

**ENGN 8170 Handover Document**

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# Introduction

This project aims to develop a sonar system capable of measuring underwater range to three beacons, expanding on existing hardware that supports one beacon.  The project involves upgrading the system, programming a microprocessor for precise timing, validating performance through experiments, and implementing a real-time data collection system integrating ranging signals, RTK-GPS, and IMU, mounted on a boat.

# Project Overview

## Project Vision and Mission Statement

To develop a multi-beacon communication and localization system for aquatic environments that allows robust signal transmission and master beacon tracking.

## Project Context

This project was previously written by an undergraduate student, and we have made improvements based on him.

This system engineering project was carried out as part of a university course to apply theoretical knowledge into a practical, real-world problem. The project progressed from planning and conceptual design to testing and feedback.

## Value to Client

This project provides the client with a flexible and modular communication system prototype, capable of being adapted to various aquatic scenarios for further research. It facilitates testing of multi-beacon signal transmission methods and supports real-world feasibility studies. The modular design allows future teams to extend functionalities such as positioning algorithms, SLAM integration, or underwater deployments.

# Project Scope

The project focused on:

1. Designing and testing a communication protocol between a master beacon and multiple sub-beacons.
2. Evaluating algorithmic options for beacon coordination.
3. Implementing and validating the hardware communication setup.
4. Planning and preparing for real-world field testing on water.

Excluded from the current scope were full SLAM integration, long-distance signal transmission in unknown environments, and waterproofing hardware for deep water use.

# Stakeholders of project

## Contact with Stakeholders

Client: Rob is Providing project directions, feedback and technical guidance.

Technical Consultant: Arthur is supporting the construction of hardware debugging and testing platforms.

Stakeholders were contacted primarily through weekly meetings. Feedback and requirements were formally captured via meeting minutes, audit comments, and feedback plan documents.

# Team Governance and Documentation

## Team Structure

System Architect：Brian Ma

Documentation Lead：Xingyu Luan

Testing Coordinator：Yoyo Lam, Brian Ma

Landing Page：Xiang Peng

Validation: Xiang Peng, Xu Ben, Yifan Wu

Test Plan: Yuqiao Xin

## Meetings

Weekly team meetings were conducted to track progress, assign tasks, and discuss decisions. Each meeting was documented with Meeting minutes.

# Project Repository

GitHub: Used for version control and code sharing.

OneDrive: Used for collaborative editing of documents and sharing diagrams.

Repository Structure:

Code is for Algorithms, communication scripts, and PC simulation.

Docs is for Meeting minutes, feedback plans, risk log and so on.

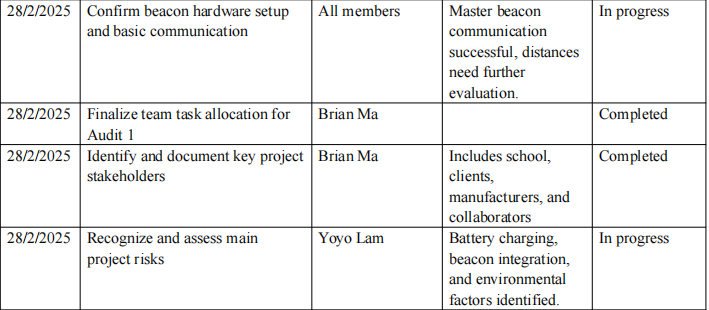
Concept is for design sketches, diagrams, system architecture files.

# Decision and Risk Logging



In the early stage of the project, our team established the key task allocation for each member in the first meeting, such as project management, engineering development, etc., to ensure the efficiency of task advancement. Subsequently, a GitHub version control repository was established for code collaboration.

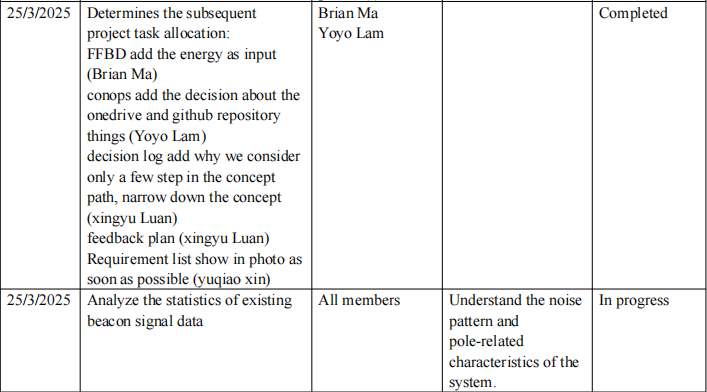
The decisions made at this stage have laid a solid foundation for the orderly development of subsequent work.

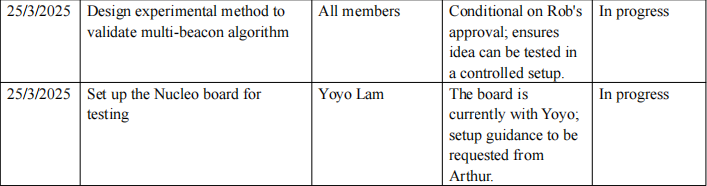


In the second meeting, we made several decisions related to technical directions and risk control:

The basic communication of the beacon hardware was successfully achieved, paving the way for the subsequent signal test. The key stakeholders of the project (schools, customers, hardware suppliers, etc.) have been identified; The main risk points were identified, such as battery life, the difficulty of beacon integration and the influence of environmental factors, and the mitigation plan was formulated led by Yoyo Lam.

These decisions enable us to manage potential risks in advance.

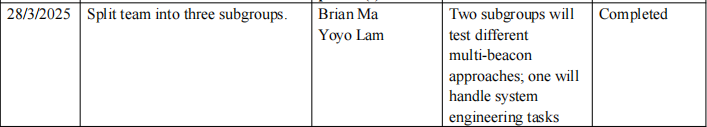


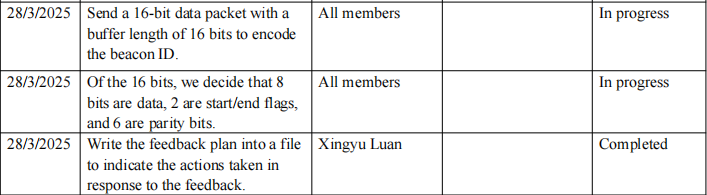


In the mid-term stage, we focus on the path of algorithm innovation and verification:

The team proposed a multi-beacon communication scheme without modifying the hardware conditions, such as: control signal transmission/non-transmission, gain adjustment or ID encoding; Meanwhile, the experimental verification route was planned, including how to build a controllable verification environment after Rob's approval;

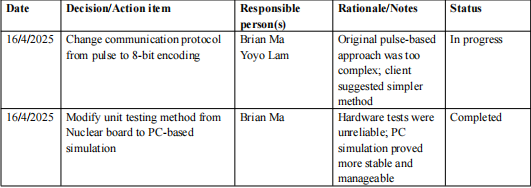
I also clarified in this meeting why we chose to focus on only a few steps to design the algorithm path and supplemented this idea into the decision log.





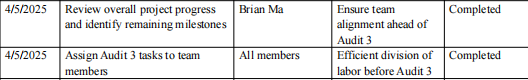
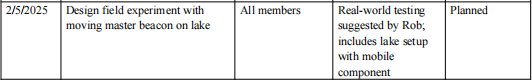
The team was divided into three groups according to functions: two for the experimental verification of different algorithms, and one focused on the integration of systems engineering; It was decided to use 16-bit data packets to transmit the beacon ID and further divide it into 8-bit data, 2-bit flag bits and 6-bit check bits to enhance the robustness of communication.

These decisions have greatly enhanced the organizational efficiency of the experiment and the scalability of the system.



The original communication method based on pulse was complex and unstable, and it was decided to change to 8-bit encoding for implementation.

The initial test on the Nuclear hardware board was not satisfactory. Therefore, the simulation test was changed to be conducted on the PC side, which is more stable and easier to debug.



In the later stage of the project, the team focused on task completion and on-site Experiment preparation:

Design a field experimental scenario for moving the main beacon on the lake surface and simulate the real environment as suggested by Rob.

The specific tasks and time nodes of all members before Audit 3 have been clarified.

Risks & Mitigation：

Battery power drop — Scheduled charging, backup devices

Environmental signal noise — Test in controlled setups first

Coordination delays — Weekly synchronization mechanism

# Stakeholder Communication Log

Rob provided directional feedback at multiple milestones. Technical suggestions such as PSK testing, 16-bit encoding structure, and test planning in lake environments were incorporated into project development. All meeting notes with stakeholders were archived and responded to in feedback documentation.

# Feedback

Audit 1 feedback resulted in clearer task division and documentation standardization.

Audit 2 feedback led to experimental redesign and better milestone tracking.

# Road map

Since the project was launched in February 2025, the team has steadily advanced various tasks in phases. In the early stage of the project (the first two weeks), we completed the team formation, role division, the setup of the GitHub version control system, as well as the initial task plan and time arrangement. From the 3rd to the 5th week, focus on the establishment and testing of communication between the primary beacon and sub-beacons, gradually clarify the system design architecture, and at the same time identify the main risk points and propose countermeasures. From the 6th to the 8th week, the team optimized the communication protocol, shifting from complex pulse signals to a more concise 8-bit encoding, which enhanced the system stability. This stage also includes the exploration of multi-beacon algorithms and the design of Nucleo plate simulation experiments. From the 9th to the 10th week, the team began to design the field test plan, including the scheme of testing mobile beacons on the lake surface. At the same time, the task allocation and progress confirmation before Audit 3 were completed.

Feasible route suggestions for the future include: further improving the robustness of the multi-beacon algorithm and introducing SLAM technology to achieve environmental perception and positioning; Continuously optimize communication stability and power consumption management; Finally, the deployment and practical verification of the system in a complex environment are achieved.

# Project Outputs

This project delivered a fully functional multi-beacon communication and localization prototype system. It includes both hardware and software components, with verified functionality in controlled indoor environments and well-documented preparations for field deployment.

The communication protocol was redesigned and implemented using an 8-bit encoding structure, improving both clarity and robustness. The PC-based simulation testing replaced unstable hardware-based methods, enhancing development speed and reliability. Multiple algorithms were proposed and partially tested to support future extensions.

The physical output consists of a master beacon unit, three sub-beacons, and a power system, all of which were assembled and tested. Though full lake deployment was not completed, a detailed plan for field testing was produced. All modules were built with re-usability and future enhancement in mind.