NU Marine: Maritime RobotX Challenge 2026 Technical Design Report

University of Newcastle Australia (NU Marine)
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***Abstract*—NU Marine, the University of Newcastle's entry to the 2026 Maritime RobotX Challenge, is fielding a System of Systems comprising the uncrewed surface vessel Atlas, uncrewed aerial vehicle Artemis, and uncrewed underwater vehicle Bastet. Atlas's hardware scope was deliberately minimal, adding only the structural, electrical, and sensing changes needed for autonomous perception and RobotX's safety requirements, while Artemis was rebuilt from the ground up around a crash-tolerant, fast-recovery design philosophy. Both hardware programs were kept simple to protect development time for a shared autonomy stack: a Behavior Tree mission planner coordinating the SoS over ROS 2 and ArduPilot, a YOLO-based computer vision pipeline feeding a landmark-based mapping system, a dedicated acoustic localisation pipeline, and a dual-layer Hybrid A*/D* Lite guidance stack.**

With RobotX 2026 introducing a substantially revised, cross-domain competition format and no published task scoring available at the time of planning, NU Marine's competition strategy centred on establishing a validated baseline of capability rather than committing to an unvalidated portfolio of high-tier task attempts. On this basis, NU Marine is confident in its ability to complete the Core Tier across all four mission tasks, and is targeting the Advanced Tier for Safe Passage and the Disruptive Tier for Dynamic Incident Response, where existing platform capability already made a higher-tier attempt low-risk.

I. Introduction

NU Marine is a team of undergraduate students from the University of Newcastle, Australia (UON). The team has developed a System of Systems (SoS) comprising of uncrewed surface vessel Atlas, uncrewed aerial vehicle Artemis and uncrewed underwater vehicle Bastet (Fig. 2). Beyond competing in RobotX the team provides opportunity for undergraduate students to complete their final-year projects (FYP) and engage with our local industry partners. Working on NU Marine's competition platform provides students with hands-on experience in mechatronic systems integration in a team environment.

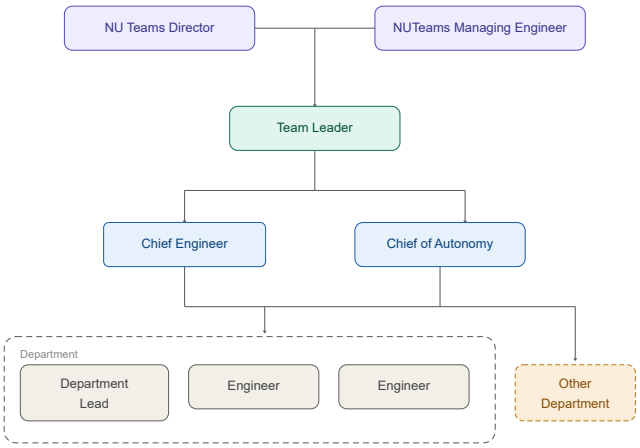


Fig. 1. NU Marine team organisational structure.

NU Marine is structured as shown in Fig. 1, the team sits under the NU Teams management and is broken into departments for our platforms. The team consists of a mix of final-year project students and junior students contributing through elective projects or in an extra-curricular capacity. A particular focus for 2026 has been increasing the number of junior students engaged in project work to improve NU Marine's year-on-year knowledge transfer. A key part of NU Marine's structure is giving FYPs and elective course students a scope of work for them to own giving accountability to each member.

With the significant changes to the competition for the 2026 cycle, NU Marine's strategy for 2026 has centred on creating a strong and validated baseline of capability for our SoS. The team has optimised the limited man hours available focusing on building a base for future team growth while submitting a competitive entry to the 2026



Fig. 2. NU Marine's System of Systems: Atlas (USV, centre), Artemis (UAV, left), and Bastet (UUV, right).

competition. The team put strong focus on the relative knowns of the USV and UAV platforms and played into our smaller size to allow strong collaboration across our departments. The hardware design for Atlas and Artemis were focused simple robust implementations that would get the vehicles in the water/air as much as possible to maximise time developing and validating software the software solution.

This strategic direction is underpinned by a testing methodology that NU Marine has progressively formalised since 2024. Every solution, from PCB design to mission-planning algorithm moves through simulation, workshop prototyping and finally on-water validation with constant evaluation that it meets the goals. This process is designed to maximise the value of time spent during development by catching potential issues early and ensuring solutions are solving the problem that is set out. Constant real-world testing also ensures that the team and platforms alike are stress tested and unknown issues can be identified and solved early.

This paper will detail how NU Marine's competition strategy has shaped the design of its three platforms and the software architecture connecting them, how the team's testing methodology was applied to validate mechanical, electrical, and software subsystems ahead of competition. Particular attention is given to the Behaviour Tree-based mission planner that coordinates the SoS, the landmark-based mapping pipeline that fuses camera and LiDAR detections and the testing methodologies NU Marine uses for different components of the SoS.

II. Testing Strategy

NU Marine focused on progressively performing appropriate tests for each solution as part of its competition platforms. Testing at a more in-depth/complex level was not completed until the requirements for the previous level had been met and demonstrated to team leadership.

At the beginning of every design, NU Marine used simulation and design software including MATLAB, Gazebo, KiCAD, OnShape and ROS/Python to test and/or flesh out the initial concept for its mechanical, electrical and software solutions.

Once simulation had been completed, team members moved on to prototypes involving physical hardware. This included rapid prototyping of mechanical solutions using additive and reductive manufacturing methods as well as breadboarding of all PCB circuits and hardware in the loop simulations (HITL) where the code was simulated again by running the software on the competition platform's processors.

The last and most critical level was "on the water" or equivalent testing, where all solutions underwent tests using real world environments to validate how they performed in less controlled conditions (Fig. 3).

NU Marine rigorously implemented these levels to reduce the amount of time and resources spent on finetuning solutions at a higher level where time was more valuable. I.e., time in the workshop for prototyping was more readily available than time on the water due to the required administrative effort.

A. *Testing Methodology*

NU Marine's testing process was developed to maximise the value gained from on-water testing and to connect directly with its design strategy. Once a design had been agreed upon, the testing process began with NU Marine leadership and its designer/s laying out a direction for testing the design. During this, the designer/s put forward two sets of pass/fail criteria, one for workshop testing and one for on-water testing, along with how each would be evaluated.

Following this, the designer/s simulated their solution across the following domains:

- Mechanical design/simulation was first undergone using OnShape, NU Marine's CAD package of choice due to its multi-user collaboration and NU Teams being sponsored by OnShape.
- Electrical circuits and PCBs were modelled in KiCad prior to prototyping. In addition to this, NU Marine implemented a detailed design review (DDR) for all its PCBs. During a DDR, the designer of the PCB and another, independent NU Marine member reviewed the PCB design using a checklist to analyse and/or correct the design choices made.



Fig. 3. Atlas (USV) navigating a buoy course during on-water testing at Throsby Creek/Carrington.

Once the solution simulation tests had been completed, team members began prototyping their solutions within NU Marine's workshop. Again, the methods for prototyping differed slightly across domains:

- Mechanical testing involved the use of rapid prototyping methods, including 3D printing, to validate physical connections and clearances.
- Electrical circuits were prototyped on breadboards before being ordered to validate they performed as expected.
- Software was run using a similar test as the first simulation step, except this simulation ran the developed software alongside the existing software solution on the competition platform's computational hardware as a hardware in the loop (HITL) simulation. In addition to this, NU Marine adopted the practice of also regularly testing the functionality of the dashboard used to start missions/tasks. This was to validate that when a mission was executed after implementing software changes/features, the competition platforms confirmed that they had successfully received the mission.

After constructing a viable prototype of their solution, the designer/s reconvened with NU Marine leadership to demonstrate their progress. During this, the workshop tests written at the beginning of the testing process were used to determine whether the solution met the requirements in the associated scope document. Once NU Marine leadership was satisfied that the solution met the requirements of the scope and the test had passed, the designer/s moved on to testing their solution on the water at one of NU Marine's "boat days" where the team simulated/worked towards simulating competition setup/runs at Throsby Creek/Carrington. During these boat days, team members tested their solutions in a real-world environment to validate their performance and robustness.

B. *Software Testing*

Before any platform is deployed in the field, NU Marine's software is validated through a combination of simulated and hardware-in-the-loop testing

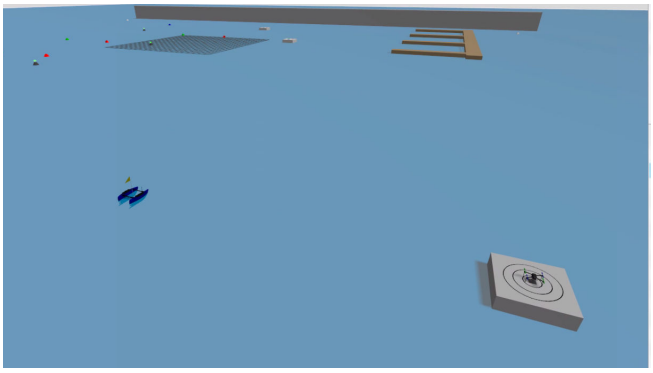


Fig. 4. Multi-domain Gazebo simulation environment, with each platform driven by its own ArduPilot SITL instance.



Fig. 5. Side-by-side of a 3D-printed UAV component prototype and the final waterjet-cut part, noting the design change between the two.

to catch integration issues early and reduce risk during physical trials. This starts with a virtual simulation environment and followed by validation in a low-risk environment – such as UAV camera testing from elevation, UUV actuation in a pool or USV navigation on an oval.

To validate its software before physical deployment, NU Marine runs a multi-domain Gazebo simulation (Fig. 4) in which the platforms operate simultaneously, each driven by its own ArduPilot Software-In-The-Loop (SITL) instance – ArduCopter for the UAV and ArduRover for the USV/UUV. These SITL environments respond to MAVProxy, identical to the physical platforms, and the tuned control parameters extracted from the physical platforms can be loaded directly into the SITL environments. Additionally, NU Marine's ROS 2 packages share the same mission logic and interfaces between simulation and physical deployment, assuming the same sensors are connected; switching between them is as simple as changing the Boolean flag on launch from `use_sim:=true` to `false`.

C. Mechanical Testing

Mechanical development for Atlas, Artemis, and Bastet relied heavily on rapid prototyping through 3D printing. Parts were printed early to check fit, mounting geometry, and structural feasibility before committing to final materials or production, allowing the team to iterate on designs in days rather than weeks.

Printed components for each platform were tested against the loads they'd actually see in operation. Artemis' airframe parts were checked for vibration resistance and mounting strength while keeping weight to a minimum, Atlas' components for water ingress and structural loading, and Bastet's external e-stop housing for durability under repeated use. Failures were treated as useful data. When a part underperformed, the failure mode was identified, the design revised, and a new version printed and retested. This print-test-revise cycle continued until each component met the reliability required for competition use.

Fig. 5 shows this process in practice, comparing an early 3D-printed prototype of a UAV component against the final waterjet-cut version. The printed part was used to validate geometry and mounting points quickly and cheaply, while the waterjet-cut part represents the design once dimensions and load requirements were confirmed. This progression from rapid, low-cost prototyping to final manufacturing was applied consistently across all three platforms, keeping design iteration fast without compromising the durability of final components.

D. On-Water Testing

Testing in an environment as close as possible to the one NU Marine will find at RobotX 2026 was crucial to ensuring the team's competition solution was as prepared for the rigors of competition as possible. The team prioritised the production of infrastructure such as buoys, light beacons and other course elements to simulate mission tasks (Fig. 3). In addition, on-water

testing is a valuable time to ensure the team's procedures and processes for things like deploying the USV/UUV/UAV, running scripts/code and practicing recovering vehicles after unexpected behaviour.

III. Design Strategy

At the beginning of the development cycle, NU Marine leadership defined a project scope addressing a problem within the competition System of Systems (SoS) and assigned it to one or more team members to solve. Each scope prescribed NU Marine's design philosophy and a decision matrix for evaluating candidate solutions. Once the assigned team member(s) had brainstormed the best available solutions and evaluated them against the matrix, they reconvened with NU Marine leadership to present their findings and agree on a plan of action.

A. USV (Atlas)

Atlas' scope was deliberately minimal: rather than redesigning the platform, the team focused on the smallest set of structural, electrical and sensing additions needed to support autonomous perception and navigation, while meeting RobotX safety requirements.

Structurally, propeller guards and rear guards were fitted to protect the twin thrusters during on-water testing, along with a light tower and E-stop assembly to satisfy RobotX's requirement for a clearly visible, physically actuatable emergency stop. The electronics enclosure was also replaced, moving from the original see-through plastic box to a matte, hinged, sealed container mounted directly to the sensor platform.

A sensor mounting platform was designed and built from aluminium extrusion, providing a rigid, modular structure independent of the hull. It carried the forward-facing Blackfly S camera, the Hesai XT32 LiDAR, and the Advanced Navigation Spatial Dual. The dual GNSS antennas were mounted on the pontoons, maximising the antenna spacing across the hull. The light tower was also mounted on this platform, consolidating all mast-height hardware into a single structure.

The onboard PC and the rest of the sensor suite ran on 19.5 V, stepped up from the 4S battery pack by a DC-DC converter; the camera was powered separately.

B. UAV (Artemis)

A major milestone for Artemis this cycle was achieving autonomous flight for the first time since the platform was reintroduced to the competition. Artemis was rebuilt from the ground up for the 2026 RobotX cycle, with only a handful of components inherited from the previous platform. This meant the rebuild started with hardware validation and systems integration rather than autonomous flight tuning. A benefit of this overhaul was that the team could build fast diagnosis and fast failure recovery into the design as requirements from day one, rather than treating them as afterthoughts. This intention paid off by reducing UAV repair downtime, the team was able to iterate on and improve Artemis' autonomous flight reliability far more quickly than would otherwise have been possible. Combined with expanded onboard telemetry, this meant that whenever an issue did arise, the team could identify the root cause, make the necessary fix, and get Artemis back in the air with minimal delay.

C. UUV (Bastet)

2026 marked the first year that NU Marine has worked on the development of a submersible since before 2020. Bastet is a Blue Robotics BlueROV2, kitted with a Ping360 Sonar from the old submersible, and a brand new DVL A50 to allow for dead reckoning, and thus autonomous movement relative to known locations. NU Marine's intention is to tether Bastet to the USV's onboard PC, utilising its known GPS coordinates as reference points, and allowing the USV to act as an intermediary for communication with the UAV. A physical E-STOP was created by attaching a 3D printed PETG collar around the electronics enclosure, holding a magnet attached to a rod. When the rod is pulled away, a magnetic switch inside of the electronics enclosure grounds the PWM input to the ESCs, stopping all movement immediately.

D. Software Solution

The NU Marine autonomy stack is designed as a distributed "System of Systems," seamlessly integrating its USV (Atlas), UAV (Artemis),

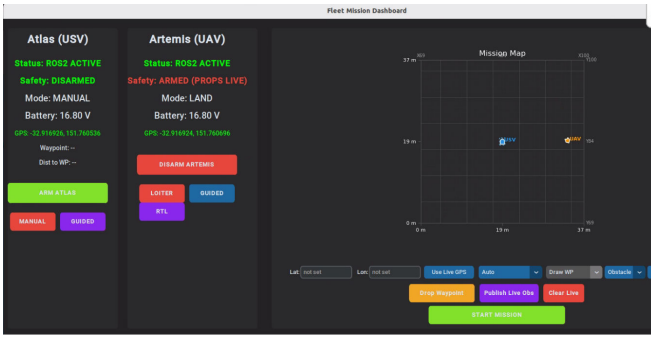


Fig. 6. NU Marine's Operator Control Station (OCS) dashboard, showing live status and control for Atlas (USV) and Artemis (UAV) alongside the shared mission map.

and ROV (Bastet). At the core of its high-level architecture is ROS 2, which facilitates asynchronous inter-process communication, sensor data fusion, and dynamic coordinate handoffs via shared topics. Low-level hardware interfacing and flight/drive mechanics are managed by ArduPilot, with telemetry and commands routed through dedicated MAVLink bridges.

To effectively command and monitor this autonomous fleet, the team developed a custom Graphical User Interface (GUI) serving as the primary Operator Control Station (OCS), shown in Fig. 6. Built using Tkinter and integrated directly into the ROS 2 network, the OCS provides real-time situational awareness and centralised mission orchestration. It translates raw telemetry and perception data, such as dynamic buoy maps populated by the UAV and local costmaps generated by the USV, into a unified, intuitive visual display. This dashboard allows operators to monitor hardware health, verify active data association, and reliably trigger master mission sequences with minimal latency, ensuring robust human-in-the-loop oversight during competition deployment.

Given the complexity of managing multi-domain robotics across a diverse engineering team, maintaining a rigorous version control pipeline is critical. The team's collaborative workflow is built entirely on Git and GitHub, enforcing strict repository management to ensure code stability.

- **Protected Branches:** The 'main' branch is highly protected, requiring peer-reviewed pull requests and successful local hardware-in-the-loop (SITL) builds prior to integration.
- **Naming Conventions:** Standardised branch naming conventions are strictly enforced to track feature development, hardware-specific integrations, and mission testing pipelines.

1) Mission Planning and System of Systems Coordination: To manage the complex, multi-domain coordination required for the RobotX Autonomy Challenge, NU Marine utilises a Behavior Tree (BT) architecture implemented via the 'py_trees' Python library. Unlike traditional Finite State Machines (FSMs), which become exponentially complex and rigid as new failure states are introduced, Behavior Trees inherently modularise decision-making. The BT acts as the centralised mission director, executing tick-based logic at 10 Hz to evaluate environmental conditions, sequence task execution, and enforce continuous fault tolerance.

Crucially, the mission planner strictly isolates high-level decision-making from low-level kinematic execution. The BT does not calculate trajectories; rather, it dispatches commands via ROS 2 Action Servers and asynchronous topics to dedicated subsystems, such as the Hybrid A* path planner, allowing for highly reactive, non-blocking mission management.

The overarching mission structure is heavily reliant on Sequence and Parallel composite nodes to coordinate the USV (Atlas) and the UAV (Artemis). For tasks such as the buoy channel navigation, the BT enforces a strict "scout-then-navigate" handoff. A Sequence node guarantees that the USV will not receive passage commands until the UAV has successfully completed its aerial search pattern, landed, and returned a 'SUCCESS' status.

Simultaneously, the execution sequences are wrapped in Parallel "Guarded Execution" nodes configured with a 'SuccessOnAll' policy. This enables the continuous background monitoring of critical hardware telemetry, such as battery voltage. If a subsystem crosses a critical threshold, the Parallel guard instantly fails, safely halting the current ROS 2 Action Server and triggering an overarching Fallback (Selector) node to initiate safety protocols.

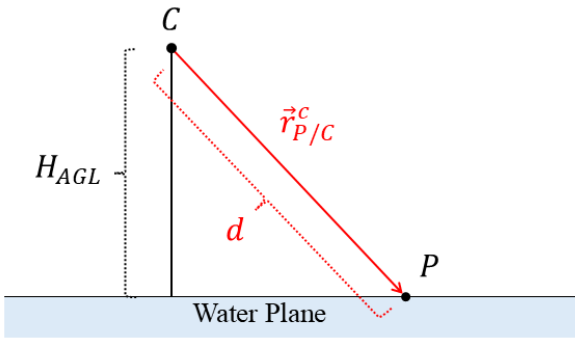


Fig. 7. Water-plane intersection: ranging a bearing ray to an arbitrary point of interest P using altitude alone.

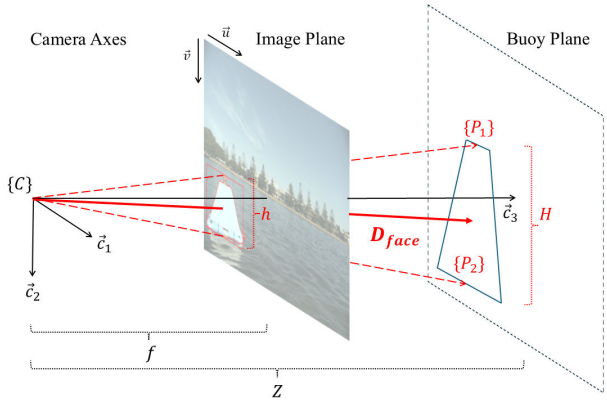


Fig. 8. Known object dimensions (buoy example): geometric model used for bearing and range estimation.

2) Computer Vision: NU Marine's platforms use onboard cameras for object detection and geolocation. NU Marine has trained fast inference YOLO 11/26 models to be able to detect objects of interest such as buoys and landing platforms. 1000s of photos have been taken to train a robust fast inference model ready for deployment. Each platform's camera is calibrated with the model appropriate to its lens: Artemis (UAV) uses the double sphere camera model [1] to account for its wide-FOV lens, while Atlas (USV) uses the standard pinhole model [2]. In both cases, calibration lets the system convert a pixel detection into a calibrated unit bearing ray $\hat{\mathbf{r}}^c_{P/C}$ from the camera C to the point of interest P. Range to P is then found in one of two ways.

Water-plane intersection. For any point of interest, using the vehicle's altitude H_{AGL} and the camera-to-world rotation $\mathbf{R}^n_c$, the ray is extended until its Down component reaches sea level (Fig. 7), adapted from the team's earlier ground-plane ranging approach [3]:

$$d = \frac{H_{\text{AGL}}}{\begin{bmatrix}0 & 0 & 1\end{bmatrix}\mathbf{R}^n_c\,\hat{\mathbf{r}}^c_{P/C}}, \qquad \mathbf{r}^c_{P/C} = d\,\hat{\mathbf{r}}^c_{P/C},$$

where $\begin{bmatrix}0 & 0 & 1\end{bmatrix}$ extracts the Down component of the rotated ray.

Known object dimensions. For any object whose physical dimensions are known in advance, e.g. buoys, docks, and landing/take-off pads, its known size and the detector's own output geometry can be used in tandem to estimate range, extending the same angular-size ranging principle used previously by the team [3]. For a buoy of known height H and width W, for example (Fig. 8), similar triangles between the detected bounding-box height h and focal length f_y, and the buoy's own physical dimensions, give the depth to its near face D_{face}; adding half the known width offsets this to the object's centre, and dividing by the ray's own component along boresight corrects depth to true range D:

$$Z = \frac{f_y H}{h}, \qquad D = \frac{Z + W/2}{\begin{bmatrix}0 & 0 & 1\end{bmatrix}\hat{\mathbf{r}}^c_{P/C}}.$$

Furthermore, by translating this camera frame bearing and range estimate to the platform's body frame, the platforms can geolocate themselves to assist in tasks such as reconnaissance, navigation or landing.

3) Mapping: Mapping fused the forward-facing camera's YOLO-based buoy classification with LiDAR range and bearing to detect and track buoys as the vessel transited the course. Confirmed detections were maintained as persistent landmarks, anchored to the Spatial Dual's global pose rather than relying on SLAM loop closure for landmark accuracy. In parallel, LiDAR returns were converted into a 2D occupancy grid for general obstacle avoidance, kept separate from the buoy landmark layer so transient detections didn't pollute the persistent course map. Buoy landmarks fed the guidance and mission-planning layers directly, while the occupancy grid fed Nav2's local costmap for reactive avoidance.

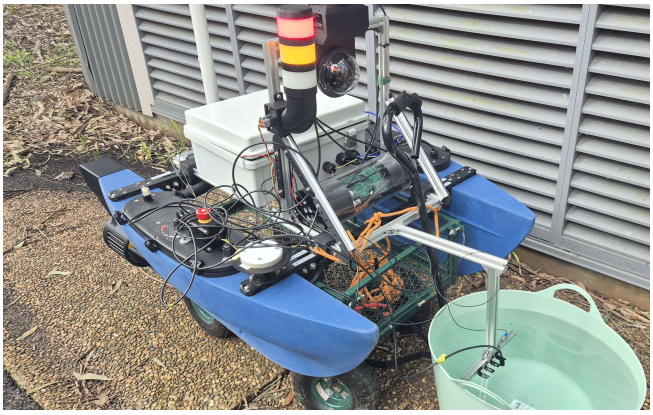


Fig. 9. Bench testing of the four-channel hydrophone array, submerged in a water tub.

4) Acoustic Localisation: The acoustic localisation pipeline is designed to passively detect, isolate, and track an active acoustic pinger in a shallow-water environment. The architecture is divided into a synchronous hardware acquisition layer, a digital signal processing (DSP) pipeline, and a probabilistic state estimation node integrated into the fleet's ROS 2 autonomy stack.

E. Hardware Acquisition & Synchronisation

Acoustic pressure waves are captured by a four-channel linear array of AS-1 hydrophones, passed through PA6 preamplifiers providing approximately +20 dB of gain, and fed into a custom signal-conditioning PCB featuring differential amplifiers and an analog bandpass filterfor each channel (Fig. 9).

Digitisation is handled by a pair of Teensy 4.0 microcontrollers utilising hardware interrupts to trigger simultaneous 12-bit ADC reads across all channels at a 100 kHz sample rate.

A background ROS 2 thread continuously ingests the serial stream from the Teensys into a 12,000-sample rolling buffer, guaranteeing 120 ms of historical data retention to prevent data loss between 10 Hz polling ticks.

F. Bearing and Range Estimation

The isolated 4 ms signal is processed to estimate both the relative angle of arrival and the physical distance to the target.

Phase Beamforming:
The pipeline employs a phase beamformer restricted to a 180° forward-facing search space to resolve bearing ambiguity. A Hilbert transform extracts the analytic signal, and phase shifts are calculated based on the precise microsecond delays between the hydrophone elements. The steering vector relies on the wave number k:

$$k = \frac{2\pi f}{c} \tag{1}$$

where f is the target frequency and c is the speed of sound in water (1500 m/s).

Passive Ranging:
Distance is estimated by calculating the True RMS voltage of the filtered acoustic slice and reversing the spherical spreading loss. Propagation loss (PL) is calculated utilising the source level (SPL_{src}) and the measured level at the hydrophone (SPL_{hyd}):

$$PL = SPL_{src} - SPL_{hyd} \tag{2}$$

The physical range r (in meters) is then extracted using:

$$r = 10^{\frac{PL}{20}} \tag{3}$$

G. State Estimation & Autonomy Integration

To make the acoustic data actionable for the navigation stack, the raw polar measurements (bearing and range) and the vessel's real-time GPS latitude, longitude, and heading are fed directly into an Unscented Kalman Filter (UKF). Because the conversion from a vehicle-relative polar observation to a global Cartesian (X/Y) state space is highly non-linear, the UKF employs the Unscented Transform to accurately map the probability distribution of the acoustic data into the global coordinate frame.

This continuous tracking approach mathematically smooths the target's estimated global position over time, intrinsically filtering out outlier pings and ghost reflections caused by multipath interference.

1) Guidance: Autonomous marine navigation requires translating high-level mission objectives into safe, kinematically feasible trajectories while continuously reacting to dynamic environmental hazards. To achieve this in the RobotX competition environment, the NU Marine guidance architecture utilises a dual-layered approach. The system dynamically switches between specialised

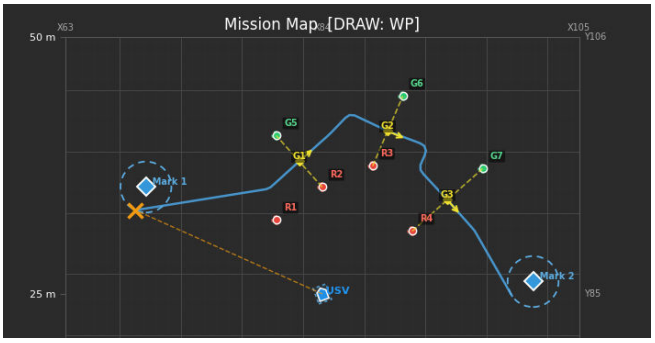


Fig. 10. Example Hybrid A* corridor plan for Mission 1 (Safe Passage): the planned path enters at Mark 1, threads the RED/GREEN buoy field keeping green buoys to port and red buoys to starboard, and exits at Mark 2.

planning algorithms depending on the spatial constraints and rule-based requirements of the active mission area.

For the taks of Mission 1 requiring strict rule adherence, NU Marine's guidance stack turns a map of detected marks into a drivable path in real time. The team built a class-labelled Voronoi roadmap of the field (the set of routes that stay maximally clear of every obstacle) and it searches the field for a corridor that respects competition rules, such as keeping green buoys port and red buoys starboard, following a Voronoi-guided Hybrid A* approach with safe-corridor constraints [4]. A Hybrid A* algorithm plans a path based on the global map delivered to the boat, and then a smoother turns that corridor into a curvature-feasible path the hull can follow, which is handed to the ArduPilot autopilot as GUIDED-mode waypoints (Fig. 10). As new or moved marks arrive, the planner re-threads the corridor on the fly, so the boat continuously replans against the world it is currently seeing, with respect to the obstacle field delivered on the global map data.

For navigation outside of Mission 1, Atlas utilises a highly optimised D* Lite planner, which provides rapid, incremental replanning across a localised Cartesian grid by updating only the affected portion of the graph as obstacles appear or move, rather than recalculating the route from scratch. To translate this discrete, grid-based output into smooth physical movement, the transit planner employs a dynamic adaptive lookahead algorithm that projects a pure-pursuit target along the route: the lookahead distance extends on open straightaways to maximise transit velocity, and clamps down around obstacles or sharp turns to force the ArduPilot controller to decelerate and track the path tightly.

IV. Competition Strategy

NU Marine's competition strategy for RobotX 2026 reflected the team's broader goal for the cycle: establishing a validated baseline of capability across Atlas, Artemis, and Bastet ahead of a substantially revised competition format. At the time the strategy was set, the RobotX 2026 Team Handbook's Scoring and Awards section had not yet published point values for individual tasks or tiers, and the mission task specifications themselves continued to change throughout the drafting period. With no reliable numeric basis on which to weigh task attempts against each other, NU Marine adopted a deliberately conservative, readiness-first strategy rather than committing to a portfolio optimised against point values it did not yet have.

Every task's Core Tier was treated as a non-negotiable floor, with Advanced or Disruptive Tier attempts committed to only where an existing platform capability already made that tier low-risk. This prioritised the amount the team could reliably learn from the competition to inform future cycles over maximising nominal task coverage, while still fielding every RobotX-compliant platform to gather the broadest possible on-water dataset regardless of any single attempt's score. Validating the RoboCommand communications interface across all three platforms was treated as a first priority ahead of any task-specific behaviour, since no attempt at any tier could score without a reliable link to the judging system.

A. Mission 1: Safe Passage

For Safe Passage, NU Marine targeted the Advanced Tier, in which Artemis (UAV) is solely responsible for detecting the buoy field's entry and exit markers and RED/GREEN buoy classifications from overhead and relaying them to Atlas (USV) for surface transit – this was judged the most validated way to demonstrate the UAV's onboard visual navigation and geolocation pipeline (Section III-D2) against a real scoring task, rather than treating aerial perception as a

standalone demonstration. Because the Core Tier's side-facing buoy lights are directly visible to Atlas's own forward-facing camera and mapping pipeline (Section III-D3), the team retained the Core Tier, USV-only perception of the buoy field. This gave an explicit fallback, so a failure of the UAV's detection capability does not sacrifice the teams ability to attempt mission 1.

B. Mission 2: Infrastructure Survey and Repair

Bastet's (UUV) diving, station-keeping, and pipeline-following capability had not been validated to a standard NU Marine was confident deploying, whether tethered to Atlas or operating independently, so Task 2 effort was redirected to the achievable subset of the Core Tier: localising the active acoustic pinger marking the survey start point and reporting its position to RoboCommand. This was implemented as a dedicated acoustic localisation pipeline (Section III-D4) designed to run on either the USV or the UUV, giving NU Marine a path to partial Task 2 credit – and a validated acoustic sensing capability to build the full pipeline survey and repair behaviour on top of in future cycles – without depending on Bastet's readiness this year.

C. Mission 3: Coordinated Logistics

NU Marine's Task 3 strategy was deliberately minimal: attempt only the first half of the Core Tier – locating and docking Atlas in the correct bay, then detecting and reporting the active, RED-lit target window (the "fire") to RoboCommand. Completing the water-delivery portion of the Core Tier was left out of scope, as investing further time in Atlas's core capabilities was judged more valuable than fielding a half-built water-delivery mechanism. The Advanced and Disruptive Tiers' UAV resource-delivery behaviours were not attempted, since Artemis had not reached a stage of development where a reliable payload-delivery system could be built.

D. Mission 4: Dynamic Incident Response

For Dynamic Incident Response, NU Marine committed to the Disruptive Tier with high confidence because the required behaviour – breaking off current tasking, avoiding a newly reported hazard, and resuming the mission – is largely a direct consequence of capability already built for other tasks rather than bespoke engineering. Atlas's D* Lite planner already re-plans continuously against a live occupancy grid (Section III-G1), and the Behavior Tree mission architecture's Parallel Guarded Execution and Fallback nodes (Section III-D1) already interrupt and reroute the active task when a monitored condition is violated; treating a RoboCommand keep-out zone or moving-object report as another such condition meant Task 4's Disruptive Tier largely fell out of the SoS's existing guidance and mission-planning design, rather than requiring a new capability built specifically for it.

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