow for milestone 4	Mar 16, 2023	Apr 10, 2023	0%						
Milestone 5 - Design Fair	Apr 10, 2023	Apr 12, 2023	0%						

Conclusions

- Difficulties Experienced:
  - Ordering additional parts late into the semester (i.e IMU, EEPROM, DJI Tello)
  - Realizing capabilities of BLE/AOA products were not as expected
    - Drone microcontroller, uBlox AOA boards
  - Late changes: using a pre-existing drone instead of building a custom drone

thanks for listening!