The Hazard Harbinger

Team 12 - Julia Hua / Noah Cherry / Timothy Borunov / Abdulaziz AlMailam

SICK
Sensor Intelligence.

BOSTON UNIVERSITY
ECE DEPARTMENT

ARROW

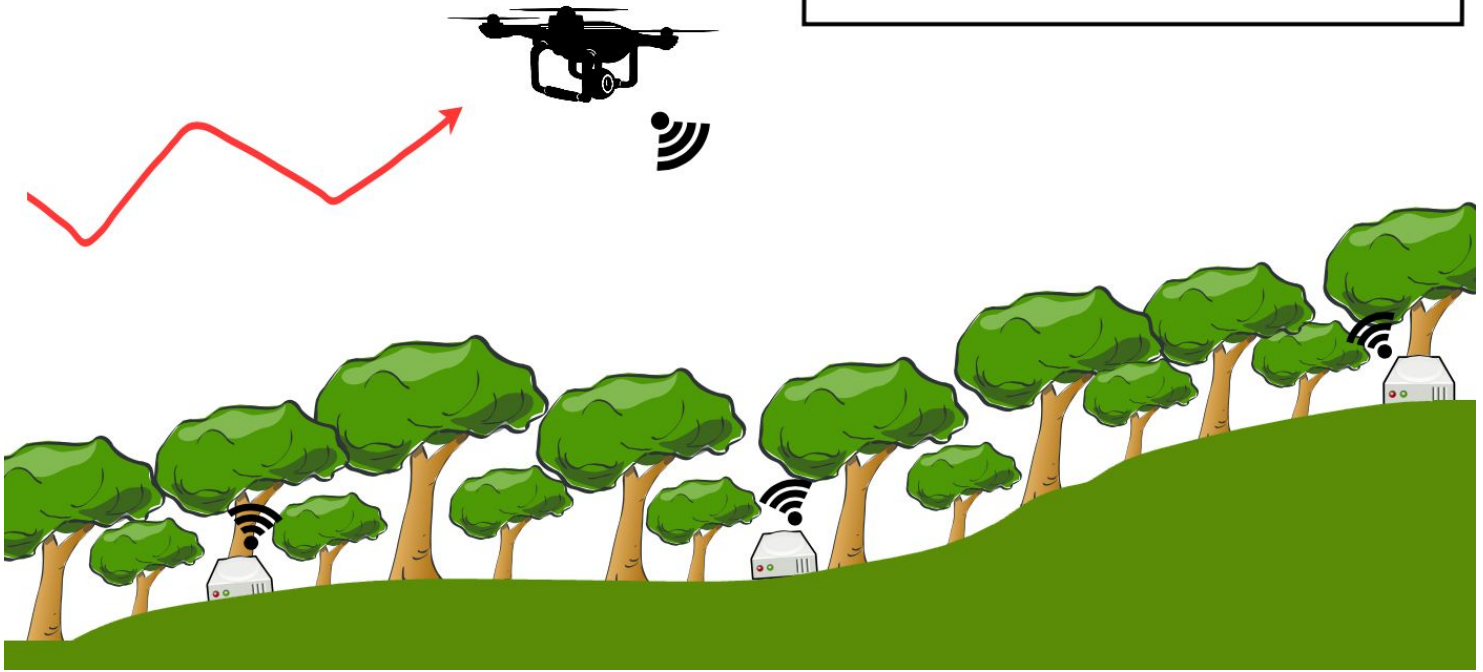
Introduction

- Problem: increasing frequency and intensity of wildfires
- Mitigation strategy: **controlled burning**
- Controlled burning mimics natural fires.
  - Reduces dead and dense vegetation
  - Create firebreaks
  - Improve ecosystem health
- How do land managers plan for controlled burning? Lots of data about the forest environment

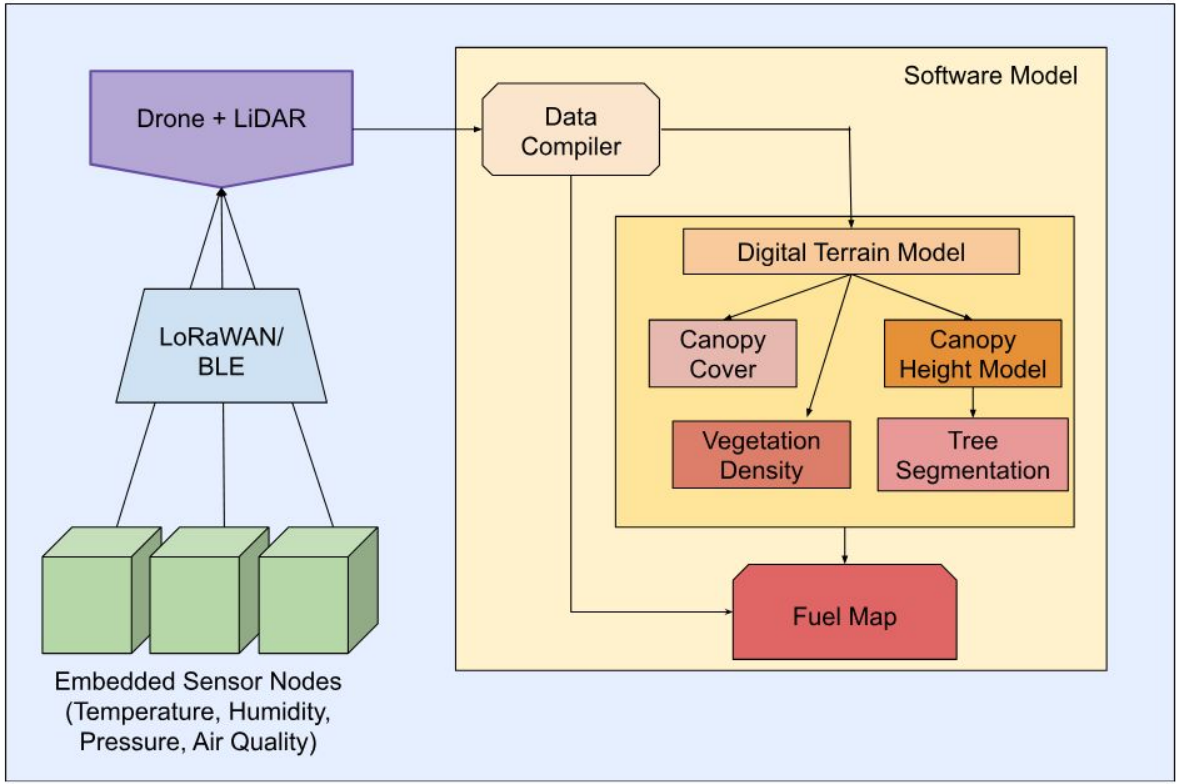
Requirements

- Embedded Sensor Nodes
  - Temperature, Humidity, Pressure
  - Index for Air Quality (IAQ), Biogenic Volatile Organic Compounds (bVOC) equivalents (ppm), CO_2 equivalents (ppm)
- Airborne LiDAR System (ALS)
- 3D Models
  - DTM and CHM
  - Identify number of tree clusters
  - Canopy Cover
  - Vegetation Density

System Visualization



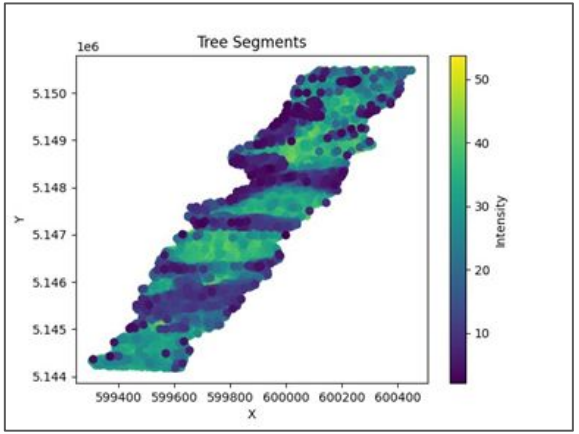
System Block Diagram



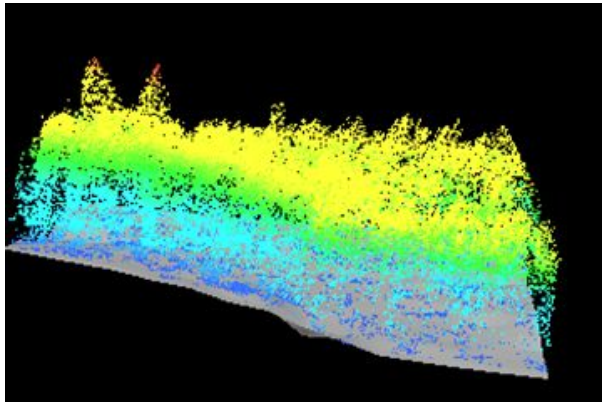
DTM, CHM, Tree Clusters

- Data: https://glihtdata.gsfc.nasa.gov/
- FUSION/LDV and LAStools libraries
  - DTM: GroundFilter and GridSurfaceCreate
  - CHM: CanopyModel
  - Tree Clusters: TreeSeg

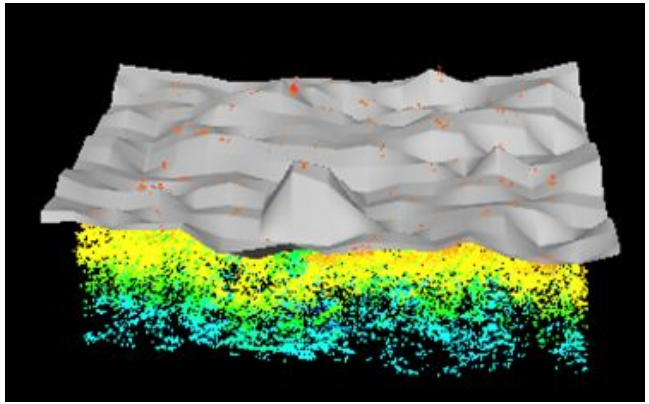
Identify Tree Clusters

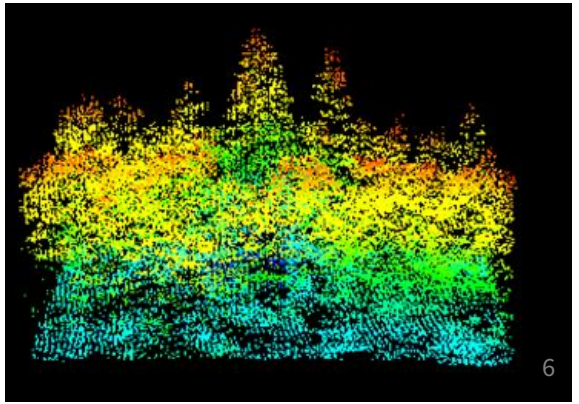


Digital Terrain Model



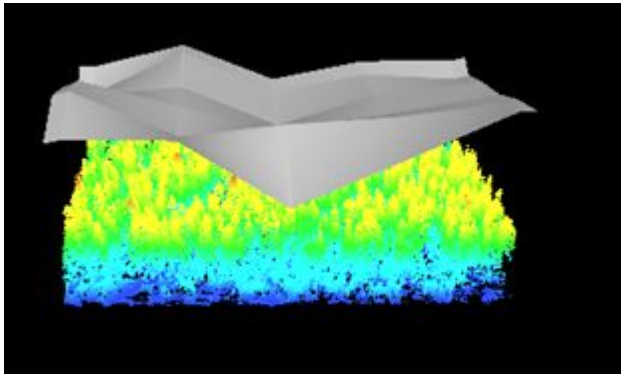
Canopy Height Model

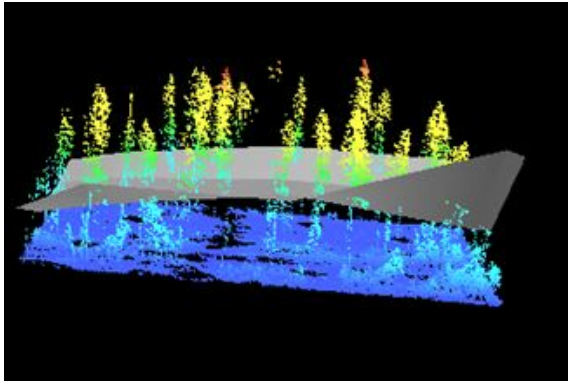


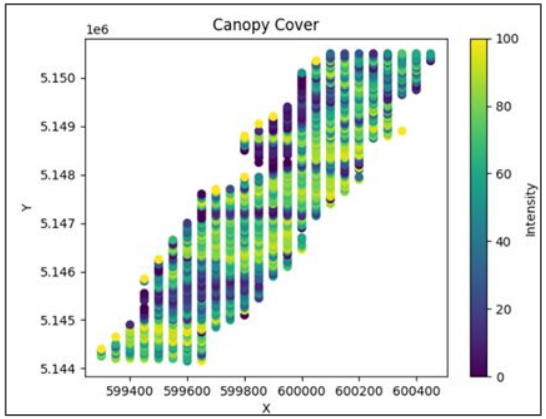


Canopy Cover

- FUSION/LDV library:
  - DTM2XYZ
  - Cover

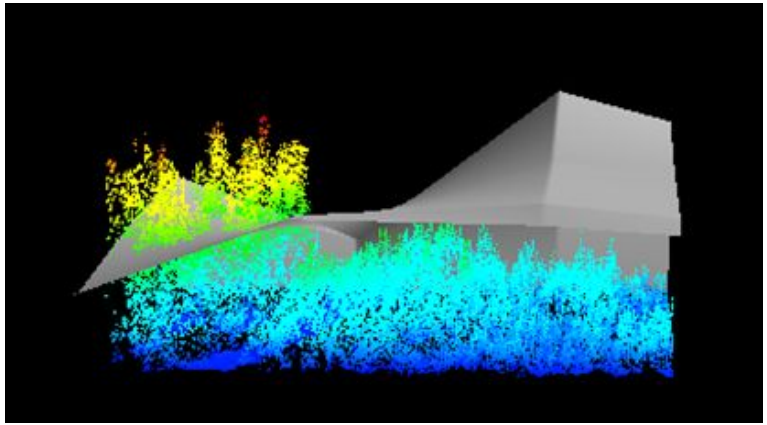




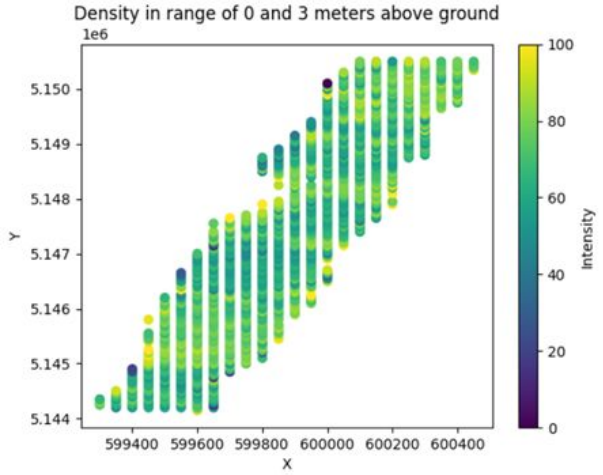


Vegetation Density at Different Height Stratas

- FUSION/LDV library:
  - DTM2XYZ
  - Cover



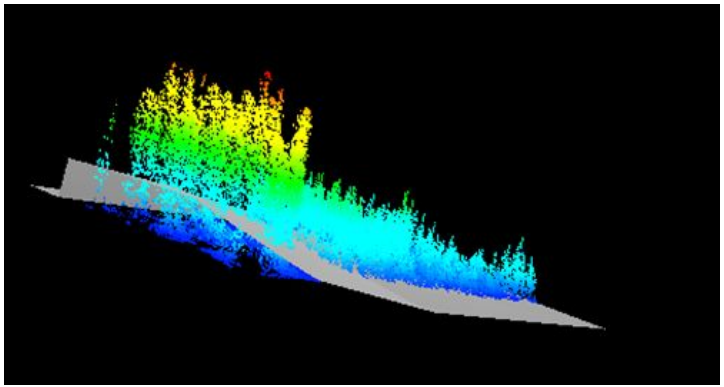
3-6 meters



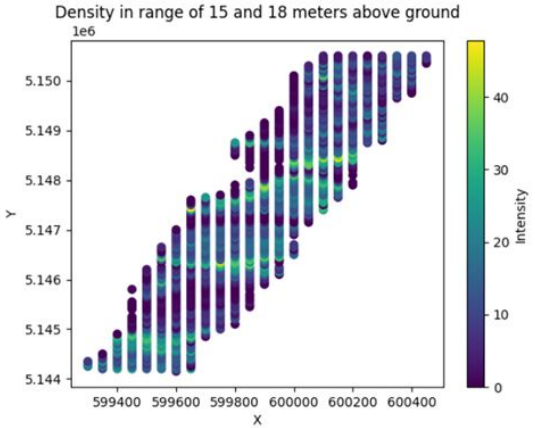
2D Visualization

Vegetation Density at Different Height Stratas

- FUSION/LDV library:
  - DTM2XYZ
  - Cover

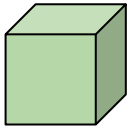


15-18 meters

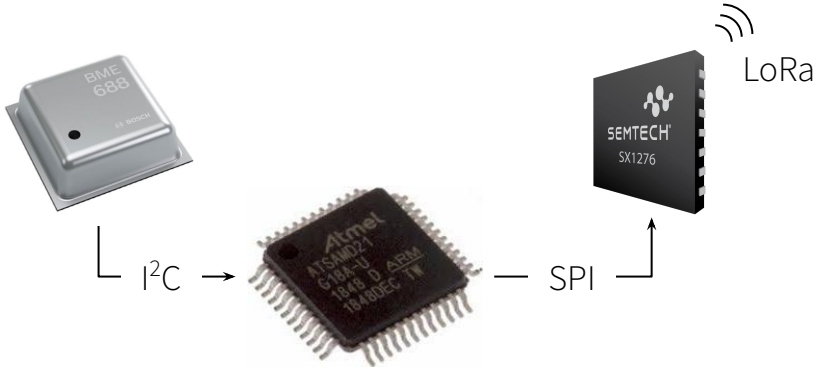


2D Visualization

Sensor Node Hardware



Embedded Sensor Nodes



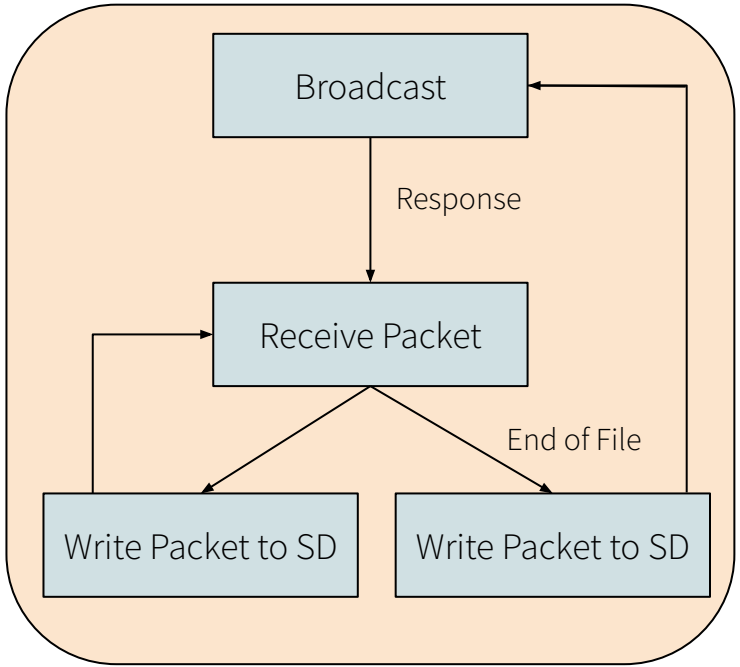
BME688 (Bosch Sensortec):

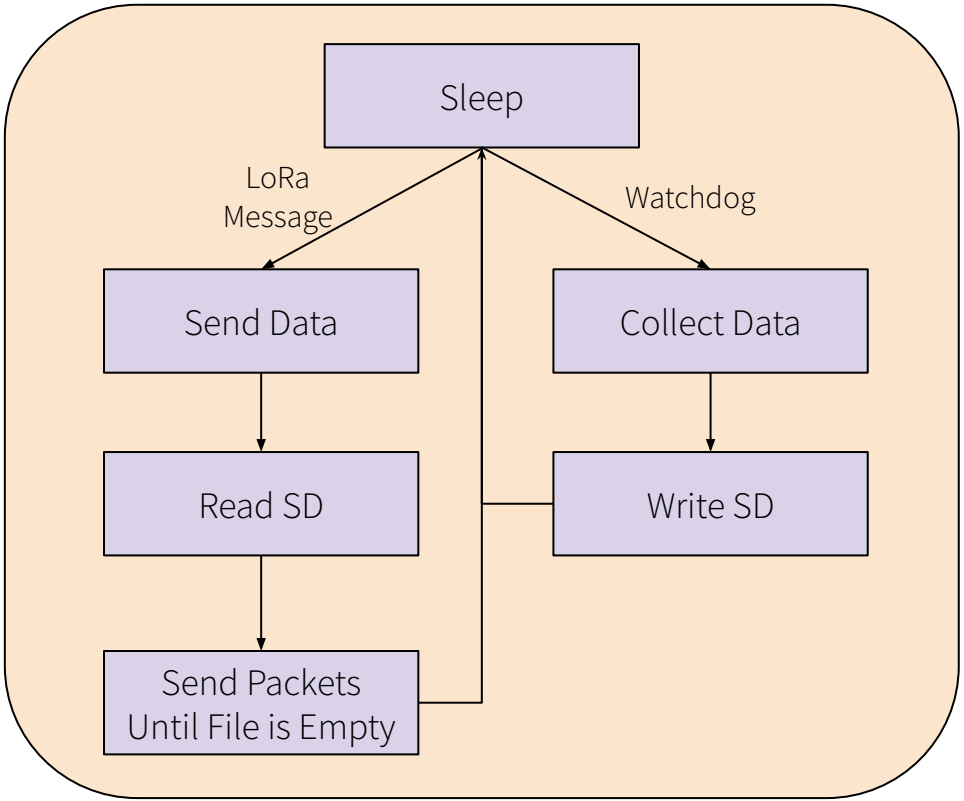
- Temperature (-40 – 85 °C, ± 3°C)
- Humidity (0 – 100 %, ± 3%)
- Pressure (300 – 1100 hPa, ± 0.25%)
- Gas (Raw Resistance of Heater kΩ) – Notable Outputs:
  - Index for Air Quality (IAQ)
  - Biogenic Volatile Organic Compounds (bVOC) (ppm)
  - CO_2 equivalents (ppm)
- Self-calibrating over a user-programmable interval
- Power consumption as low as 2.1 µA at 1 Hz sample rate

SAMD21G18A Pro RF:

- Semtech SX1276 transceiver with 1W amplifier
  - Integrated LoRa Capabilities
- Atmel SAMD21 MCU ARM Cortex-M0+ @ 48MHz
  - 256 KB Flash, 32 KB SRAM
  - I^2C, SPI, QSPI, UART
- 3.3V Integrated regulated output supply
- Power consumption <10µA in RTC-driven sleep

Sensor Node Flow of Operation





Sensor Node Next Steps

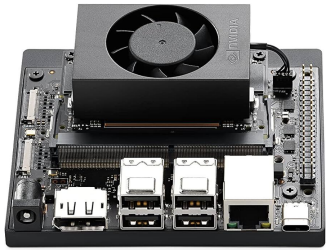
- Software
  - Modify RadioHead library source code to redirect LoRa interrupt
  - Implement interface to adjust data collection/sleep interval
- Hardware
  - Testing for weather resistant lining
    - Waterproof lining may not be necessary and will help reduce cost
  - Perfboard /PCB implementation

Drone Hardware

Drone + LiDAR/Data Collection

DJI Inspire 1 Pro V2

~22.8V LiPo Battery Supply



NVIDIA Jetson Orin Nano

Ubuntu w/ ROS1 Noetic

10W @ 5V - 20V

Ethernet

SICK multiScan100

360° LiDAR Scanner

7W @ 9V - 30V

Drone Hardware

Drone + LiDAR/Data Collection

DJI Inspire 1 Pro V2

~3.3V 2AA Battery Supply

SAMD21G18A (Atmel)

ARM Cortex-M0+ MCU

SPI

LoRa

SX1276 (Semtech)

LoRa Transceiver

Standard microSD Card

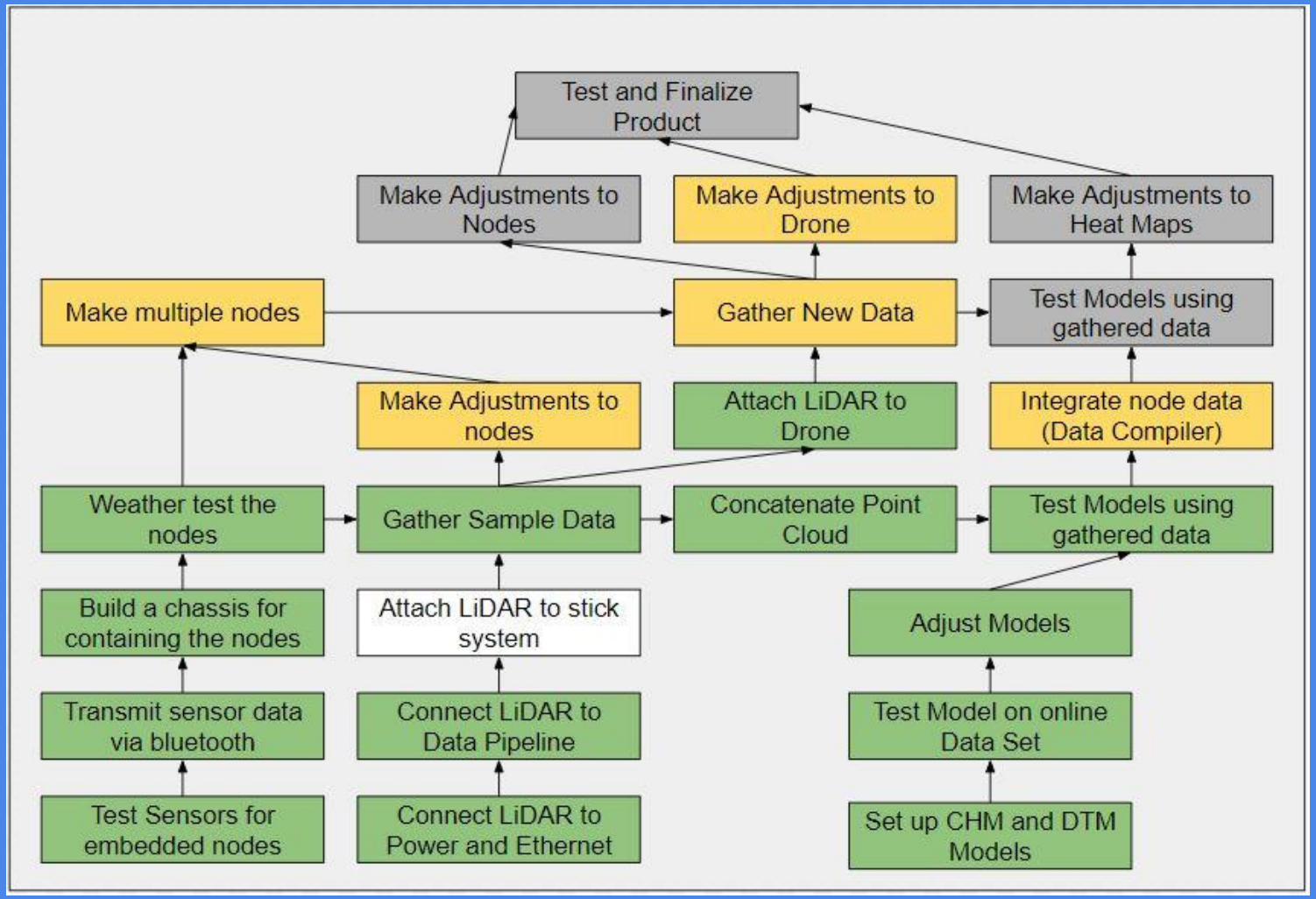
Larger capacity for collected data

Drone Software

- Drivers
  - We set up how to run a simulation using Rviz (ROS visual simulator)
  - Fullframe scan of the LiDAR is manipulable and processable
- Laser Scan Assembler
  - Assembles the fullframe scan based on fixed frame
  - Currently works on multiple scans of similar orientation of the LiDAR
  - Needs to be tested to make sure fixed frame works correctly

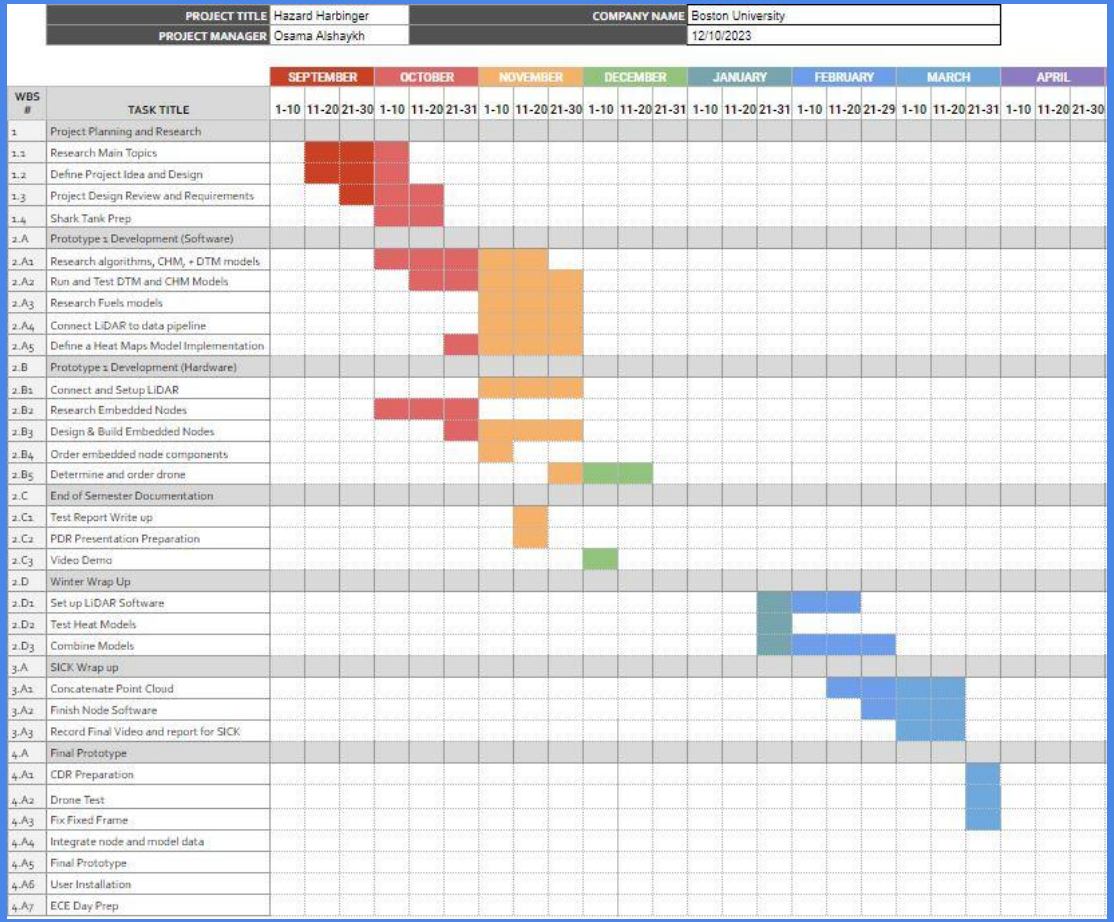
Progress so Far

- Software Models are done, including CHM, DTM, and tree segmentations
- Node prototypes for receiver and transmitter are complete and store all necessary data
- Drone node capable of collecting data from sensor nodes
- LiDAR is operational and has been mounted on the drone with an operable small computer powered by a common energy supply
- Software to convert LiDAR data to format usable by models is also complete and has been tested
- End to end completion has been achieved, however not fully automated.
- Video and report to SICK USA has been produced and sent last week


Test and Finalize Product
Make Adjustments to Nodes
Make Adjustments to Drone
Make Adjustments to Heat Maps
Make multiple nodes
Gather New Data
Test Models using gathered data
Make Adjustments to nodes
Attach LiDAR to Drone
Integrate node data (Data Compiler)
Weather test the nodes
Gather Sample Data
Concatenate Point Cloud
Test Models using gathered data
Build a chassis for containing the nodes
Attach LiDAR to stick system
Adjust Models
Transmit sensor data via bluetooth
Connect LiDAR to Data Pipeline
Test Model on online Data Set
Test Sensors for embedded nodes
Connect LiDAR to Power and Ethernet
Set up CHM and DTM Models

Gantt Chart of progress so far

PROJECT TITLE	Hazard Harbinger	COMPANY NAME	Boston University
PROJECT MANAGER	Osama Alshaykh		12/10/2023

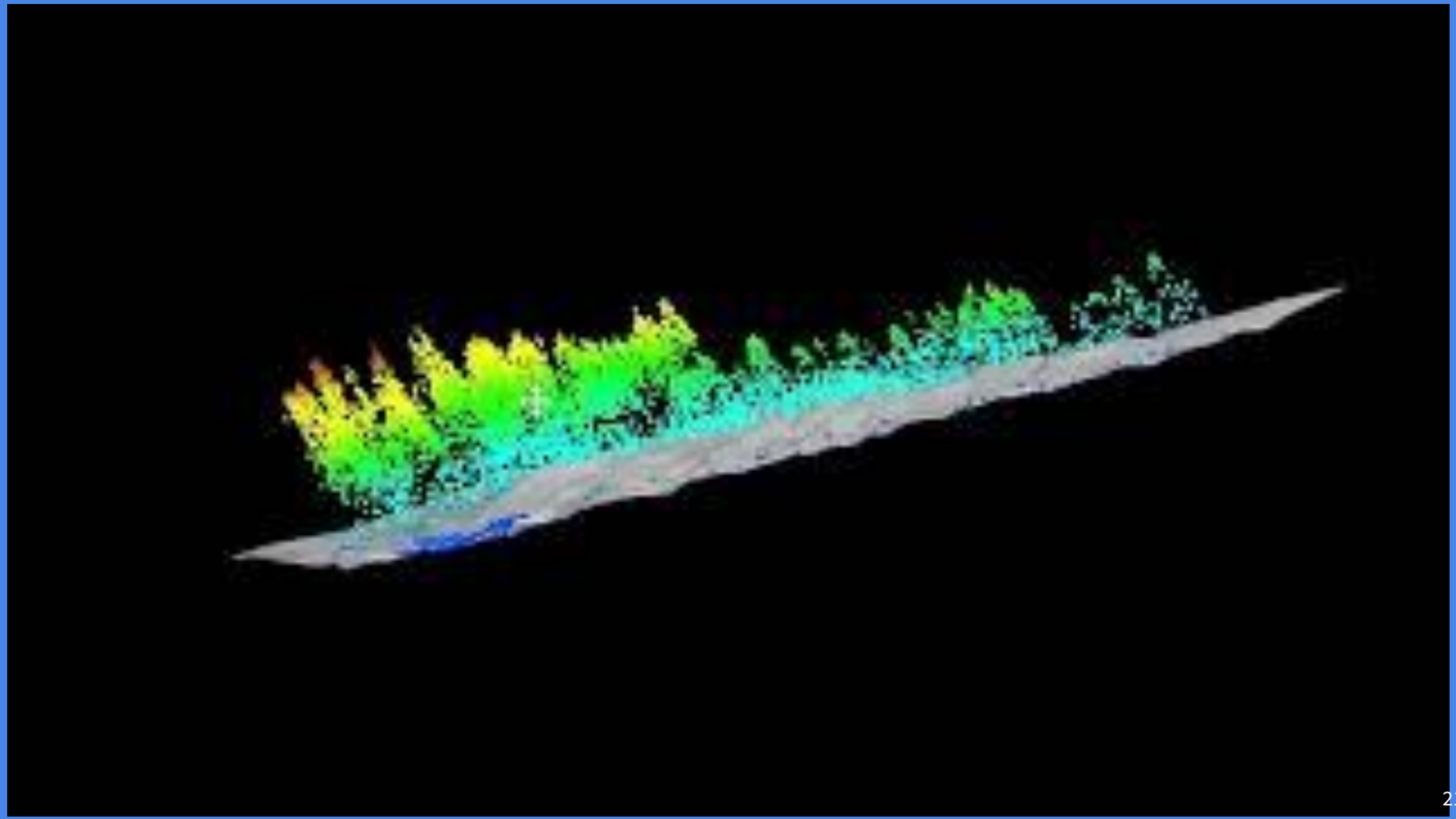


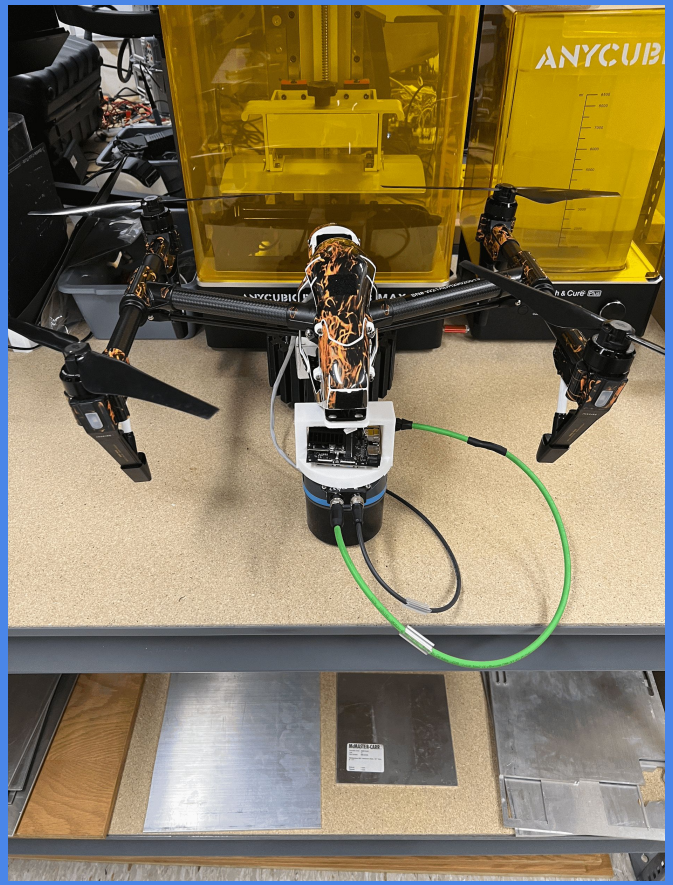
WBS #	TASK TITLE
1	Project Planning and Research
1.1	Research Main Topics
1.2	Define Project Idea and Design
1.3	Project Design Review and Requirements
1.4	Shark Tank Prep
2.A	Prototype 1 Development (Software)
2.A1	Research algorithms, CHM, + DTM models
2.A2	Run and Test DTM and CHM Models
2.A3	Research Fuels models
2.A4	Connect LiDAR to data pipeline
2.A5	Define a Heat Maps Model Implementation
2.B	Prototype 1 Development (Hardware)
2.B1	Connect and Setup LiDAR
2.B2	Research Embedded Nodes
2.B3	Design & Build Embedded Nodes
2.B4	Order embedded node components
2.B5	Determine and order drone
2.C	End of Semester Documentation
2.C1	Test Report Write up
2.C2	PDR Presentation Preparation
2.C3	Video Demo
2.D	Winter Wrap Up
2.D1	Set up LiDAR Software
2.D2	Test Heat Models
2.D3	Combine Models
3.A	SICK Wrap up
3.A1	Concatenate Point Cloud
3.A2	Finish Node Software
3.A3	Record Final Video and report for SICK
4.A	Final Prototype
4.A1	CDR Preparation
4.A2	Drone Test
4.A3	Fix Fixed Frame
4.A4	Integrate node and model data
4.A5	Final Prototype
4.A6	User Installation
4.A7	ECE Day Prep

Schedule for Last Steps

- Next Week
  - Test flight the drone to collect data outside and not just in the lab
  - Make sure there are no issues with the fixed frame of the LiDAR reference
- April - Mainly testing and polish
  - Attach receiver node to drone to test mobile node data collection
  - *Add a user friendly method to begin scanning with drone*
  - *Automate conversion of data and representation in model view*
  - *Make the nodes less finicky when it comes to signal transmission*

Thank you!
Any questions?

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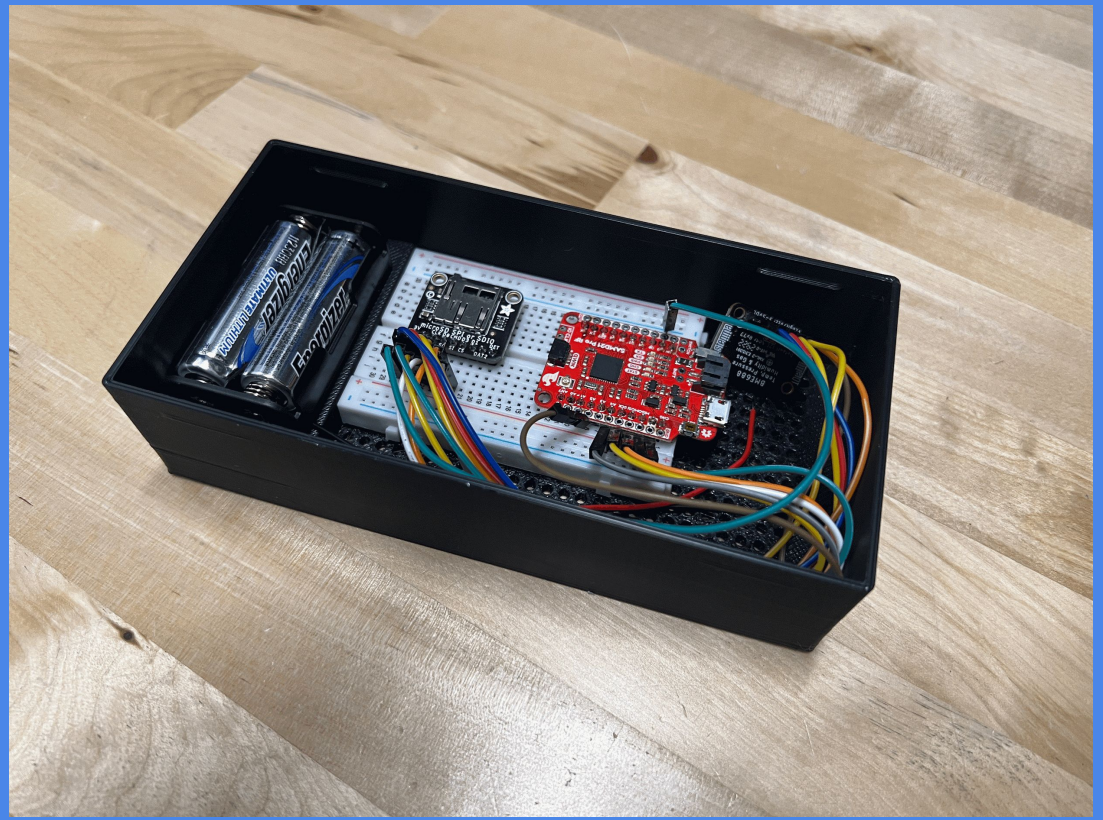
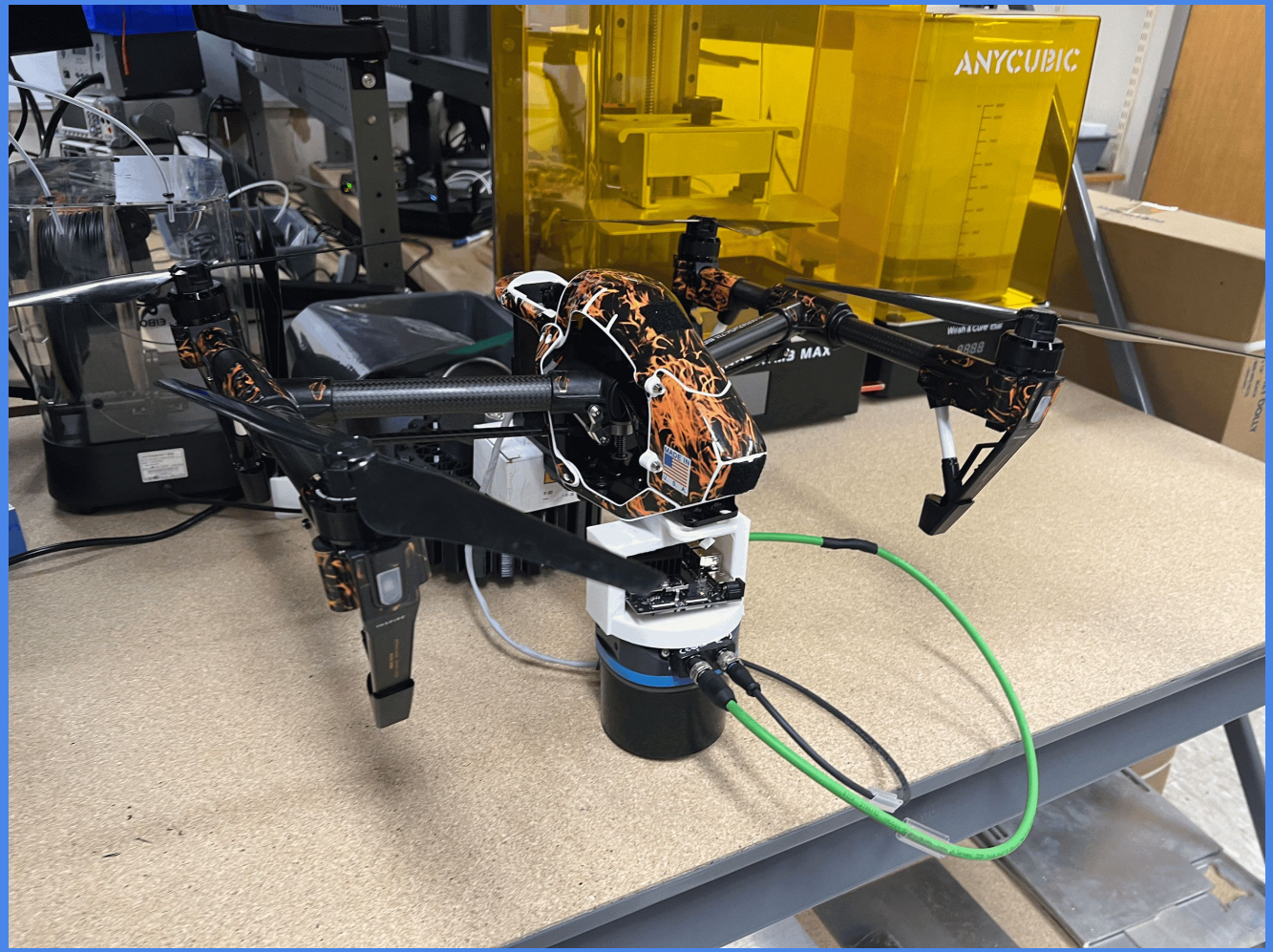

energizer
energizer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