MESH Operational Testing Strategy

Jonathan Walsh, 7678721, Bachelor of Mechatronic Engineering

Project Overview

This project aims to design, develop, and evaluate a passive acoustic detection and classification system for small marine craft operating in shallow coastal environments. It is known as the Modular Economical Sonobuoy Heuristic (MESH) and more information can be found at the project website[1]. The system will be tested progressively through laboratory validation, controlled experiments, pilot deployments, and operational coastal trials.

The full schedule can be found in the appendix. It serves as an update to the one in the proposal[2]. The premise and methodology are influenced by standard engineering R&D procedures as referenced in the proposal. More relevant projects, such as Salvatore Mauro's research on Calibration standards for hydrophones and autonomous underwater noise recorders for frequencies below 1 kHz[3], shall be consulted for operational strategies.

The operational strategy has been developed to ensure:

- fulfilment of project objectives
- safe and structured testing,
- realistic environmental evaluation,
- contingency planning,
- stakeholder coordination,
- and progressive risk reduction throughout development.

Contents

[1] https://jonowalsh.net/projects/MESH.html
[2] https://jonowalsh.net/projects/MESH/260209%201009%20MESH%20Proposal.pdf
[3] https://www.academia.edu/49777767/Calibration_standards_for_hydrophones_and_autonomous_underwater_noise_recorders_for_frequencies_below_1_kHz_current_activities_of_EMPIR_UNAC_LOW_project#title

Access and Facility Management

These facilities provide sufficient access windows to complete fabrication, assembly, testing, and validation activities.

- Fluids Laboratory (buoyancy testing): Monday-Friday, 9:00am-5:00pm
- Makerspace (primary 3D print and electronics workshop): Monday-Friday, 12:00pm-4:00pm (reduced outside of session)
- 8G22 laboratory spaces (secondary electronics workshop): access 24/7

Should access restrictions or scheduling conflicts arise:

- 8G22 will be used as an alternative electronics assembly and bench-testing environment,
- Wollongong harbour testing may substitute unavailable pool and ocean testing,

This contingency structure ensures project continuity even if stakeholders or facilities become unavailable.

Testing Philosophy

Testing will follow a staged systems engineering approach, progressing from:

1. controlled laboratory validation (fluids laboratory),
2. controlled experimental testing (pool),
3. pilot deployment verification (harbour),
4. full operational testing (ocean).

This staged approach reduces technical and operational risk by validating each subsystem before progressing into more complex environments.

Risk, Safety and Ethics compliance.

Risk, safety, and ethics compliance will be maintained throughout all laboratory, pool, harbour, and coastal testing activities through controlled operational procedures, environmental condition assessments, safe deployment and recovery practices, and adherence to relevant university and maritime safety requirements. All acoustic data collected during the project will be non-identifiable and limited to passive environmental and vessel-generated sound signatures, ensuring no personal, private, or sensitive information is recorded or retained. Testing activities will also aim to minimise environmental impact and operational interference with marine users, wildlife, and surrounding coastal activities.

Phase 1: Controlled Laboratory Validation

Dates: 14/12/2026 - 15/12/2026. Location: UOW Fluids Laboratory and UOW Pool.

Objective: To ensure suitable buoyancy and validate the basic functionality of the acoustic acquisition and classification pipeline under controlled conditions.

Methodology

Preliminary experiments will utilise acoustically distinct household appliances, including:

- stick blenders,
- kitchen mixers,
- and similar mechanically driven devices.

These devices will be operated in a controlled pool environment to emulate differing acoustic source signatures and mechanical frequency profiles.

If pool access is unavailable, equivalent testing will be conducted in calm ocean or harbour conditions.

Outcomes

This phase will evaluate:

- signal acquisition quality,
- detection reliability,
- feature extraction performance,
- source discrimination capability,
- clipping behaviour,
- and baseline DSP functionality.

The results will guide iterative refinement of:

- gain staging,
- filtering,
- sampling configuration,
- and classification algorithms.

Phase 2: Controlled Experimental Testing

Dates: 16/12/2026 - 19/12/2026. Location: UOW Pool.

Objective: To validate system performance using known acoustic targets under semi-controlled conditions.

Testing will include:

- calibration procedures,
- data collection and labelling,
- and repeatability analysis.

Calibration activities include:

- hydrophone sensitivity verification,
- system gain calibration,
- frequency response evaluation,
- environmental noise characterisation,
- and self-noise measurements.

Iterative Development Strategy

Controlled testing will intentionally support iterative refinement cycles between:

- hardware,
- DSP,
- and operational configuration.

Examples include:

- hardware testing informing DSP threshold selection,
- DSP analysis informing analogue filter redesign,
- environmental noise analysis informing gain-stage optimisation,
- and computational performance informing sampling-rate adjustments.

This iterative methodology ensures the system evolves according to observed operational behaviour rather than theoretical assumptions alone.

Phase 3: Pilot Deployment Verification

Dates: 14/12/2026 - 23/12/2026. Location: Wollongong Harbour and UOW Pool.

Objective: To verify operational readiness before full coastal deployment.

A short-duration harbour deployment will be conducted to evaluate:

- waterproofing integrity,
- enclosure stability,
- buoyancy behaviour,
- data logging reliability,
- battery endurance,
- and deployment/recovery procedures.

This phase is intended to reduce operational risk before open-water testing.

Phase 4: Full Operational Testing

Stakeholder Collaboration

Operational testing is proposed in collaboration with the Nowra Culburra Surf Life Saving Club. The full operational testing can occur during a training Search and Rescue Exercise.

Testing focuses on passive acoustic classification of:

- Rescue Water Craft (RWC / jet skis),
- Inflatable Rescue Boats (IRBs),
- and combined multi-vessel acoustic environments.

Alternative testing arrangements may be conducted through harbour-based operations if surf conditions or stakeholder availability prevent deployment.

Operational Deployment Procedure

Deployment Area

The preferred testing location is described by Figure 1:

- approximately 15 metres north of the race break,
- approximately 300 metres offshore,
- in water depths exceeding 5 metres,
- and approximately 50 metres clear of nearby rock formations.

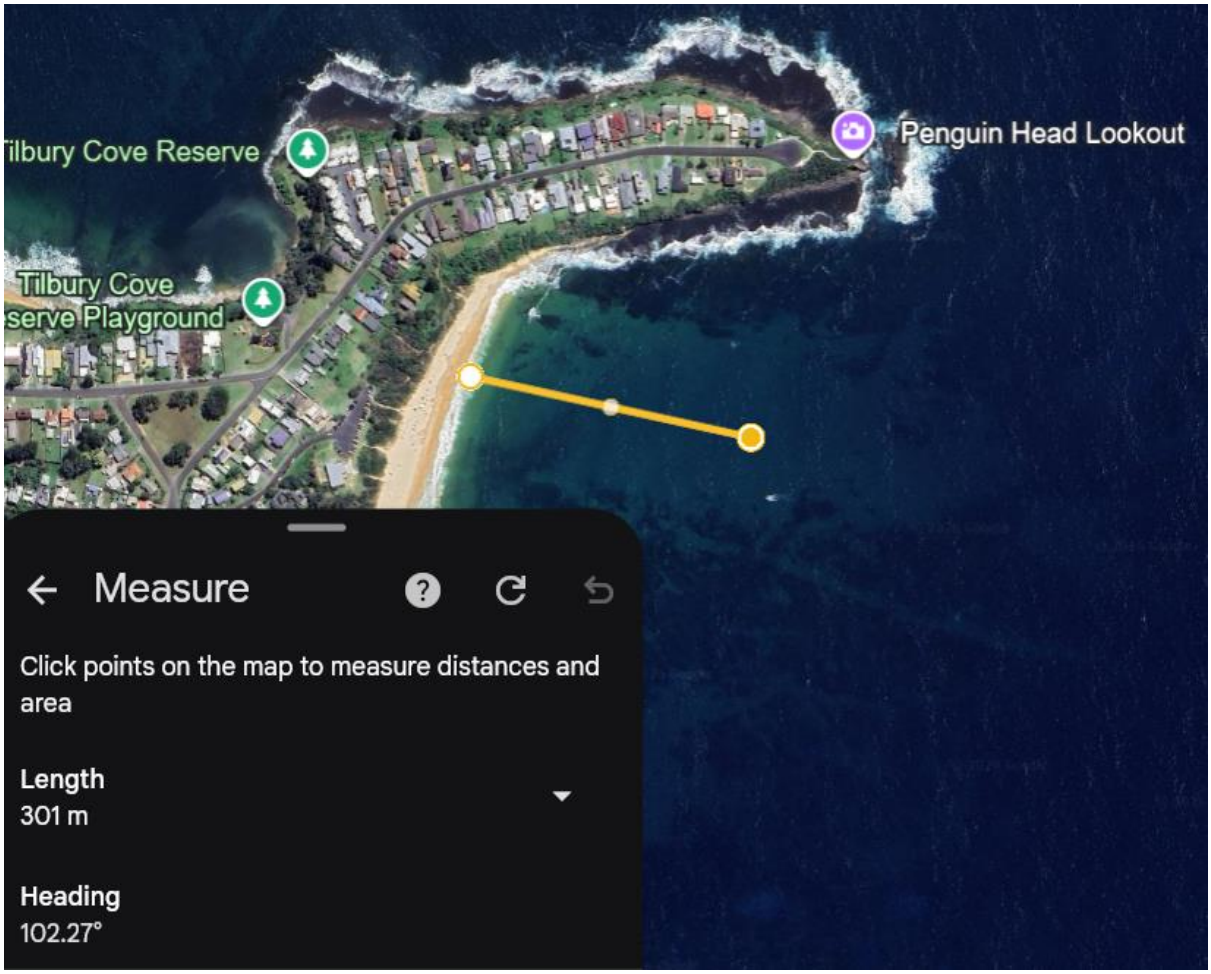

Figure 1

This location was selected to:

- minimise interference from shoreline reflections,
- reduce vessel congestion,
- minimise marine life disturbance,
- shielded from NE wind by headland
- and maintain operational visibility by safety crew

- minimum 430m range to LoRa communications, as described by Figure 2.

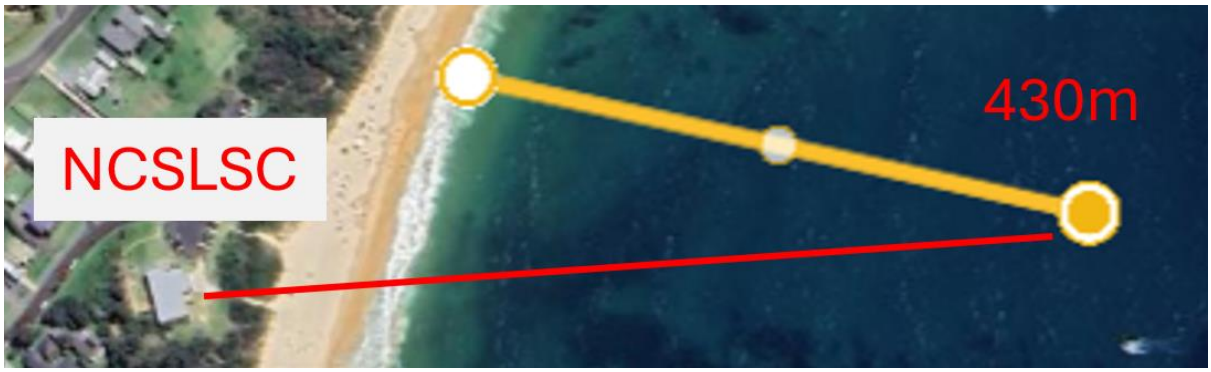

Figure 2

The sonar buoy will be deployed and recovered by the IRB.

Vessel Testing Regime

Testing will follow a structured creeping-line-search methodology with the path shown in black in Figure 3.

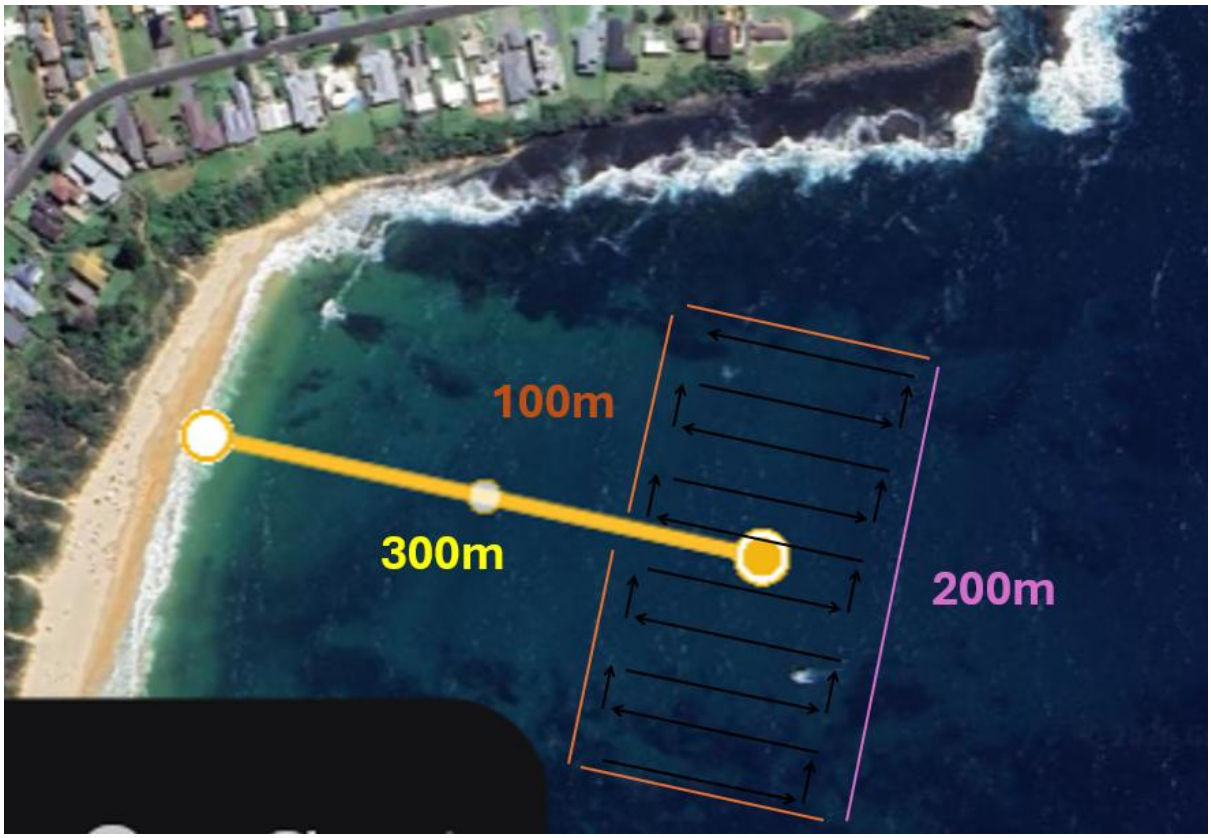

Figure 3

Sequence:

1. IRB-only testing
2. RWC-only testing
3. Combined IRB and RWC testing

This approach provides:

- varying acoustic aspect angles,
- varying distances,
- changing Doppler characteristics,
- and multiple SNR conditions for analysis.

Schedule

Full operational testing dates can occur on either of the following:

Date	Day	Start	End	Hours
02/01/2027	Saturday	8:00:00	17:00:00	9:00:00
03/01/2027	Sunday	8:00:00	17:00:00	9:00:00

It is understood that these dates occur during a busy time of the Surf Lifesaving Season. NCSLSC reserves every right to withdraw from participation with no indemnity. If this is the case, constringency deployment testing strategies shall be employed.

Start	End	Research Activity	Power craft Activity
8:00:00	10:00:00	Arrive and conduct setup of hardware.	Preparation of craft can occur anytime during this window.
10:00:00	11:00:00	Monitor and access sonobuoy via LoRa for recording.	Deploy, conduct the three creeping line searches, and recover sonobuoy. This can all occur in a one-hour window with an expected duration of thirty minutes.
11:00:00	13:00:00	Labelling and implementation of the recordings into classification data.	Break for operators.
13:00:00	14:00:00	Monitor and access sonobuoy via LoRa for detection and classification.	Deploy, conduct the three creeping line searches, and recover sonobuoy. This can all occur in a one-hour window with an expected duration of thirty minutes.
14:00:00	17:00:00	Collate results for documentation.	As required by PC

Environmental Requirements

Testing should ideally occur under the following conditions:

Parameter	Preferred Condition
Wind Direction	Any direction except easterly
Wind Speed	Less than 20 km/h
Significant Wave Height	Less than 1.5 m
Visibility	Clear
Rain/Fog	Minimal
Water Movement	Minimal
Pollutants/Contaminants	Minimal

These conditions are intended to:

- maximise recording quality,
- reduce environmental acoustic masking,
- and maintain safe operational conditions.

Safety and Operational Management

The testing regime includes:

- operator rest periods,
- controlled deployment/recovery procedures, {to be further developed}
- and environmental condition assessment before deployment.

Operational testing will only proceed when conditions are considered safe for:

- vessel operators,
- deployment personnel,
- and equipment recovery

Further risk assessments shall be completed on the 25/07/2026 during the assessment of risk, safety and ethics compliance.

Data Processing and Evaluation

Collected recordings will be incorporated into the detection and classification framework for:

- offline DSP analysis,
- algorithm training,
- feature extraction,
- and real-time detection validation.

System performance will be evaluated against:

- detection reliability,
- false positive rate,
- classification accuracy,
- environmental robustness,
- and operational consistency.

Contingency Strategy

The proposed testing regime remains adaptable.

If planned facilities or stakeholder participation become unavailable:

- harbour environments may substitute surf deployments and pool testing
- and alternative laboratory environments may substitute Makerspace or Fluids Laboratory access.

This flexibility ensures continuity of testing while maintaining project objectives and timeline requirements.

Project Delivery Strategy

The project schedule has been structured around:

- staged subsystem validation,
- iterative refinement loops,
- progressive operational complexity,
- and risk-managed deployment milestones.

Development progresses from:

1. theoretical research,
2. DSP and instrumentation design,
3. embedded implementation,
4. controlled experimentation,
5. pilot deployment,
6. operational field testing,
7. analysis and documentation.

Conclusion

This strategy is intended to maximise technical reliability while maintaining realistic engineering development practices suitable for an operational research project.

Appendix

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	System Architecture & Trade Study	Selecting hydrophone type (piezo vs electret) Designing analogue front-end: Gain staging, Filtering (anti-aliasing, band-pass), ADC
07/07/2026 00:00:00	Tuesday	8:00:00	17:00:00	9:00:00	72:00:00		
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		selection and sampling rate justification. DSP prototyping of classification methods using TensorFlow Lite for Microcontrollers. Validate algorithms
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 dependencies to be developed
24/07/2026 00:00:00	Friday	8:00:00	17:00:00	9:00:00	207:00:00		
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	Full Deployment Verification	Deploying system in real coastal conditions, Recording acoustic data from RWCs
03/01/2027	Sunday	8:00:00	17:00:00	9:00:00	324:00:00		

							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							

END OF DOCUMENT