MESH Feasibility Report

Low-Cost Sonobuoy for Passive Acoustic Detection and Classification of Marine Vessels

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Nomenclature and Abbreviations

Symbol	Description	Units
f	Frequency	Hz
P	Power	W
V	Voltage	V
I	Current	A
T	Temperature	°C
t	Time	s
λ	Acoustic wavelength	m
c	Speed of sound in water	m/s
dB	Sound pressure level (decibel)	dB
kHz	Kilohertz	Hz × 10^3
MHz	Megahertz	Hz × 10^6

ABBREVIATION **MEANING**

AE	Autoencoder
AI	Artificial Intelligence
ANN	Artificial Neural Network
BMS	Battery Management System
CAPSE-VIT	Channel Attention Pyramid Squeeze-Excitation Vision Transformer
CATFISH	Classification Algorithm with Trainable Filter-banks
CNN	Convolutional Neural Network
CMOE	Conditional Mixture of Experts
CTD	Conductivity, Temperature and Depth
DEMON	Detection of Envelope Modulation on Noise
DSP	Digital Signal Processing
EVMD	Enhanced Variational Mode Decomposition
FFT	Fast Fourier Transform
GMM	Gaussian Mixture Model
GPS	Global Positioning System
GRU	Gated Recurrent Unit
HMM	Hidden Markov Model
IMF	Intrinsic Mode Function
ICL	Interpretable Contrastive Learning
IOT	Internet of Things
KNN	K-Nearest Neighbours
LDA	Linear Discriminant Analysis
LI-ION	Lithium-ion
LOFAR	Low Frequency Analysis and Recording
LSTM	Long Short-Term Memory
MCU	Microcontroller Unit
MESH	Modular Economical Sonobuoy Heuristic
ML	Machine Learning
MVP	Minimum Viable Product

NCSLSC	Nowra Culburra Surf Life Saving Club
PCB	Printed Circuit Board
PPE	Personal Protective Equipment
PWM	Pulse Width Modulation
R&D	Research and Development
RF	Radio Frequency
RNN	Recurrent Neural Network
SCAE	Separable Convolution-Based Autoencoder
SNR	Signal-to-Noise Ratio
SOP	Standard Operating Procedure
SPL	Sound Pressure Level
SVM	Support Vector Machine
TRL	Technology Readiness Level
UOW	University of Wollongong
USB	Universal Serial Bus
VIT	Vision Transformer
WIL	Work Integrated Learning
WI-FI	Wireless Fidelity
XGBOOST	Extreme Gradient Boosting

Executive Summary

This document reports the feasibility of the 420-hour professional experience project known as MESH (Modular Economical Sonobuoy Heuristic). This project aims to design and evaluate a low-cost, embedded hydrophone system for passive acoustic detection and classification of marine vessels. The research focuses on instrumentation design, embedded digital signal processing, and acoustic feature-based classification under realistic deployment conditions to satisfy the Professional Experience Requirements for an Undergraduate Engineering Degree as stipulated by Engineers Australia [1]. More information can be found at the project website [2]. Assessing the feasibility of this project is necessary to ensure technical, operational, schedule, safety, ethical, environmental, regulatory, and stakeholder satisfaction. This has been completed by identifying the required tasks and their resources to satisfy them.

Key Findings

Technical Feasibility: High. All required technologies, including hydrophones, embedded processors, digital signal processing algorithms, LoRa communications, and machine learning classifiers, are mature technologies with proven implementations in similar applications. The primary challenge is system integration rather than invention of new technology.

Operational Feasibility: High. Required facilities, equipment, and testing environments are available through university facilities, public waterways, and collaboration with the surf lifesaving club.

Financial Feasibility: High. The estimated project cost of approximately $300 is within personal funding capacity.

Schedule Feasibility: Moderate to High. The project schedule allocates 438 hours across multiple development and testing phases with contingency periods for delays.

Safety and Ethics Feasibility: High. The project uses passive acoustic sensing only and records non-identifiable environmental and vessel-generated acoustic data.

Environmental Feasibility: High. Testing activities produce negligible environmental impact and do not emit acoustic energy into the environment.

Regulatory Feasibility: High. Activities fall within university project requirements and standard recreational marine operations.

Introduction

Background

This project aligns strong intrinsic motivation with high employability prospects in the field of national security. Most project requirements will be successfully met using technical skills acquired in prior coursework. For any remaining skill gaps of the research student, detailed and feasible action plans have been established to ensure complete compliance. Furthermore, all resource and logistical needs can be fully satisfied utilizing existing University of Wollongong (UOW) facilities.

Objectives

The project will pursue the following objectives:

- Design and construct a low-cost hydrophone signal acquisition chain, including analogue amplification, filtering, and analogue-to-digital conversion, suitable for shallow-water passive acoustic sensing.
- Characterise the performance of the instrumentation through laboratory testing, including noise floor, frequency response, and dynamic range.
- Develop embedded digital signal processing algorithms for acoustic detection, spectral analysis, and feature extraction on a RPi platform.
- Implement and evaluate multiple acoustic classification techniques, including feature-based statistical and machine-learning approaches, with consideration of computational load and power usage.

Scope

This project is scoped as prototype development of passive acoustic detection and classification system rather than the development of a defence-grade sonobuoy. The work emphasises engineering feasibility, experimental validation, and performance trade-offs under realistic constraints, thus performance is constrained. With cost being self-funded and the duration of this project shaped to occur outside the semesters, the following project priority matrix can be defined.

	TIME	PERFORMANCE	COST
CONSTRAIN		X	
ENHANCE	X		
ACCEPT			X

Project priority matrix Table i

The scope includes:

- Design and implementation of a low-cost hydrophone-based acoustic sensing front end.
- Embedded software development for real-time acoustic acquisition, digital signal processing, and feature-based classification.
- Evaluation of multiple classification techniques with respect to accuracy, computational complexity, and power consumption.
- Notification of blacklisted acoustic signatures to a base station through LoRa.
- Laboratory testing to detect acoustic signatures of appliance. Limited field deployment to detect acoustic signatures of jet skis and inflatable rescue boats.
- Analysis of system performance, limitations, and scalability for future development.

The scope excludes:

- Active sonar transmission or acoustic emission.
- Long-term unattended deployments beyond short experimental trials.
- Secure communications, encryption, or Defence-classified systems.
- Detection or classification of submarines or military platforms.
- Large-scale sensor networks or multi-node data fusion.

Technical Feasibility

Technical Aims

The technical requirements are informed by the project aims. The primary aim of this project is to design, implement, and experimentally evaluate a low-cost, autonomous sonobuoy capable of passively detecting and classifying marine vessels in shallow-water environments. The system seeks to balance instrumentation quality, embedded processing capability, power consumption, and classification performance within the constraints of a deployable and economical platform. The minimum viable product would be the comparison of detection & classification methods in simulation through propagation [3] and detection [4]. Such methods shall be compared via simulation in MATLAB. Once successfully simulated, they shall be employed into the sonobuoy prototype.

Technical Requirements

The sonobuoy is composed of the buoy, hydrophone, detection & classification methods, positioning, communication of data. The various methods to satisfy these technical requirements shall be analysed in the literature review.

Buoy:

The simplest of all the parts.

- Costed using minimal componentry required to meet aims sourced through mass produced retailers. See the list of components in Financial Feasibility.
- Weight reduced using minimal componentry required to meet aims. 3D printed enclosure and buoy shall be designed to minimise weight.
- Power and computation budget using minimal componentry and processes required to meet aims. On-board consumption management shall limit functionality by necessity. For example, the classification processes shall be active if detection processes are active if the sonobuoy is upright on the water as informed by the GY85 Inertial Measurement Unit.
- Real-time acoustic acquisition using piezoelectric setup as detailed in Analogue-Digital-Conversion

Hydrophone:

The hydrophone subsystem shall satisfy the acoustic performance requirements for passive monitoring of marine vessels. The design draws upon the low-cost hydrophone solutions presented by CoPiDi [5] and Ryckebusch's work for the elaborate [6] and the condensed.

The effective frequency range is optimized for the 10Hz-1 MHz range [7], which is suitable for identifying and classifying based on spectral features. Such spectral features encompass acoustics from machinery and propeller cavitation.

This can be satisfied via two Transducer Configurations. Either a dual 27 mm piezoelectric disks connected in a balanced configuration (CoPiDi design), or a cylindrical piezoelectric element providing near-omnidirectional sensitivity (Ryckebusch design).

For signal conditioning, the transducer output shall be buffered using a low-noise, wide-bandwidth preamplifier. Suitable implementations include: an OPA1642 operational amplifier buffer (Ryckebusch), or a 2N3819 JFET differential preamplifier (CoPiDi). Both preamplifiers shall provide approximately 15 dB of voltage gain.

As for the required power supply, there is a clear distinction in feasibility. Whilst the CoPiDi laboratory implementations relies on 48 V phantom power, the MESH hydrophone shall operate from the system's 3.7-5 V lithium-ion with an auxiliary battery to use the 9 V Ryckebusch design. Whilst both could require a DC-DC boost converter voltage step up or additional power source, the addition of the 9 V battery to facilitate the Ryckebusch design would be much more feasible. This would require a 3.5mm to USB adapter for the RPi4 because it does not have 3.5mm audio input. Both have componentry able to fit in a container measuring 37 x 37 x 67 mm.

Consequently, there are multiple feasible options to create the hydrophone.

Detection & Classification Methods:

There are several acoustic detection & classification methods that are technologically feasible and shall have accuracy and power efficiency comparisons made between them. All of which will analyse the 24 bit Wav, 96Khz sampling frequency resolution, audio stream on the FreeRTOS RPi4 with 4GB of RAM. Acoustic classification methods shall focus on the 0Hz to 1600Hz band , where the most discriminative machinery components and propulsion signatures are concentrated [8]. Whilst prior skills in computer vision development have been demonstrated in the 2025 Triple I QUACK project [9], formal development of Machine Learning and Deep Learning has not occurred. Consequently, skill gaps of the research student shall be addressed via the Andrew NG Machine Learning Specialization course on Coursera [10] and the Deep Learning Specialization on Coursera [11] for the necessary concepts at the appropriate time.

The acoustic detection & classification methods can be broadly grouped into Statistical Learning Methods, Deep Learning Architectures, and Hybrid and Feature-Based Techniques. Statistical learning methods include Support Vector Machines (SVM), Hidden Markov Models (HMM), Gaussian Mixture Models (GMM), and K-Nearest Neighbours (KNN), all detailed by Xinwei Luo et al [12]. The XGBoost and Linear Discriminant Analysis (LDA) are detailed by Allyson A. da Silva et al [13] and which are generally computationally efficient and well suited to smaller datasets. Lucas C. F. Domingos et al [8] detailed the deep learning architectures include Convolutional Neural Networks (CNNs) and their variants (ResNet, VGGNet, DenseNet and MobileNet), Recurrent Neural Networks (LSTM and GRU), Autoencoders, Mixture of Experts (CMoE), and transformer-based approaches. Hybrid and feature-based techniques combine signal processing with machine learning. These have been detailed in various novel approaches including DEMON [14], LOFAR enabled CAPSE-ViT by Najamuddin et al [15], EVMD by Hamada Esmaiel et al [16], CATFISH by Jonas Elsborg et al [17], and by ICL Yuan Xie et al [18]. All seek to improve inference robustness under varying environmental conditions.

These approaches represent a range of computational complexity, feature extraction methodologies, and classification performance, making them suitable candidates for comparison within this project. They shall be understood thoroughly through the literature review to assess their suitability for simulation and prototype implementation. The CAPSE-ViT [15] framework has been selected as an example of a high-complexity transformer-based architecture to establish an upper performance feasibility benchmark. Since CAPSE-ViT can be feasibly implemented and evaluated, then the lower-complexity statistical and deep learning methods are expected to be readily implementable on the proposed RPi platform. All classification methods will be trained and evaluated using the same high-quality underwater acoustic dataset to ensure fair comparison of detection and classification performance [8]. Following laboratory validation, the most promising algorithms will be deployed on the sonobuoy prototype, where classification accuracy, computational load, memory usage, inference latency, and power consumption will be compared in the laboratory and deployment demonstrations.

Computer Vision Analysis of Spectral Representation example: CAPSE-ViT

Signal enhancement from the hydrophone could be achieved from the Coherently Averaged Power Spectral Estimation (CAPSE) technique [15], to preserve phase coherence across multiple signal segments, providing a substantial improvement in SNR for detecting tonal machinery signatures in noisy littoral environments. Once enhanced, the signal can be transformed into 50 x 4000 Low Frequency Analysis and Recording (LOFAR) grams, to emphasise sustained engine sounds and mechanical spectral components. To maintain a classification accuracy above 50% even at low signal-to-noise ratios (5 dB), focus shall be targeted on distinguishable vessel-specific global features.

The Lightweight Vision Transformer (ViT) utilizing self-attention mechanisms to capture both local patterns (individual machinery sounds) and global dependencies (overall vessel signatures). With a highly efficient design that utilises 1.90 million parameters, specifically optimized for real-time performance on resource-constrained embedded platforms, it is suitable for the RPi4.

CAPSE is Optimized via TensorFlow Lite for Microcontrollers to facilitate high-speed local inferences. To optimize power, it implements a two-stage "Detect and Classify" [8] workflow where a low-complexity energy trigger monitors the environment and only activates the transformer model upon detecting a potential target, minimizing RPi power consumption. Target classification shall be tuned to distinguish between vessel classes jet skis and IRBs.

To ensure tuning of the model's target classification parameters in one environment doesn't inhibit its ability to detect the same vessel in a different environment, data generalisation techniques shall be employed. This can be achieved by Local Masking and Replicating (LMR) augmentation to prevent overfitting and ensure reliability across different littoral deployment sites.

Positioning:

The sonobuoy shall use a U-blox NEO-6M GPS [19] receiver to provide global positioning and high-precision timing. The GPS module supplies the buoy's latitude and longitude for telemetry while also providing an accurate time reference for synchronizing acoustic detections. This timing information supports future implementation of Time of Arrival (ToA) localisation [20] where, in future developments, detections from multiple buoys can be correlated to estimate the position of an acoustic source via trilateration.

The NEO-6M is a mature and widely adopted GPS receiver designed for embedded applications, making it a feasible choice for the proposed system. It provides continuous position, velocity, and UTC time information through a standard UART interface, allowing straightforward integration with the RP2040 microcontroller. Under open-sky conditions, the receiver offers typical positioning accuracy of approximately 2.5 m CEP while maintaining low power consumption, making it suitable for battery-powered marine deployments. Stability measurements shall be taken by the GY85 IMU. The module also supports update rates of up to 5 Hz, which is sufficient for tracking the relatively slow drift of a floating sonobuoy.

Communication of data:

Telemetry of coordinates, system health, vessel classification data, shall be transmitted from the sonobuoy via LoRa communication (915 MHz) to a centralized base station. The Open-Source LoRa Buoy (OLB) [21] framework provides the primary technological context for this sonobuoy's communication infrastructure and the Australian AU915 frequency allocation [22].

The MESH system utilizes a shore-based base station as an intermediary between the floating sonobuoy and the user. Received data can be forwarded to a cloud backend through a secondary GSM or Internet connection. Communication between the MESH sonobuoy and the base station follows a lightweight point-to-point protocol designed to minimise energy consumption while maintaining reliable long-range communication.

To conduct the availability notification, the base station regularly broadcasts its unique ID and a specific listening frequency at a predefined transmission frequency (e.g., 434 MHz) to notify the buoy in the area that it is ready for data. When a buoy has detection results, it listens for the base station signal. Once detected, it performs a handshake by transmitting a "ready" signal containing the base station ID and the buoy's unique ID to ensure a stable connection and avoid interference. Following successful acknowledgement, the sonobuoy transmits its payload as a compact raw byte array containing vessel detection and classification results, timestamps, GPS coordinates, IMU information, and onboard diagnostic information.

Drawing from the OLB framework, adjusted for the Australian convention, is used as the basis for this sonobuoy prototype, the following technical parameters apply to LoRa notifications in *Table ii.*

Parameter	Specification	Notes
Upstream Channels (200 kHz spacing)	64 channels from 915.2 MHz to 927.8 MHz	Linear spacing of 200 kHz.
Upstream Channels (1.6 MHz spacing)	8 channels from 915.9 MHz to 927.1 MHz	Linear spacing of 1.6 MHz.
Downstream Channels	8 channels from 923.3 MHz to 927.5 MHz	Linear spacing of 600 kHz.
Operating Band	915-928 MHz ISM Band	Suitable for regions supporting the 915 MHz LoRaWAN band (e.g., AU915/US915).
Default Bandwidth	125 kHz	Standard for high-sensitivity LoRa links.
Spreading Factor	8	Configurable integer between 5 and 12.
Coding Rate\	6	Range: 5 to 8 (commonly represented as 4/6).
LoRa Output Power	20 dBm	Configurable from -9 dBm to 22 dBm.
Transmission Range	~2 km to 5.4 km	Up to 2 km in ocean water; up to 10 km under ideal line-of-sight conditions.
Data Format	Raw byte array	Minimizes payload size for improved energy efficiency.

Table ii: LoRa technical parameters

The base station is also capable of transmitting configuration updates, measurement parameters, and remote reset commands to the MESH sonobuoy over the same LoRa communication link.

The proposed communication hardware is based on the RP2040-LoRa-HF development board, integrating the RP2040 dual-core Arm Cortex-M0+ microcontroller with the SX1262 LoRa transceiver. Compared with the Wio-E5 Mini used in the Open-Source LoRa Buoy platform, the RP2040 provides greater processing capability while maintaining low-power operation suitable for onboard acoustic processing and vessel classification.

The SX1262 supports LoRa, FSK, and GFSK modulation, providing receiver sensitivity of up to -148 dBm and configurable transmit power up to +22 dBm. The HF (850-930 MHz) hardware variant operates within the Australian 915-928 MHz ISM band, making it compatible with the proposed AU915 communication configuration.

The shore-based base station uses a USB-to-LoRa-HF module incorporating the same SX1262 transceiver, providing a USB serial interface to the host computer. The module functions as a transparent LoRa modem, receiving telemetry packets from the MESH sonobuoy and forwarding them to the monitoring application over a virtual serial connection. Like the OLB architecture, all acoustic processing and vessel classification are performed onboard the sonobuoy, with only event notifications, telemetry, and diagnostic information transmitted via LoRa, thereby minimising communication power consumption and extending deployment endurance.

Summary:

All core system components have achieved Technology Readiness Level 9 (TRL 9) according to DSTG standards [23], meaning the hardware, software, and algorithms are fully mature, proven in operational environments, and ready for commercial deployment. Because the individual technologies are already optimized for stable, full-scale operations, the primary technical risk does not lie in component development. Instead, the critical engineering challenge centres entirely on the complex integration, interoperability, and interconnection between these distinct systems. Consequently, efforts will focus heavily on system architecture and interface compatibility to achieve the objectives.

Challenge	Likelihood	Impact	Control Measure	Resources
Water ingress into enclosure	Moderate	High	Progressive waterproofing and harbour verification testing	[24]
Excessive environmental noise	High	Moderate	Adaptive filtering and controlled testing	[25] [15]
Insufficient classification accuracy	Moderate	High	Multiple classification methods evaluated	[26] [8] [27] [17] [16] [14] [28] [18] [29]
LoRa communication reliability	Low	Moderate	Range testing and onboard data logging	[30] [31] [21] [22]
Component delivery delays	Moderate	Moderate	Early procurement and contingency schedule	Not required

Battery endurance limitations	Moderate	Moderate	Pilot deployment endurance testing	[5] [24]
False positive detections	Moderate	Moderate	Threshold optimisation and feature selection	[32] [13] [33]

Table iii: Technical challenge summary

Preliminary reading indicates that the tools and techniques described in the referenced sources are suitable for this project. A more detailed literature review will determine which aspects of their methodologies will be incorporated into the proposed control measure, in accordance with the project's scope. Therefore, there is a high likelihood of technical success with a low risk of failure.

Operational Feasibility

The operational feasibility of the MESH system has been assessed by considering the project's Operational Testing Strategy [2], stakeholder requirements, resource availability, and contingency planning. The project has been structured to progressively validate system functionality through laboratory experimentation, controlled field testing, and performance evaluation before considering potential large-scale deployment.

Initial validation will be conducted through controlled laboratory experiments using representative mechanical sound sources to verify the functionality of the acoustic sensing, signal processing, and vessel classification algorithms. These experiments provide a repeatable environment for evaluating the performance of multiple acoustic detection and classification techniques prior to deployment in open-water environments.

Following laboratory validation, field trials will be undertaken within realistic coastal environments to assess the system's capability to detect and classify small marine vessels, including jet skis and inflatable rescue craft. These trials will evaluate the complete sensing chain, from acoustic acquisition through onboard processing to wireless transmission via the LoRa communication system. Testing across multiple environments enables assessment of system robustness under varying environmental and operational conditions.

System performance will be evaluated using several criteria, including detection accuracy, classification accuracy, computational complexity, power consumption, communication reliability, and overall system cost. Multiple statistical learning, deep learning, and feature-based classification methods will be compared to determine the most appropriate balance between inference performance and embedded resource requirements. The resulting trade-offs between hardware capability, energy efficiency, and classification performance will inform future iterations of the MESH platform. All testing outcomes, limitations, and engineering observations will be documented in accordance with professional engineering standards [1].

Operational success also depends upon satisfying the requirements of the project's key stakeholders. These requirements are summarised in *Table iv*

Stakeholder	Requirement
University	Completion of a technically rigorous engineering project demonstrating professional competencies
Project Supervisor	Safe execution, appropriate methodology, and meaningful outcomes

Researcher	Development of skills in embedded systems, DSP, instrumentation, and acoustic sensing
NCSLSC (Nowra Culburra Suf Lifesaving Club)	Safe participation with minimal operational disruption
Future Users	Low-cost and scalable acoustic monitoring capability

Table iv: Stakeholder requirements

User Requirements for the different stakeholders are listed below. The Stakeholder Satisfaction is detailed in Ethical Feasibility section.

The project is considered operationally achievable as the required facilities, equipment, and personnel are available throughout the development lifecycle. Most of the specialised hardware has either been procured or is accessible through University of Wollongong laboratories. Development activities will primarily be undertaken by the research student under academic supervision, with operational assistance from Surf Life Saving volunteers during field deployments.

The principal facilities supporting the project are summarised in *Table v*.

Facilities	**Availability**
8G22 Electronics Laboratory	Available
Makerspace	Available
Fluids Laboratory	Available
UOW Pool	Probable; subject to further inquiry
Wollongong Harbour	Available
Coastal Deployment Locations	Available; subject to conditions

Table v: facilities

The integration of these facilities, personnel, and testing environments is coordinated through the MESH Operational Testing Strategy [2], providing a structured framework for laboratory validation, controlled aquatic testing, and coastal deployment. Consequently, the overall operational feasibility of the project is assessed as high, with a correspondingly low operational risk.

Should unforeseen constraints prevent full-scale field deployment, a viable contingency plan has been established. Under this scenario, the project's minimum viable outcome will comprise the implementation and evaluation of the acoustic detection and classification algorithms within a simulated environment. Acoustic propagation [3] and detection [4] models will be developed in MATLAB to generate representative underwater acoustic datasets, allowing multiple classification techniques to be evaluated with respect to detection accuracy, computational complexity, and estimated power consumption. Successful algorithms will subsequently be integrated into the MESH sonobuoy prototype, ensuring that the project's primary research objectives remain achievable even if operational deployment opportunities are limited.

Financial Feasibility

The proposed MESH sonobuoy is financially feasible, with an estimated prototype cost of AUD $277.83, excluding incidental consumables and Makerspace-supplied components. This represents a relatively low-cost solution compared with commercial passive acoustic monitoring systems, which typically require significantly greater investment due to specialised underwater acoustic hardware and proprietary software.

The revised budget is marginally lower than the original estimate following the adoption of an alternative hydrophone implementation, while maintaining the required functionality for prototype validation. The complete system, including development hardware and auxiliary equipment, is estimated at AUD $305.73, with a total system weight of approximately 983 g.

The budget is distributed across the categories shown in *Table vi*.

Category	**Description**
Hardware (Costed)	Embedded electronics, acoustic sensor, LoRa communication modules, GPS, power system, and supporting electronic components.
Manufacturing (Costed)	Hydrophone encapsulation materials, enclosure fabrication, fasteners, sealants, and Makerspace consumables.
Testing (No cost)	Laboratory consumables, field deployment accessories, and replacement components where required.
Software (No cost)	MATLAB, Arduino IDE, Python, and supporting software tools (existing university licences or free/open-source software).
Miscellaneous (No cost)	Travel expenses, consumables, and food during field testing activities.

Table vi: Cost categories

The detailed Bill of Materials identifies the estimated cost, supplier, delivery time, and expected weight of each component used within the prototype.

Most of the project expenditure is associated with hardware procurement, including the Raspberry Pi 4 processing platform, hydrophone assembly, LoRa communication hardware, battery system, and acoustic instrumentation. Software costs are none, as development will utilise existing University of Wollongong software licences together with open-source development environments.

The project is self-funded, with no external funding being sought. Consequently, there is minimal financial risk associated with grant availability, funding approval processes, or sponsor withdrawal. The estimated project cost is considered manageable within the available personal budget.

Potential cost increases may arise from:

- replacement or damaged components during prototype development;
- additional enclosure manufacturing iterations;
- shipping delays requiring components to be sourced from alternative suppliers;

- additional consumables required during laboratory or field testing.

To mitigate these risks, a contingency allowance of approximately 10% has been incorporated into the project budget. This contingency of $300 of personal funding is considered sufficient to accommodate foreseeable variations in component pricing and procurement costs without materially affecting project viability.

Although some components have comparatively long lead times (up to approximately 60 days), these items will be ordered early in the project schedule to minimise their impact on development activities. Furthermore, several low-cost consumables and fabrication materials are available through the University Makerspace, reducing procurement costs and improving development flexibility.

Overall, the financial feasibility of the MESH project is assessed as high. The total development cost remains well within the available budget, relies predominantly on commercially available off-the-shelf components, and presents a low financial risk to successful project completion.

Schedule Feasibility

The proposed project schedule spans the 2026 mid-year and summer breaks, providing approximately 438 hours of dedicated project work. The schedule has been structured to follow a systems engineering lifecycle, progressing from requirements definition and system design through prototype development, laboratory validation, controlled experimentation, field deployment, and final evaluation. This staged approach ensures that each phase produces outputs required by subsequent activities while allowing sufficient time for testing, refinement, and documentation.

The schedule incorporates several contingency measures to improve project resilience, including iterative design cycles, multiple testing environments, backup deployment locations, and allocated periods for analysis and redesign. These provisions reduce the likelihood that a single unsuccessful test or environmental constraint will prevent completion of the project.

Whist a simulation comparison would satisfy the MVP, the successful full implementation of the project depends upon several external and technical factors that influence the schedule. The principal dependencies include:

- Procurement and delivery of electronic components, particularly those sourced internationally.
- Availability of university laboratories, Makerspace facilities, and testing equipment.
- Access to controlled testing environments including the University pool, Wollongong Harbour, and coastal deployment sites.
- Suitable weather and sea-state conditions for harbour and coastal trials.
- Availability of project supervisors and technical support.

- Coordination with the Nowra Culburra Surf Life Saving Club and vessel operators for field testing.
- Availability of representative vessels, including jet skis and inflatable rescue boats, during deployment activities.

The project schedule incorporates several risk mitigation strategies, including:

- progressive laboratory validation before field deployment;
- multiple prototype iteration and redesign opportunities;
- pilot testing prior to full operational deployment;
- contingency deployment at Wollongong Harbour should coastal testing become unavailable;
- allocated analysis periods following each testing stage to enable design refinement before progressing.

The most significant scheduling risks relate to factors outside the control of the research student. Adverse weather conditions may delay coastal deployments, while surf lifesaving operational commitments or stakeholder availability may restrict opportunities to collect representative acoustic data. International shipping delays may also affect component availability, although the procurement schedule places component ordering well before assembly activities to minimise this risk.

Should field testing be significantly delayed, the project retains a viable contingency path through simulation-based evaluation and laboratory experimentation. This ensures that the primary research objectives, namely the comparison and evaluation of acoustic detection and classification techniques, can still be achieved within the project timeframe.

Consequently, there is a moderate schedule risk. The overall schedule is considered achievable within the allocated 438 project hours. However, several critical activities, including harbour trials and coastal deployment verification, are dependent on environmental conditions, external stakeholders, and operational availability. The inclusion of iterative testing, contingency deployment locations, and simulation-based fallback options substantially reduces the likelihood of significant project delays, resulting in an overall moderate schedule risk.

Safety Feasibility

The MESH project has been assessed for hazards associated with laboratory development, prototype manufacture, electrical testing, and field deployment. Most development activities are undertaken within University of Wollongong laboratories and Makerspace facilities, where existing safety procedures and supervision apply.

Field deployment presents the greatest potential hazards due to the marine environment. However, deployment and recovery of the sonobuoy will be undertaken by qualified personnel from the Nowra Culburra Surf Life Saving Club (NCSLSC) using established operational procedures and approved rescue vessels. The researcher will remain shore-based except where specifically authorised, significantly reducing exposure to marine operational hazards. Potential hazards and mitigation measures are documented in the published risk assessment [2]. A summary is included below in *Table vii*.

Hazard	**Likelihood**	**Impact**	**Control Measure**
Electrical fault during prototype testing	Low	Moderate	Low-voltage operation (5 V), insulated enclosures, inspection prior to energising, compliance with laboratory procedures.
Soldering and electronics assembly	Low	Minor	Use of appropriate PPE, solder fume extraction, and supervised laboratory operation.
3D printing and fabrication equipment	Low	Minor	Operate within Makerspace guidelines and complete required equipment inductions.
Water ingress causing equipment failure	Moderate	Moderate	Controlled waterproof testing, enclosure inspection, staged pool and harbour validation before coastal deployment.
Manual handling of equipment	Low	Minor	Lightweight prototype (<1 kg), appropriate lifting techniques and transport containers.
Marine deployment and recovery	Low	High	Deployment and retrieval performed by qualified NCSLSC personnel using approved operational procedures.
Adverse weather and sea conditions	Moderate	High	Deployments only undertaken following weather assessment and approval by NCSLSC personnel.
Battery hazards (Li-ion)	Low	Moderate	Battery protection circuitry (BMS), appropriate charging equipment, inspection for damage before use.

Table vii: Hazard summary

Risk Controls

Appropriate engineering and administrative controls have been incorporated throughout the project to minimise risk.

Electrical Safety

The prototype operates exclusively from low-voltage DC supplies, eliminating exposure to mains voltages during normal operation. All electrical testing will be conducted within university laboratories using regulated power supplies, with wiring inspected prior to energisation. Lithium-ion batteries incorporate a battery management system (BMS) providing over-current, over-voltage, and short-circuit protection.

Laboratory Safety

Electronics assembly, soldering, and instrumentation activities will be undertaken in the 8G22 Electronics Laboratory under established laboratory safety procedures. Fabrication activities, including enclosure manufacture and 3D printing, will be completed within the University Makerspace following equipment inductions and standard operating procedures.

Water Safety

Waterproof integrity will be verified progressively through laboratory testing, pool trials, and harbour validation before any coastal deployment. Enclosure inspections and buoyancy testing will be conducted prior to each field trial to minimise the likelihood of equipment failure in the marine environment.

Field Deployment Safety

Marine deployment and recovery activities are outside the direct responsibility of the researcher and will be undertaken by qualified NCSLSC operators using approved rescue vessels and existing operational procedures. The researcher will primarily conduct shoreline monitoring, equipment preparation, and data collection, thereby substantially reducing exposure to vessel operations and open-water hazards. Field activities will only proceed when environmental conditions are considered suitable by NCSLSC personnel.

Residual Risk Assessment

Following implementation of the proposed engineering and operational controls, all identified hazards are considered to present low to moderate residual risk. The highest inherent risks relate to marine operations and environmental conditions; however, these are mitigated with qualified surf lifesaving personnel, established operational procedures, staged testing, and weather-dependent deployment decisions.

Overall, the safety feasibility of the project is considered acceptable, with no hazards identified that would prevent successful completion of the project under normal operating conditions.

Consequently, the risk is tolerably low. The project predominantly involves low-voltage electronics, laboratory-based development, and controlled testing environments. Higher-risk marine activities are managed by trained NCSLSC personnel under established operational procedures, effectively transferring the operational risks associated with vessel deployment and recovery. Combined with staged testing, university laboratory safety protocols, and engineering controls, the residual project risk is considered acceptable.

Ethical Feasibility

The MESH project presents minimal ethical concerns as it involves the passive monitoring of environmental underwater acoustic signals for engineering research purposes. No human participants are the subject of the research, no personally identifiable information is collected, and the system does not interfere with normal marine operations or wildlife beyond the passive recording of ambient acoustic signals. The project has been designed to align with the ethical principles of transparency, voluntary participation, responsible data management, and professional engineering practice.

Successful completion of the project depends upon collaboration between academic supervisors, operational stakeholders, and the University. The interests and influence of each stakeholder are summarised in *Table viii*.

Stakeholder	**Interest**	**Influence**
Jonathan Walsh (Research Student)	Successful completion of the project and development of professional engineering competencies.	High
Dr Son Lam Phung (Supervisor)	Academic quality, research methodology, and project supervision.	High
Col Lawrence (NCSLSC President)	Operational guidance and deployment planning.	Moderate
Dr. Faisel Tubbal (University of Wollongong)	Achievement of educational and research outcomes. Overseeing compliance with Engineers Australia professional experience standards.	Moderate

Table viii: Stakeholder interest and influence

All principal stakeholders have had their requirements acknowledged and incorporated within their respective roles in the project scope. Engineers Australia's Stage 1 Competency Standards for graduate engineers are addressed through the University of Wollongong Work Integrated Learning (WIL) coordination process. This oversight has been administered sequentially by Dr Guangqing Zhang, followed by Dr Brad Stappenbelt, and currently Dr Faisel Tubbal, ensuring continuity of accreditation-aligned project governance.

Academic supervision is maintained throughout the project to ensure all activities are conducted in accordance with appropriate engineering methodologies, ethical research practices, and professional standards expected of an accredited engineering program.

Operational support for deployment activities will be provided by members of the Nowra Culburra Surf Life Saving Club (NCSLSC), with participation being entirely voluntary and coordinated around existing operational commitments.

As field testing is dependent upon qualified vessel operators, participation will only occur where sufficient volunteer availability exists and where testing does not interfere with normal lifesaving operations.

Stakeholder communication will occur throughout the project to ensure safe, coordinated, and transparent execution of research activities. Extensive consultation has already been undertaken between the researcher and the academic supervisor regarding the research methodology, technical design, and project milestones. Consultation has also occurred with Col Lawrence regarding the planning and execution of field deployment activities.

Once the NCSLSC patrol roster has been released, qualified members holding the appropriate Rescue Water Craft (RWC) and Inflatable Rescue Boat (IRB) driver or crew awards will be invited to participate in the deployment trials on a voluntary basis. A dedicated WhatsApp group will be established to coordinate deployment schedules, communicate weather updates, distribute testing procedures, and ensure all participants understand their responsibilities prior to field activities.

The project collects only technical data necessary to evaluate system performance. Data collected includes:

- underwater hydrophone recordings;
- vessel acoustic signatures;
- GPS location of the sonobuoy;
- IMU information;
- system diagnostic information (battery voltage, processor utilisation, communication status);
- LoRa communication performance metrics;
- environmental conditions recorded during testing;
- vessel operating scenarios used during controlled experiments.

All collected data is used solely for engineering analysis, system validation, and academic research.

Experimental data will be stored on secure University-approved storage systems and project development computers with regular backups maintained throughout the project. Source code and documentation on the GitHub [2] will be managed using version control where appropriate, while access to raw datasets and project files will be restricted to the researcher and supervising academic staff. No public release of raw data will occur without appropriate approval.

The collected data is non-identifiable. The hydrophone records passive underwater acoustic signatures generated by vessels and the surrounding environment only. No personal information, conversations, photographs, video recordings, or identifying characteristics of individuals are collected. The system cannot identify individual operators or vessel occupants, and GPS data relates solely to the deployed sonobuoy rather than any individual.

The ethical implications of the project have been assessed with respect to the broader community, participating stakeholders, environmental impact, and responsible data use.

From a community perspective, the project seeks to improve maritime situational awareness through the development of a low-cost passive acoustic monitoring platform that may contribute to future safety and environmental monitoring applications. Participation by NCSLSC personnel is voluntary and undertaken within existing operational procedures, ensuring that normal lifesaving activities are not adversely affected.

The project employs passive acoustic sensing and therefore does not introduce acoustic energy into the marine environment. Consequently, environmental disturbance is expected to be negligible compared with active sonar systems. All collected data will be used exclusively for research purposes, with project methods, assumptions, limitations, and results documented transparently within the final thesis.

Overall, the project presents minimal ethical concerns because:

- no human experimentation is conducted;
- participation by operational stakeholders is voluntary;
- no personally identifiable information is collected;
- only passive environmental acoustic data is recorded;
- environmental disturbance is negligible; and
- data collection and reporting are conducted transparently in accordance with professional engineering standards.

The project involves passive environmental sensing for engineering research, with no collection of personal information or human subject experimentation. Stakeholder participation is voluntary, operational activities are coordinated with NCSLSC to avoid disruption, and all collected data is non-identifiable and used solely for academic and engineering purposes. Consequently, the ethical risks associated with the project are considered minimal.

Environmental Feasibility

The MESH sonobuoy system has been assessed as having minimal environmental impact due to its passive sensing design, low power consumption, and short-duration deployment strategy. The system does not emit acoustic energy into the environment and therefore does not contribute to acoustic pollution. Instead, it passively records ambient underwater sound generated by natural sources and marine vessels. The summary of environmental impacts can be found in *Table ix*

Impact Area	**Assessment**
Acoustic Pollution	None (passive acoustic sensing only)
Wildlife Disturbance	Minimal
Waste Generation	Minimal
Energy Consumption	Very Low (battery-powered embedded system)
Water Pollution	Negligible

Table ix: Summary of environmental impacts

The system operates as a passive acoustic monitoring platform, meaning it does not introduce additional sound energy into the marine environment. As such, its environmental footprint is significantly lower than active sonar or propulsion-based sensing systems.

Wildlife disturbance is expected to be minimal, as the device does not generate sound and is deployed for short operational periods under controlled conditions. Any interaction with marine fauna is limited to incidental exposure to existing environmental noise conditions.

Waste generation is limited to small-scale electronic prototyping materials, including printed enclosures, batteries, and minor electronic components. These are retained and retrieved following deployment, with no intentional release of materials into the marine environment.

Energy consumption is very low due to the use of low-power embedded processing hardware and duty-cycled operation of the sensing and communication systems. Water pollution risk is considered negligible as all electronic components are fully sealed within waterproof housings designed for retrieval after each deployment.

To minimise environmental impact, the following controls are implemented:

- Full retrieval of all deployed equipment following each testing session;
- Use of passive acoustic sensing only (no active acoustic transmission);
- Short-duration deployments to minimise environmental exposure;
- Selection of testing locations away from environmentally sensitive habitats where possible;
- Progressive testing approach to reduce unnecessary field exposure;
- Careful sealing of electronic enclosures to prevent leakage of materials or battery contamination;
- Investigation into reducing microplastic generation from 3D-printed buoy components, including consideration of alternative materials, surface coatings, and enclosure reuse strategies.

These measures ensure that the system operates within acceptable environmental boundaries while supporting iterative engineering development.
The MESH system is a passive acoustic monitoring platform with no active acoustic emission and minimal physical interaction with the marine environment. Environmental effects are limited to short-duration deployments of sealed, retrievable equipment. Waste generation is small-scale and controllable, and no long-term environmental degradation is expected. As a result, the overall environmental impact is assessed as minimal.

Regulatory Feasibility

Regulatory Feasibility

The regulatory assessment confirms that the MESH project can be conducted within existing university, laboratory, and maritime operational frameworks without requiring special permits for research deployment activities.

The project complies with the following requirements and standards:

- University of Wollongong (UOW) professional experience and engineering project requirements [34];
- UOW laboratory safety procedures and risk management frameworks [35];
- Makerspace operational safety procedures for fabrication and prototyping [36];
- Maritime operational safety practices administered by the Nowra Culburra Surf Life Saving Club (NCSLSC), who are responsible for field deployment and recovery activities [37].

Maritime operational risks and vessel handling responsibilities are fully managed by NCSLSC personnel operating under their existing certifications and procedures. The researcher does not directly operate rescue vessels or conduct independent offshore deployment activities.

The project is designed to comply with relevant institutional, safety, and operational requirements through the following strategy:

- All development activities are conducted within approved University facilities under established safety procedures;
- Field testing is conducted in coordination with NCSLSC using approved operational vessels and personnel;
- Deployments are short-duration, non-invasive, and involve passive sensing only;
- Equipment is classified as low-risk electronic instrumentation with no hazardous emissions or controlled substances;
- Testing activities are conducted within recreational-scale or controlled operational environments, avoiding regulated commercial or industrial maritime activity.

Based on these factors, no specific external permits or regulatory approvals are expected to be required for project execution.

The MESH project operates within established university safety frameworks and utilises passive sensing technology deployed in coordination with qualified surf lifesaving personnel. Activities are limited to short-duration experimental deployments and do not involve regulated maritime operations, active acoustic emission, or hazardous materials. Consequently, the project is considered fully compliant with relevant institutional and operational requirements.

Overall Feasibility Assessment

The feasibility assessment indicates that the MESH project is viable from technical, operational, financial, schedule, safety, ethical, environmental, and regulatory perspectives. The proposed system utilises mature, commercially available hardware and well-established signal processing and machine learning techniques, reducing technical uncertainty. Required facilities, equipment, testing environments, and stakeholder support are available through the University of Wollongong and the Nowra Culburra Surf Life Saving Club.

The project has been designed using a staged systems engineering approach, incorporating laboratory validation, controlled aquatic testing, and field deployment with contingency plans at each stage. Although schedule uncertainty exists due to weather conditions, stakeholder availability, and component procurement, these risks are mitigated through early procurement, iterative development, alternative testing environments, and a simulation-based minimum viable product.

Safety, ethical, environmental, and regulatory assessments demonstrate that the project presents minimal residual risk when the proposed engineering and administrative controls are implemented. Overall, the project is considered feasible for completion within the allocated Professional Experience timeframe and provides an appropriate opportunity to demonstrate Engineers Australia Stage 1 Competencies.

Project Strengths

- Uses mature, commercially available technologies with high Technology Readiness Levels, reducing technical risk.
- Low overall development cost (approximately AUD $300) by off-the-shelf hardware and university facilities.
- Progressive testing strategy incorporating laboratory, pool, harbour, coastal, and simulation environments with contingency plans.
- Strong alignment with Mechatronic Engineering learning outcomes, integrating instrumentation, embedded systems, digital signal processing, communications, machine learning, and systems engineering.
- Access to appropriate facilities, equipment, academic supervision, and operational support throughout the project.
- Minimal safety, ethical, environmental, and regulatory risks due to passive sensing and controlled deployment procedures.

Project Limitations

- Single-node passive acoustic sensing prevents direct localisation of detected vessels without future multi-node expansion.
- Limited field deployment duration restricts evaluation of long-term reliability, durability, and endurance.
- Classification performance is dependent on the availability and diversity of representative underwater acoustic datasets.
- Environmental noise and changing marine conditions may reduce repeatability and classification performance during field trials.
- Successful field testing depends on favourable weather conditions and the availability of qualified NCSLSC personnel.

Summary of Findings

The feasibility assessment demonstrates that the project requirements can be achieved using the technical knowledge developed throughout the Bachelor of Mechatronic Engineering, supplemented where necessary by independent learning through academic literature, online resources, and professional training courses.

Technical Feasibility

High. Mature technologies, commercially available components, and established signal processing and machine learning techniques make successful implementation achievable, with system integration representing the primary technical challenge.

Operational Feasibility

High. Required laboratories, fabrication facilities, testing environments, personnel, and operational support are available, with simulation providing an effective contingency should field deployment be restricted.

Financial Feasibility

High. The project can be completed within the available self-funded budget using predominantly commercially available components and university resources.

Schedule Feasibility

Moderate to High. The allocated project timeframe is sufficient to complete the proposed work, with contingency planning reducing the impact of weather, procurement, and stakeholder availability.

Safety Feasibility

High. Risks are effectively controlled through low-voltage operation, laboratory safety procedures, staged testing, and qualified surf lifesaving personnel managing marine operations.

Ethical Feasibility

High. The project employs passive environmental sensing, collects no personally identifiable information, involves voluntary stakeholder participation, and complies with professional engineering standards.

Environmental Feasibility

High. Passive sensing, low power consumption, equipment retrieval after testing, and short-duration deployments minimise environmental impact.

Regulatory Feasibility

High. Activities comply with university requirements, laboratory safety procedures, Makerspace operating procedures, and existing NCSLSC operational frameworks without requiring additional regulatory approvals.

Recommendation

The feasibility assessment demonstrates that the required technology, facilities, funding, personnel, schedule, and testing environments are available to successfully complete the MESH project. Identified technical, operational, schedule, and safety risks have appropriate mitigation strategies, while ethical, environmental, financial, and regulatory risks remain low.

The project also provides an excellent opportunity to integrate knowledge acquired throughout the Bachelor of Mechatronic Engineering, including instrumentation, embedded systems, digital signal processing, communications, machine learning, systems engineering, experimental testing, and professional engineering practice. Where additional knowledge is required, realistic learning pathways and supporting resources have been identified.

Accordingly, the project is considered technically achievable, operationally practical, financially sustainable, and suitable for completion within the allocated Professional Experience timeframe.

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Appendices

Appendix A - Bill of Materials

TOTAL	Est Cost (AUD)	Est Weight (g)	Est Delivery Time (Days)
System and setup	$305.73	983	60
System (excluding Makerspace parts)	$277.83	-	-

Component	Est Cost (AUD)	Est Weight (g)	Est Delivery Time (Days)	URL
Raspberry Pi 4 (4GB)	$80.00	50	10	https://core-electronics.com.au/raspberry-pi-4-model-b-2gb.html?staticblockpopup=rpi_mixed
USB To 3.5mm Jack	$1.93	13	14	https://www.aliexpress.com/item/1005011581054350.html
Hydrophone transducer (PZT)	$30.00	15	15	https://www.aliexpress.com/item/1005005532825972.html
Power supply adapter (USB-C 5V 3A)	$2.14	60	11	https://www.aliexpress.com/item/1005005703532263.html
LoRa module (node)	$16.29	15	15	https://www.aliexpress.com/item/1005006539361701.html

Li-ion battery pack (1260110)	$10.89	60	60	https://www.aliexpress.com/item/1005007611232592.html
Microphone cable (5m)	$34.98	50	2	https://www.amazon.com.au/Outdoor-Lights-Waterproof-Connectors-Extension/dp/B07SZPZ769
32–128 GB high-end SD card	$19.00	5	0	https://www.cheapchips.com.au/sandisk-ultra-microsdxc-uhs-i-64gb
Mogami W2524 Unbalanced Instrument Cable	$4.60	50	30	https://toughaudio.com.au/product/mogami-w2524-bulk-gold-guitar-instrument-cable-black
MOGAMI W2964 Double Shield Coax Cable	$3.38	20	30	https://toughaudio.com.au/product/mogami-w2964-double-shield-coax-cable-4-8mm-od-per-m/

Mogami W2697 Miniature Balanced Mic Cable	$1.75	10	30	https://toughaudio.com.au/product/mogami-w2697-mini-balanced-microphone-cable-per-m
3.5mm Jack Male Terminal	$1.46	5	14	https://www.aliexpress.com/item/1005005812715035.html
GY-85	$5.23	10	14	https://www.aliexpress.com/item/1005012143179868.html
ClearWeld 5 Minute Epoxy	8.5	20		https://www.amazon.com/J-B-Weld-ClearWeld-Syringe-25mL/dp/B09C6R4VSQ/?th=1
Hydrophone buffer PCB	$30.00	56	14	https://www.jlielectronics.com/diy-accessories/dual-hydrophone-pcb/
Urethane resin (small kit)	$12.00	500	14	https://www.temu.com/au/-16-9oz--kit-clear-and-non-yellowing--self-leveling--1-1-casting-and--for--making-art-n-and-epoxy--g-601100807235659.html
Battery BMS / protection board	$5.05	12	12	https://www.temu.com/au/18650-battery-charging-module-type-c-port-charging-circuit-board-charging-board-suitable-for-3-6-3-7v-lithium-batteries-and-polymer-lithium-battery-charge--protection-featuring--functions-g-605811124354884.html

Stereo Aux Cable 3.5mm length 3m	$1.46	12	12	https://www.aliexpress.com/item/1005007286786952.html
GPS module (external)	$7.69	10	10	https://www.temu.com/au/-gy-neo6mv2-neo-6m-module-featuring-an--kit-for-with--and--in-robotics-g-601103014730725.html
On/off switch	$1.48	10	10	https://www.temu.com/au/one-piece-of-on-off-stop-switch-for-chainsaws-4500-5200-5800-and-45-52-58cc-suitable-for-replacement-of-spare-parts-g-601100220306963.html
USB to LoRa Data Transfer Module, Based On SX1262, Suitable For Data Acquisition In Industry And Agriculture	$19.79	30	14	https://www.aliexpress.com/item/1005010333249217.html
Hydrophone mold / misc	$1.00	50	14	Makerspace
9V Connector	$1.46	5	10	Makerspace
Silicone Grease	$2.00	5	1	Makerspace

Misc wiring/connectors/heat shrink	$0.50	20	1	Makerspace
Enclosure / buoy housing	$3.00	200	1	Makerspace
Fasteners (Rubber Band)	$0.05	5	1	Makerspace
Sealants / grommets	$0.10	50	1	Makerspace
Not counted in system weight.				

Appendix B - Risk Assessment RSK2600460

The published risk assessment [2]/

Appendix C - Testing Strategy

The MESH Operational Testing Strategy [2].

Appendix D - Project Schedule

Date	Day	Start	Finish	Total	Running Total	Phase	Plan
29/06/2026 00:00:00	Monday	8:00:00	17:00:00	9:00:00	9:00:00	Literature Review & Requirements Definition	Research existing systems. Project Requirements: Passive sonar, Shallow water acoustics, Marine Vessel Acoustic Signatures Databases, Vessel acoustic features, Range (frequency & distance), Minimum SNR, classification methods (neural networks, K-nearest neighbours, Gaussian, and decision tree techniques) System Constraints and Success: Power budget, Computation budget, Cost & Weight, Deployment (storage duration, time until active), Environmental (waterproofing, material degradation), Sampling Frequency, Processing Latency.
30/06/2026 00:00:00	Tuesday	8:00:00	17:00:00	9:00:00	18:00:00		
01/07/2026 00:00:00	Wednesday	8:00:00	17:00:00	9:00:00	27:00:00		
02/07/2026 00:00:00	Thursday	8:00:00	17:00:00	9:00:00	36:00:00		
03/07/2026 00:00:00	Friday	8:00:00	17:00:00	9:00:00	45:00:00		
04/07/2026 00:00:00	Saturday	8:00:00	17:00:00	9:00:00	54:00:00		
05/07/2026 00:00:00	Sunday	0:00:00	0:00:00	0:00:00	54:00:00	Break	
06/07/2026 00:00:00	Monday	8:00:00	17:00:00	9:00:00	63:00:00		Selecting hydrophone type

07/07/2026 00:00:00	Tuesday	8:00:00	17:00:00	9:00:00	72:00:00	System Architecture & Trade Study	(piezo vs electret) Designing analogue front-end: Gain staging, Filtering (anti-aliasing, band-pass), ADC selection and sampling rate justification. DSP prototyping of classification methods using TensorFlow Lite for Microcontrollers. Validate algorithms
08/07/2026 00:00:00	Wednesday	8:00:00	17:00:00	9:00:00	81:00:00		
09/07/2026 00:00:00	Thursday	8:00:00	17:00:00	9:00:00	90:00:00		
10/07/2026 00:00:00	Friday	8:00:00	17:00:00	9:00:00	99:00:00		
11/07/2026 00:00:00	Saturday	8:00:00	17:00:00	9:00:00	108:00:00		
12/07/2026 00:00:00	Sunday	0:00:00	0:00:00	0:00:00	108:00:00	Break	
13/07/2026 00:00:00	Monday	8:00:00	17:00:00	9:00:00	117:00:00	Data Acquisition	Timestamping, buffering, logging, sample integrity, clipping behaviour, synchronization.
14/07/2026 00:00:00	Tuesday	8:00:00	17:00:00	9:00:00	126:00:00		
15/07/2026 00:00:00	Wednesday	8:00:00	17:00:00	9:00:00	135:00:00	DSP Fundamentals	Time-domain detection FFT-based spectral analysis Feature extraction (band energy, harmonics, spectral centroid) Detection and catagorisation via different techniques
16/07/2026 00:00:00	Thursday	8:00:00	17:00:00	9:00:00	144:00:00		
17/07/2026 00:00:00	Friday	8:00:00	17:00:00	9:00:00	153:00:00		
18/07/2026 00:00:00	Saturday	8:00:00	17:00:00	9:00:00	162:00:00		
19/07/2026 00:00:00	Sunday	0:00:00	0:00:00	0:00:00	162:00:00	Break	
20/07/2026 00:00:00	Monday	8:00:00	17:00:00	9:00:00	171:00:00	Analogue Front-End & Instrumentation Design	Raspberry Pi Optimisation Algorithms: CPU load, Memory, Power, Performance, Documenting trade-offs.
21/07/2026 00:00:00	Tuesday	8:00:00	17:00:00	9:00:00	180:00:00		
22/07/2026 00:00:00	Wednesday	8:00:00	17:00:00	9:00:00	189:00:00	3D print Prototype	Test (buoyancy, instability, water ingress, vibration issues). Enclosure fabrication. Use both Makerspace and Fluids Lab.
23/07/2026 00:00:00	Thursday	8:00:00	17:00:00	9:00:00	198:00:00	Embedded Software	Configure RTOS with all local

24/07/2026 00:00:00	Friday	8:00:00	17:00:00	9:00:00	207:00:00		dependencies to be developed
25/07/2026 00:00:00	Saturday	8:00:00	17:00:00	9:00:00	216:00:00	Design Test	Evaluating test methodology: detection accuracy, false positives, compliance (risk, safety and ethics)
26/07/2026 00:00:00	Sunday	0:00:00	0:00:00	0:00:00	216:00:00	Break	
27/07/2026 00:00:00	Monday	8:00:00	17:00:00	9:00:00	225:00:00	Order parts	Order all online parts and continue buoyancy tests.
Total Mid Year Hours. Recommence in Summer Break					**225:00:00**	**Break**	
14/12/2026	Monday	8:00:00	17:00:00	9:00:00	234:00:00	Assemble System	Use both 8G22 and Makerspace. Bench testing: Noise floor measurement, Frequency response testing
15/12/2026	Tuesday	8:00:00	17:00:00	9:00:00	243:00:00		
16/12/2026	Wednesday	9:00:00	18:00:00	9:00:00	252:00:00	Controlled Experimental Testing	Running pool experiments with controlled sound sources, collecting and labelling data Evaluating detection accuracy and false positives Refining algorithms based on results, Calibration (sensitivity, System gain, Frequency response, Self-noise, Environmental noise).
17/12/2026	Thursday	8:00:00	17:00:00	9:00:00	261:00:00		
18/12/2026	Friday	8:00:00	17:00:00	9:00:00	270:00:00		
19/12/2026	Saturday	8:00:00	17:00:00	9:00:00	279:00:00		
20/12/2026	Sunday	0:00:00	0:00:00	0:00:00	279:00:00	Break	
21/12/2026	Monday	8:00:00	17:00:00	9:00:00	288:00:00	Controlled Experimental Testing	Iterate improvements in the testing regime according to performance requirements. Pilot testing regime in harbour to verify: waterproofing, logging, battery life, recovery procedure
22/12/2026	Tuesday	8:00:00	17:00:00	9:00:00	297:00:00		
23/12/2026	Wednesday	9:00:00	18:00:00	9:00:00	306:00:00		
Recommence in after New Years					**306:00:00**	Break	
02/01/2027	Saturday	8:00:00	17:00:00	9:00:00	315:00:00		

03/01/2027	Sunday	8:00:00	17:00:00	9:00:00	324:00:00	Full Deployment Verification	Deploying system in real coastal conditions, Recording acoustic data from RWCs and IRBs, Break for operators. Implementation of the recordings into classification data, Conduct testing of the system to detect and classify
04/01/2027	Monday	8:00:00	17:00:00	9:00:00	333:00:00	Full Deployment Verification (Backup)	Conduct intended Full Deployment Verification in Wollongong harbour instead. If this is not required because the Deployment Verification was successfully completed at NCSLSC, then skip onto the next section.
05/01/2027	Tuesday	8:00:00	17:00:00	9:00:00	342:00:00		
06/01/2027	Wednesday	8:00:00	17:00:00	9:00:00	351:00:00		
07/01/2027	Thursday	8:00:00	17:00:00	9:00:00	360:00:00		
08/01/2027	Friday	8:00:00	17:00:00	9:00:00	369:00:00	Analysis	Compilation of the data to conduct analysis of results. Evaluating real-world performance vs lab results
09/01/2027	Saturday	8:00:00	17:00:00	9:00:00	378:00:00		
10/01/2027	Sunday	0:00:00	0:00:00	0:00:00	378:00:00	Break	
11/01/2027	Monday	8:00:00	17:00:00	9:00:00	387:00:00	Documentation & Professional Reflection	Comparing performance vs requirements Identifying limitations and future improvements Writing technical documentation and reflection
12/01/2027	Tuesday	8:00:00	17:00:00	9:00:00	396:00:00		
13/01/2027	Wednesday	8:00:00	17:00:00	9:00:00	405:00:00		
14/01/2027	Thursday	8:00:00	17:00:00	9:00:00	414:00:00		
15/01/2027	Friday	8:00:00	17:00:00	9:00:00	423:00:00		
16/01/2027	Saturday	8:00:00	17:00:00	9:00:00	432:00:00		
17/01/2027	Sunday	0:00:00	0:00:00	0:00:00	432:00:00	Break	
18/01/2027	Monday	8:00:00	14:00:00	6:00:00	**438:00:00**	Finalisation and submission	Formatting, references and styling.
PEX Hours Obtained							

Appendix E - List of Tables

Project priority matrix Table i

Table ii: LoRa technical parameters

Table iii: Technical challenge summary

Table iv: Stakeholder requirements

Table v: facilities

Table vi: Cost categories

Table vii: Hazard summary

Table viii: Stakeholder interest and influence

Table ix: Summary of environmental impacts

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