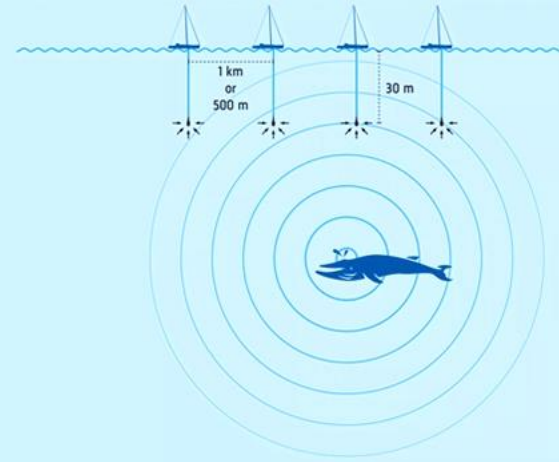




Université
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SAVOIR, C'EST POUVOIR

Localization and tracking of moving targets by hydrophones

MASTER ARTIFICIAL INTELLIGENCE AND ROBOTICS
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I21913

Agenda

- Introduction
- The tasks accomplished in the S1.
- The aim of the project S2.
- Localization Techniques
 - Sound localization and target
 - Design concept
 - Hardware Block Diagram
 - Live data in Matlab via Arduino (Experiment and Result)

Introduction

- **Localization and tracking of moving targets by hydrophones:** technique to determine position and motion in water through analysis of received sound signals.
- **Triangulation:** Placing hydrophone array at different locations to determine sound source position and track movement.
- **Localization and tracking process:**
 - Signal processing: Filtering, analysis, and feature extraction from acoustic signals.
 - Acoustic modeling: Estimating acoustic propagation properties of underwater environment.
 - Numerical methods: Beamforming and time delay estimation for direction and time difference of arrival estimation.

The tasks accomplished in the S1.

- Research delves into the comprehensive exploration of hydrophones, encompassing their characteristics, technologies, and wide-ranging applications.
- The methodology utilized for the localization and tracking of a target. (*Triangulation technique with 3 hydrophones*)
- The implementation involves establishing the structure and determining which algorithms to use.

The aim of the project S2.

WHAT?



To accurately identify the source location of a sound.

WHERE?



In a spatially segmented environment.

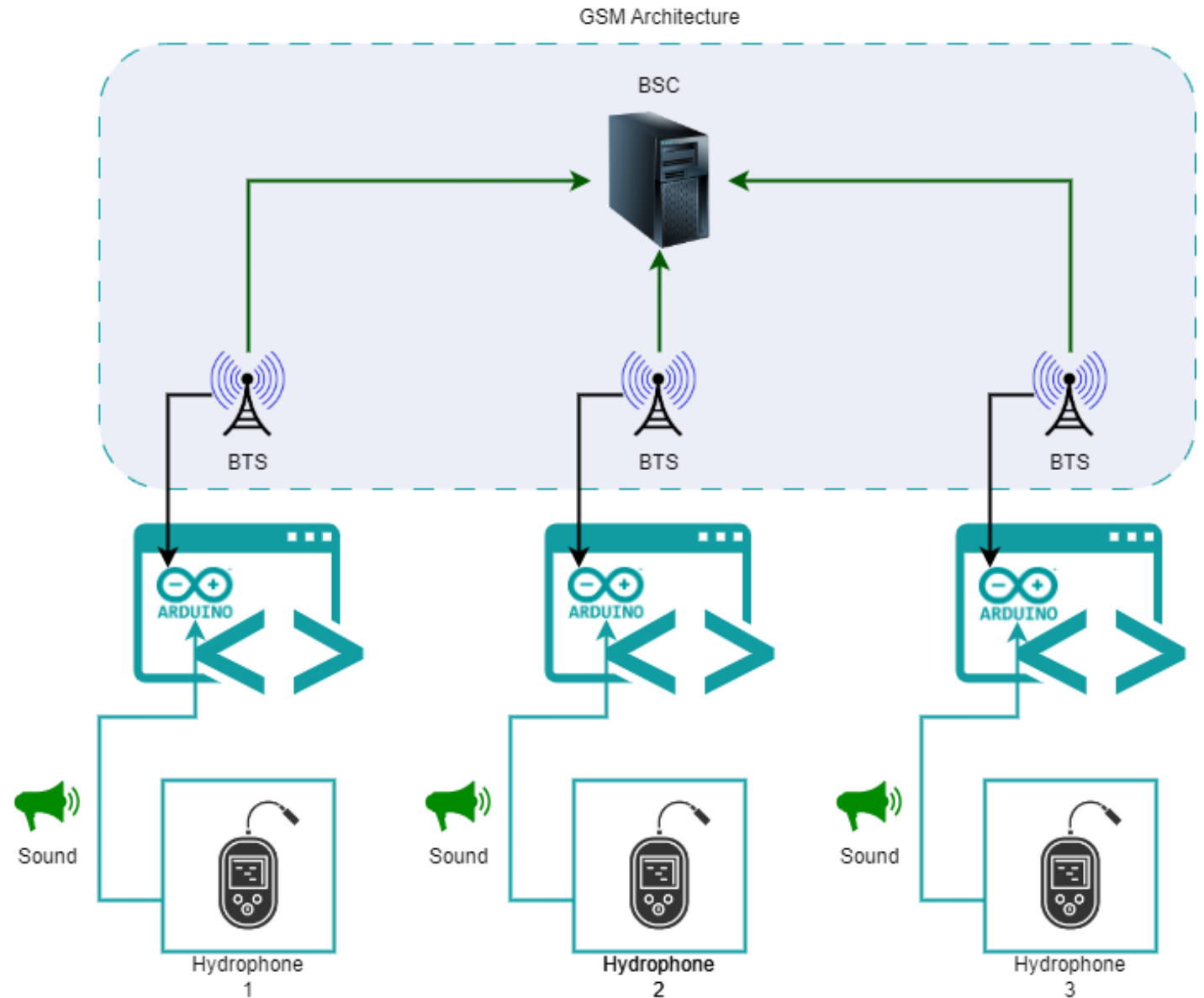
HOW?



By employing hydrophones (*microphones used for experimental purposes*) and measuring the sound intensity.

Sound localization & target Prototype

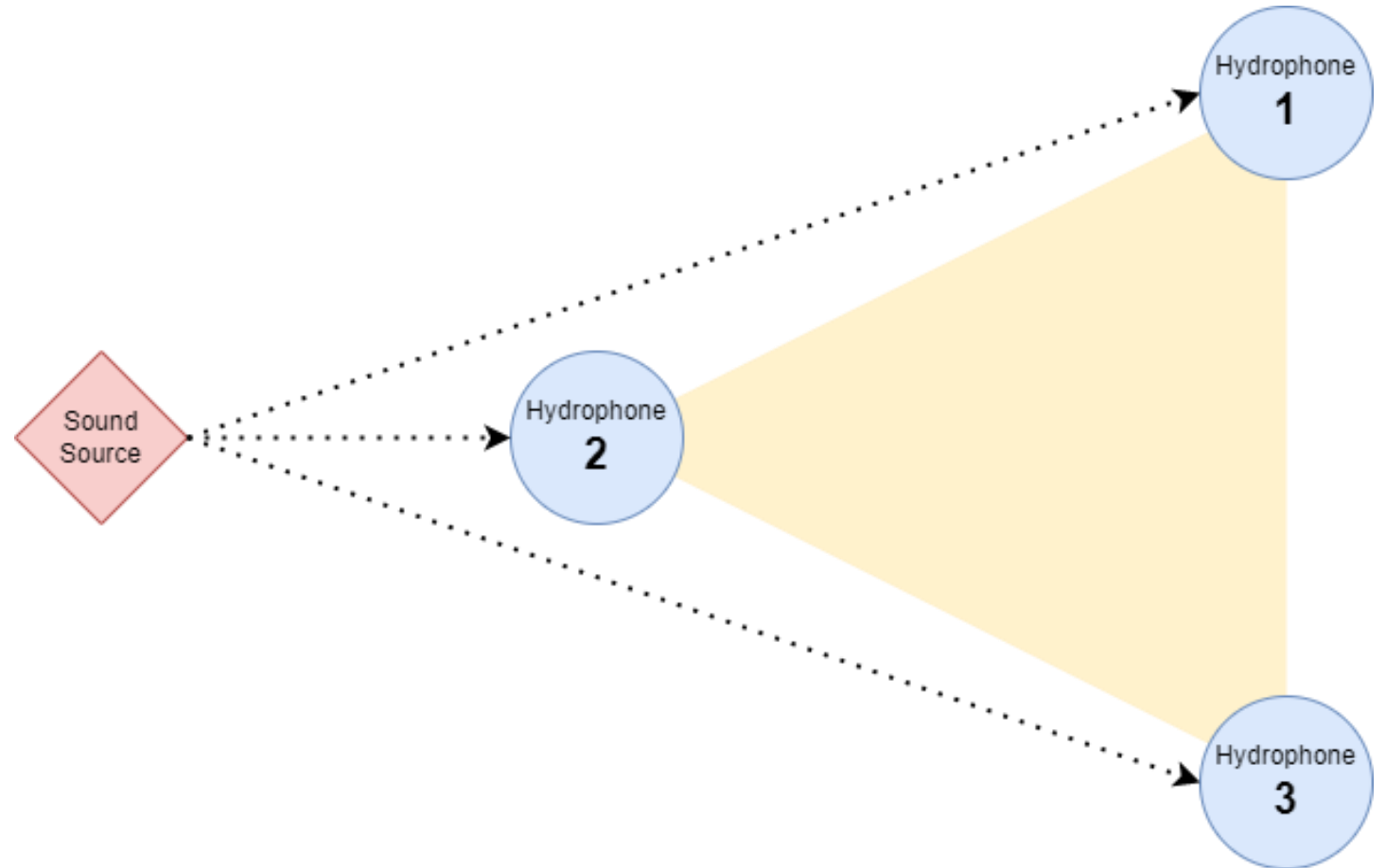
- Hydrophone Localization and Tracking System
- Data Transmission
- GSM Module Integration
- Remote Monitoring and Control
- Data Management and Analysis



Sound localization & target Design Concept

Important Note:

Sound localization based on an acoustic source using **multiple microphone array** (instead **hydrophone array**) in an indoor environment

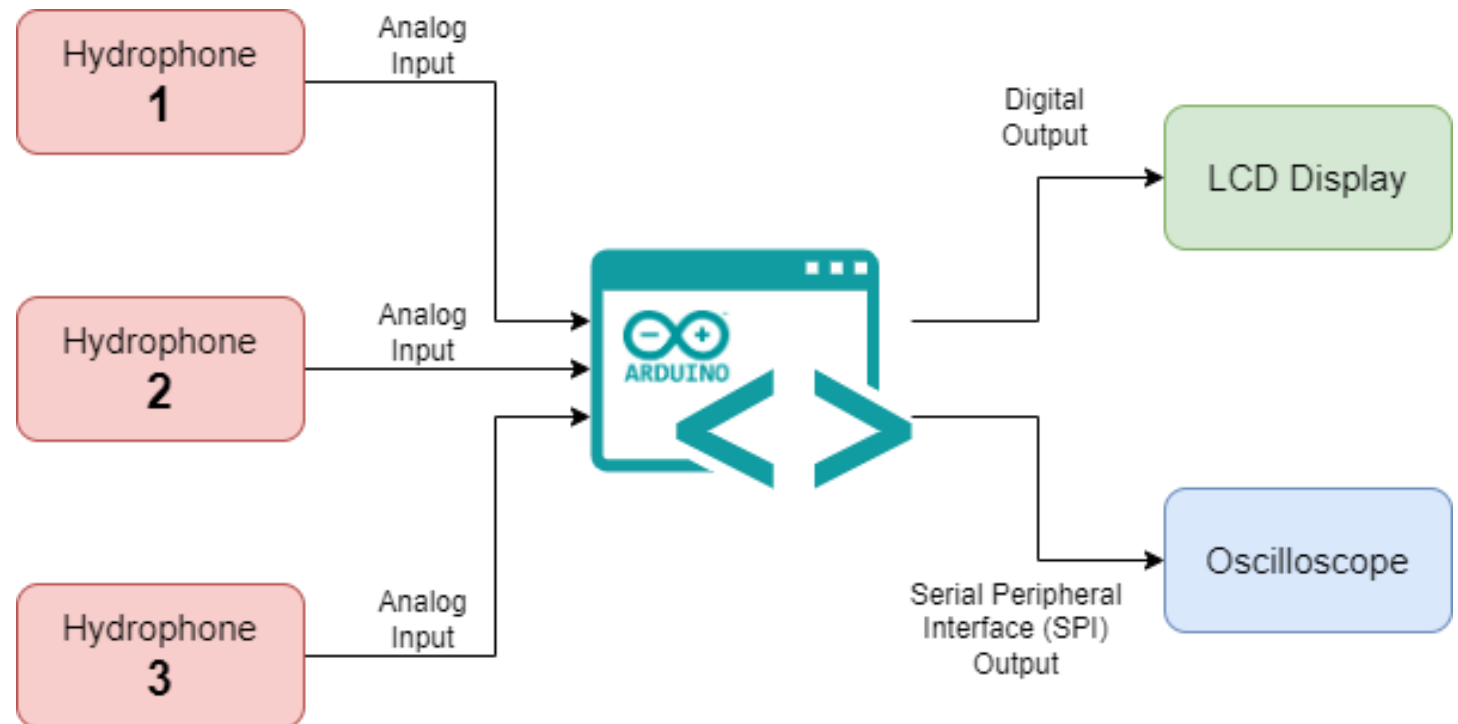


Sound localization & target

Hardware Block Diagram

Prerequisites:

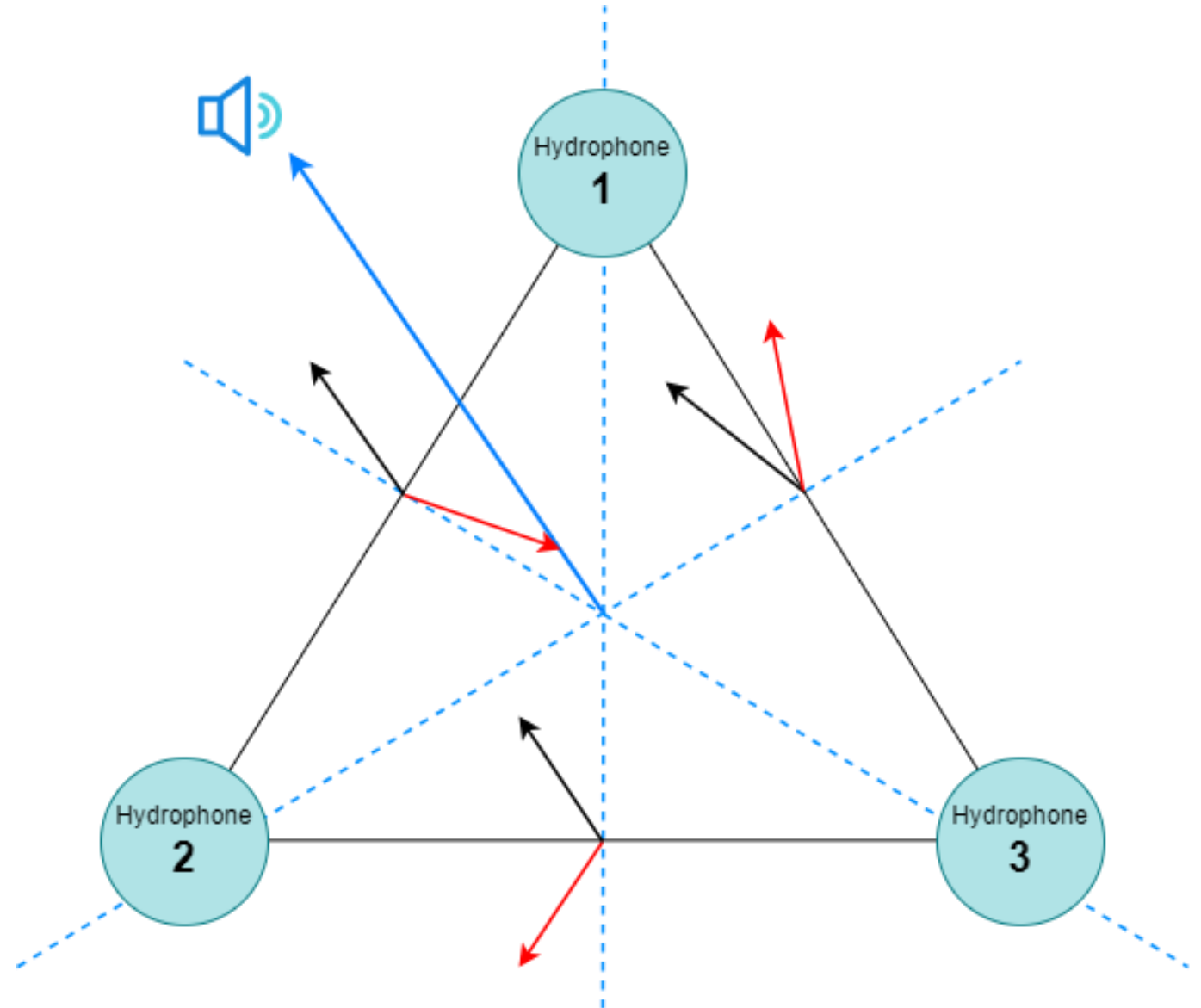
- **Arduino IDE**
- **MATLAB** for computation and demonstration
- Calibration process of the **microphones** (instead **hydrophones**)



Sound localization & target

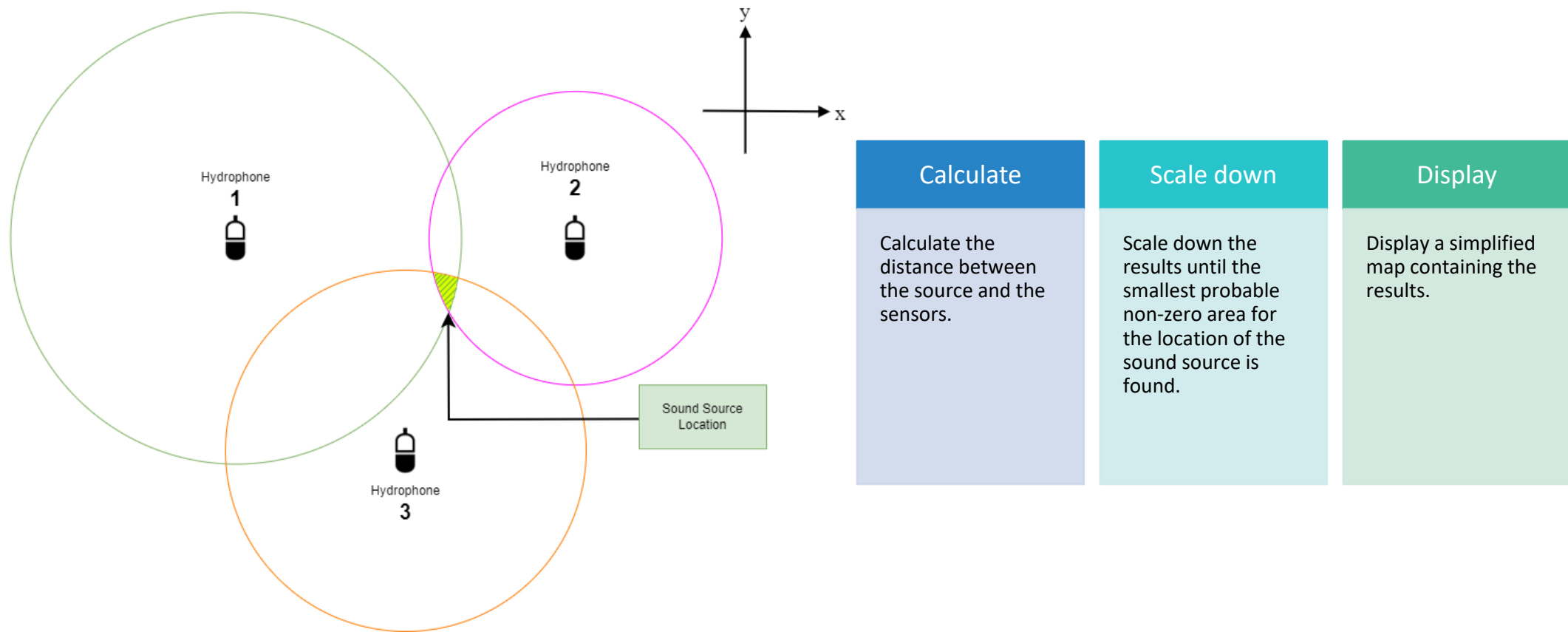
Mathematical technique

- Cross-correlation technique.
- To compute the time delay between two signals.



Sound localization & target

The approach



bull1.ino

launch.json

```

78 int mic3val = analogRead(mic3);
79
80 // Calculate the time delay between microphones
81 int delay12 = calculateDelay(mic1val, mic2val);
82 int delay13 = calculateDelay(mic1val, mic3val);
83
84 // Calculate the time difference of arrival (TDOA) between microphones
85 float tdoa12 = (float)delay12 / 1000000.0 * soundSpeed;
86 float tdoa13 = (float)delay13 / 1000000.0 * soundSpeed;
87
88 // Calculate the x and y coordinates of the sound source using triangulation
89 float x = ((micPositions[0][0] - micPositions[1][0]) * (micPositions[0][0] + micPositions[1][0] + 2.0 * tdoa12) - (micPositions[0][0] - micPositions[2][0]) * (micPositions[0][0] + micPositions[2][0] + 2.0 * tdoa13)) / (4.0 * (micPos
90 float y = ((micPositions[0][1] - micPositions[1][1]) * (micPositions[0][1] + micPositions[1][1] + 2.0 * tdoa12) - (micPositions[0][1] - micPositions[2][1]) * (micPositions[0][1] + micPositions[2][1] + 2.0 * tdoa13)) / (4.0 * (micPos
91
92 // Calculate the distance between the sound source and each microphone
93 float distances[3];
94 for (int i = 0; i < 3; i++) {
95     distances[i] = calculateDistance(i, x, y, micPositions);
96 }
97
98 // Determine the nearest microphone
99 int nearestMic = 0;
100 float shortestDistance = distances[0];
101 for (int i = 1; i < 3; i++) {
102     if (distances[i] < shortestDistance) {
103         shortestDistance = distances[i];
104         nearestMic = i;
105     }
106 }

```

Output Serial Monitor x

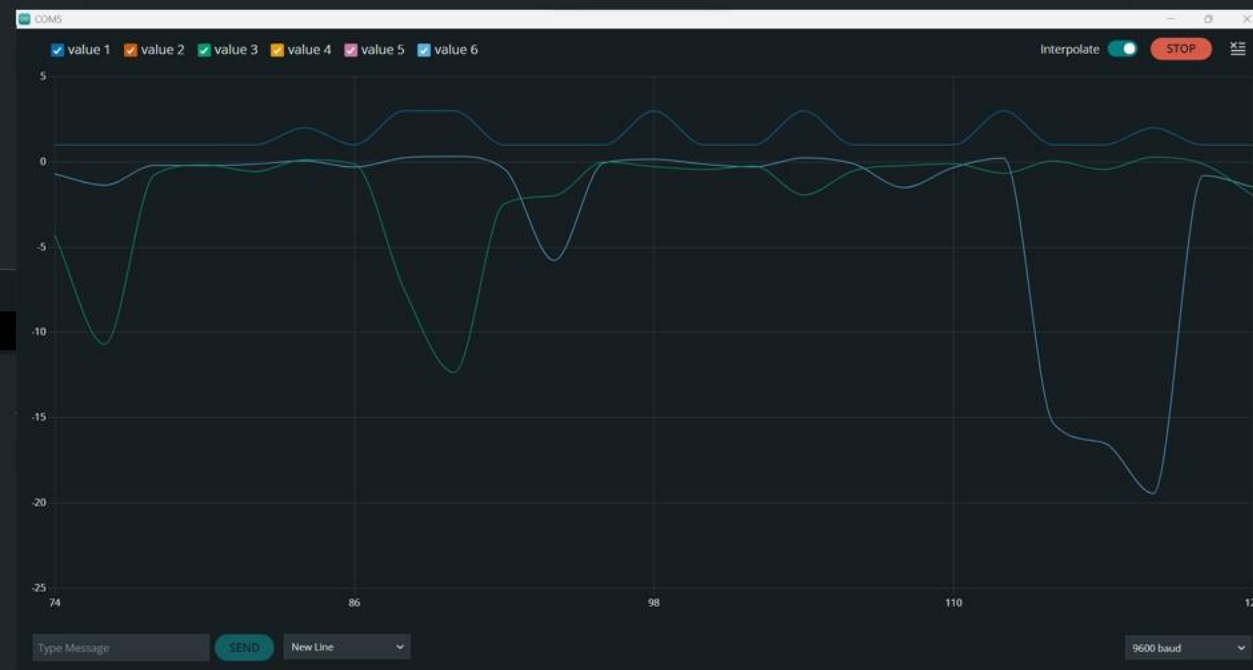
Message (Enter to send message to 'Arduino Uno' on 'COM5')

```

x = -4.18 y = -1.10
Nearest microphone: 1
x = -6.74 y = -3.34
Nearest microphone: 3
x = -3.62 y = 0.25
Nearest microphone: 1
x = -6.17 y = 0.25
Nearest microphone: 1
x = -3.56 y = 0.25
Nearest microphone: 2
x = 11.35 y = 0.24
Nearest microphone: 1
x = -3.24 y = 0.24
Nearest microphone: 1
x = -5.21 y = 0.25

```

Emit a sound anywhere on the grid panel.



New Session

Libraries

I2C

SPI

CONFIGURE

Workspace Variable:

Duration(s):

Record

Signal Analyzer

Generate Script

Export Log

Close Session

RECORD ANALYZE EXPORT CLOSE

Device List

All Hardware

ramphul's Arduino Uno



Board: Uno
Connection: USB
Port: COM5

Pin Explorer

Show Pins: ☒ All ☐ Analog ☐ Digital ☐ In use

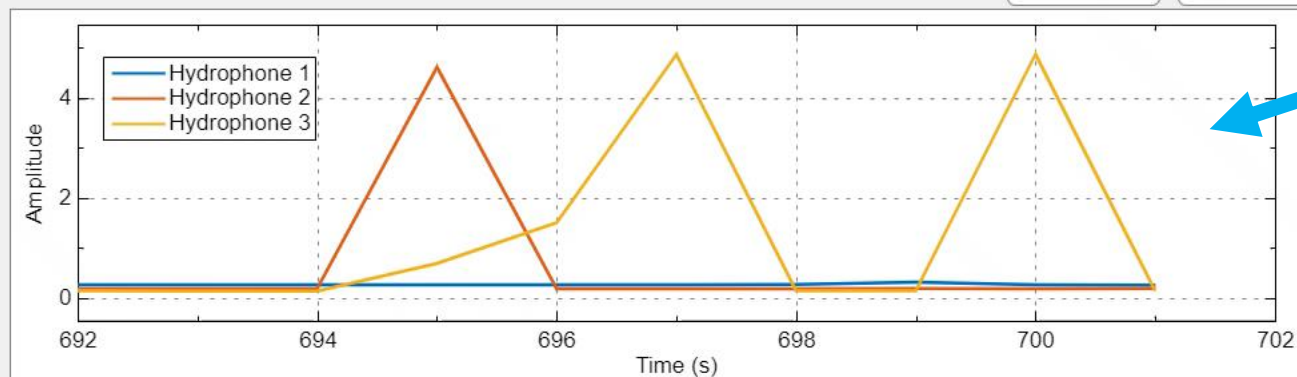
Pin	Mode	Read Value	Write Value	Record Pin	Label
A0	AnalogInput	0.25904 V		<input checked="" type="checkbox"/>	Hydrophone 1
A1	AnalogInput	0.19062 V		<input checked="" type="checkbox"/>	Hydrophone 2
A2	AnalogInput	0.14174 V		<input checked="" type="checkbox"/>	Hydrophone 3
A3	Unset				
A4	Unset				
A5	Unset				
D2	Unset				
D3	Unset				
D4	Unset				

Pin Configuration

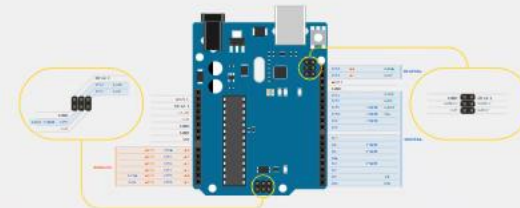
Select a pin in the table to configure

Plot

Log



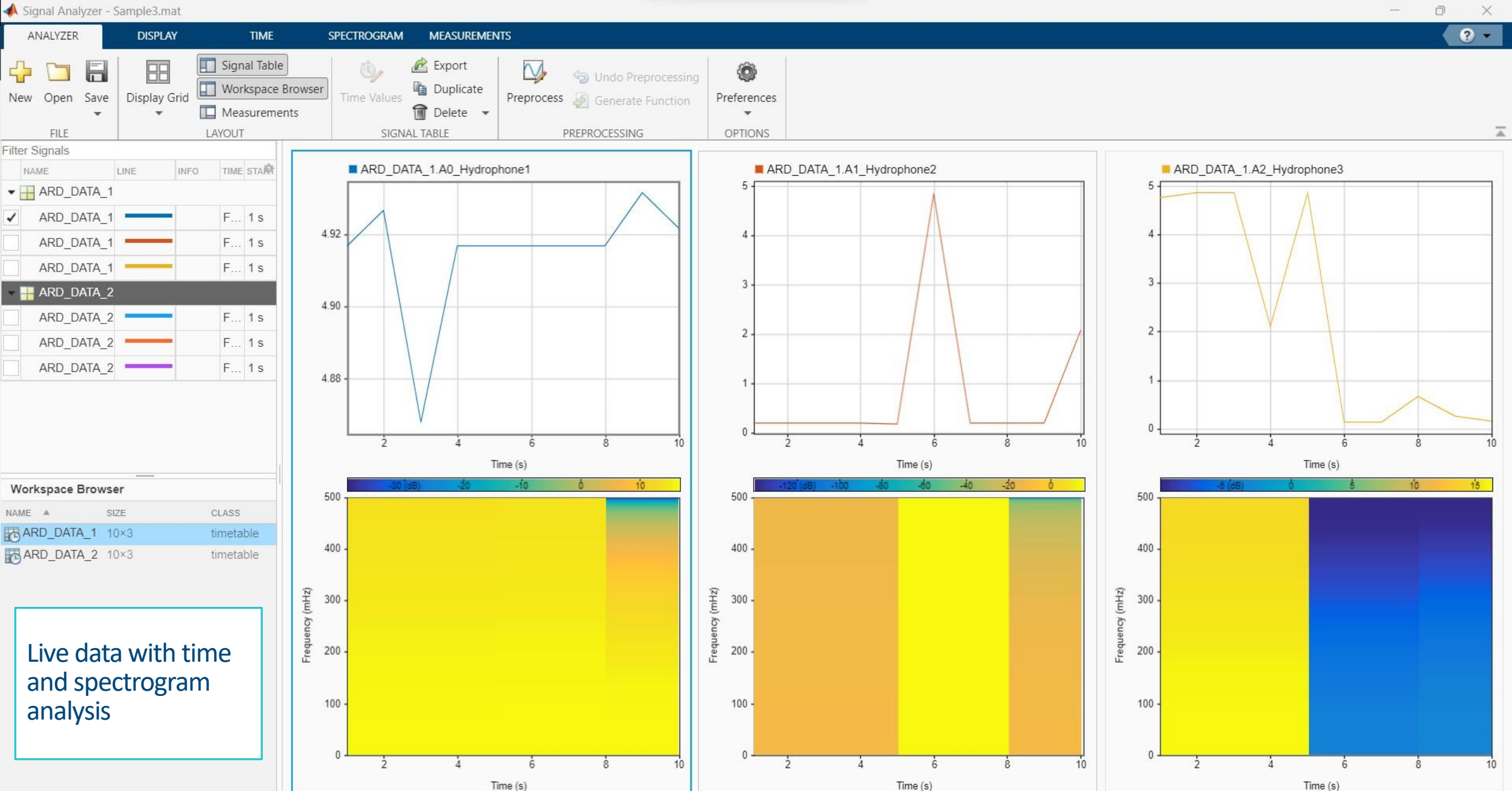
Pinout



Click to finish recording. Don't show this again.

Obtain live data about the sound intensities of the 3 microphones.

Data saved to MATLAB workspace variable "ARD_DATA_1"



Further development



Better performing hardware.



An uninterrupted process.



Positioning microphones
further away.

Conclusion

- Understanding the principles of target localization and tracking has been achieved.
- The algorithm operates within a limited space using the triangulation method with a basic algorithm.
- This approach can yield greater efficiency when employed with recommended equipment and in an appropriate environment.
- Overall, this project has provided valuable insights and expanded knowledge in various aspects of the field.

THANK YOU

