RoboSub 2026 Technical Design Report

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Abstract— **For the 2026 RoboSub competition, AUVic is designing, constructing, and deploying Snappy, a drastically improved AUV specifically designed for the tasks of RoboSub 2026. The vehicle features a ground up redesign of the electrical system encompassed by a redesigned lightweight aluminum chassis. Each design change stemmed from a past struggle or complaint creating a more robust, successful, and user-friendly submarine. The software system has been overhauled to account for all new mission equipment, sensors, as well as changes in the name of computational speed. Each of the claw, dropper, and torpedo systems have been re-designed to create the most repeatable and accurate systems.**

I. Competition Strategy

Our main objectives for RoboSub 2026 have been split up dependent on the sub teams. For both Electrical and Mechanical teams, the goal has been to produce a hardware package that is able to complete every course component including all advanced and disruptive challenges. For the software team, the main goal has been to design a robust movement system to effectively navigate the slalom and align the AUV with tasks, as well as implementing advanced perception to reliably classify objects in its path.

A. Overall strategy

After competing in RoboSub 2025 AUVic learned a lot as a team about features missing from the vehicle as well as better approaches to the given problems. For this reason, the team undertook a full rebuild immediately following our return from competition. While this introduced a large amount of risk into the competition plan, it was a unanimous decision to move forward. This would bring with it a platform capable of completing all competition tasks while also allowing for future development in following years.

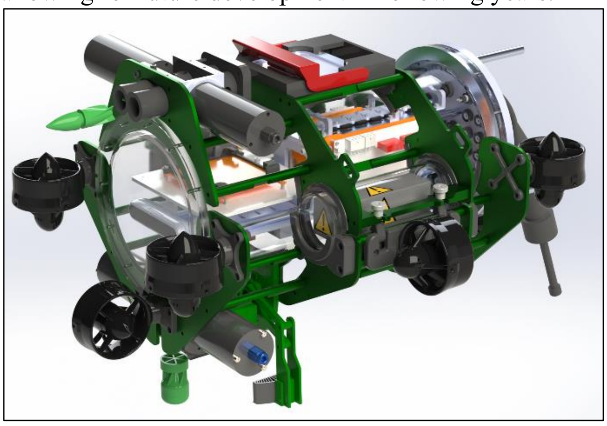

Figure 1: Snappy Vehicle Render

The team's realistic goal for competition this year will be to have a fully functional navigation computer system model able to confidently complete the coin flip, gate, barrel roll, and slalom portions of the course repeatably. Once the team is confident with this, the team is expecting to have the ability to have a chance at completing the dropper, torpedo, and octagon tasks. With the electrical and mechanical teams being fully prepared for these tasks, software implementation of these tasks will take second priority to the main navigational based tasks. It was decided that this approach will create the most robust competition plan; one can be added upon without infringing on our ability to complete the initial tasks.

B. Platform changes

1) Mechanical

After using the same vehicle chassis passed down from the 2018 team, it was decided that the chassis needed a full redesign to optimize new regulations as well as improved technology. A lesson learned at the last competition was that time is everything when something goes wrong during practice and finals runs. For this reason, the new chassis was designed with quick access and diagnostics in mind.

Alongside the new upgrades to the electrical system, new battery enclosures were needed. With the size of the batteries decreasing by more than half, smaller less buoyant enclosures were needed.

With the ambition of having the ability to complete all tasks and challenges in competition, one of the main changes needed was a more acrobatic vehicle. The previous chassis was designed with a very safe static stability limiting the number of challenging maneuvers it was capable of. The software team was confident that we would be able to build a PID system capable of handling a more aggressive design. To have some natural stability it was decided that we would create a COB and COG within 3 inches vertically. This would introduce a large amount of instability while being controllable. This year's chassis design has attained this while still creating a user friendly and quickly accessible vehicle.

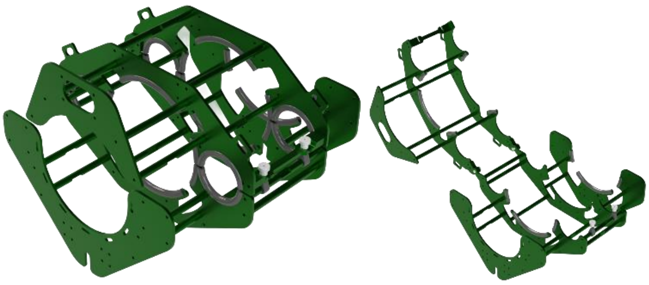

Figure 2: Snappy Chassis

2) Electrical

Like Mechanical, the electrical system was given a large overhaul from previous years. The previous system struggled due to technical debt which made integrations with new components difficult. The goal was to streamline the design, enabling a greater level of control and reliability, while simplifying control and firmware design.

The main change to the system this year was to create a new power distribution board, dubbed the "Mower" board. This consolidated the power distribution and motor control signals to one board. This reduced cost, increased efficiency, and enabled a more convenient board shape for cable routing and stress easing.

The firmware was simultaneously updated as the Mower board required new firmware. Some of the previous firmware could be ported to the new board as stm32 chips were used for both systems. The firmware was also restructured to create a ROS node on the Mower board.

Finally, the wiring harness was redesigned for this year. In part because the power system is using a new board to ensure reliable operation of the sub this year.

3) Software

After competition in 2025, the software team identified 2 main issues. The first is that, using Python as the main programming language, computer vision became a bottle neck, especially as the frame rate increased. Secondly, the computer vision model used in competition lacked preprocessing functionality which led to the model performing poorly on data with differing conditions from the training data. Because of these two issues, the software team decided to move from Python to C++ for greater performance, and the computer vision pipeline has been redesigned from the ground up to appropriately handle varying real-time data.

II. Design Strategy

A. Snappy Mechanical Improvements

With last year's goals of qualification, task specific equipment was limited. This year the team took on the tasks of designing an all-new claw, torpedo, and dropper systems.

1) Torpedo System

The torpedo subsystem was designed to complete the RoboSub deployment task with improved accuracy and repeatability at increased firing distances. The system uses a spring-driven launch mechanism with a pull-type solenoid release, which enables consistent firing. Early prototypes exhibited unreliable release and insufficient actuation force. The redesign focused on quantifying release requirements and improving actuation reliability.

Release force was experimentally determined using a scale and pin setup. Results showed that ~8 N was required to disengage the mechanism under load. Additional friction from waterproofing elements, such as O-rings, was accounted for, and a higher force solenoid was selected to ensure reliable actuation. To further improve the system, a pull-rod style mechanical advantage was added. This removed off axis reaction forces from cocking the shaft in the O-ring sealed bore.

The launcher assembly prioritizes manufacturability and consistency. Delrin barrel tubes were selected for low friction, corrosion resistance, and ease of machining. Delrin is also used for structural mounts to provide lightweight, rigid support. The design uses standardized fasteners for ease of assembly, with custom fasteners where required. Barrel features, including water inflow holes, reduce hydrodynamic resistance during firing, supporting reliable and repeatable operation.

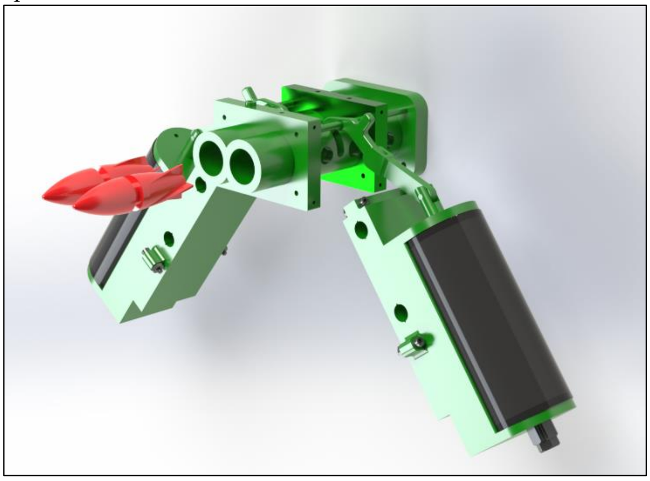
Figure 3: Snappy Torpedo System

The torpedo projectiles are custom 3D printed components iteratively optimized. Metal inserts control mass distribution, with center of mass verified in SolidWorks to improve stability. The design targets near-neutral buoyancy to minimize vertical drift throughout the trajectory. Rifled fins provide spin stabilization for improved trajectory consistency. Iterative testing and CFD analysis were used to refine body geometry, fin design, and mass placement.

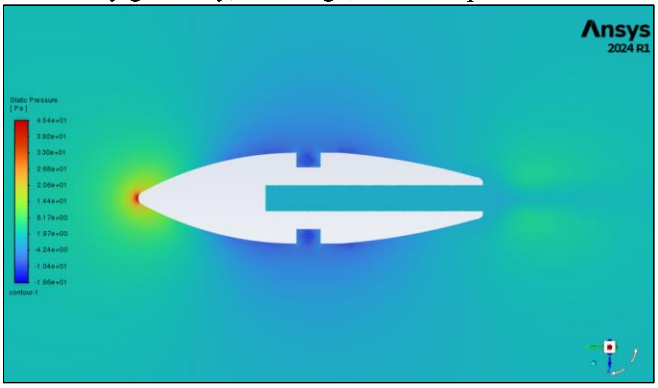

Figure 4: Torpedo CFD

2) Claw System

The design of the claw was completely overhauled for this year's competition cycle to meet cost and space constraints. The claw consists of two mirrored four-bar mechanisms driven by a single ~5 V, ~1.7 Nm servo motor, transmitting torque to both mechanisms simultaneously through a geared connection.

The mechanism was designed to have no profile while fully retracted, allowing it to fit entirely within the frame and remain fully protected from damage caused by the pool floor or obstacles. To prevent obstructing Snappy's bottom facing camera view, the claw is designed to have a minimal longitudinal profile.

Most of the system, excluding the fasteners, servo, and servo shaft/hub, are 3D printed to reduce cost. The claw pads were printed with flexible material and designed to conform around different shapes to maximize contact area.

Due to the high cost of waterproof servos, a custom waterproof enclosure was designed in-house. The enclosure was 3D printed and coated in epoxy to prevent water ingress through the printed part's layer lines. The wire connection is also coated in epoxy, preventing water ingress through the wires. The shaft hole has a machined Delrin seal bonded to the 3D printed enclosure, providing a smooth surface for an O-ring seal.

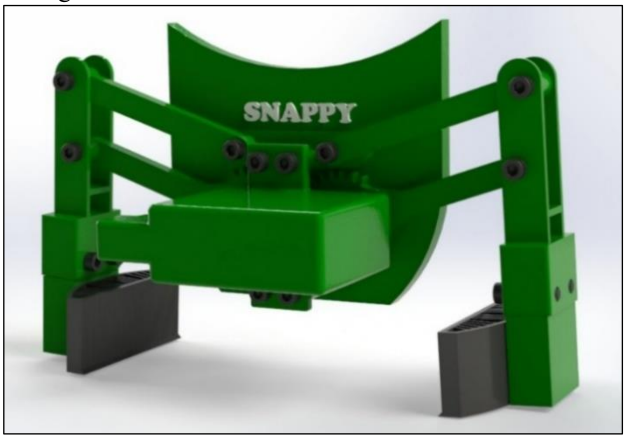

Figure 5: Claw System

3) Dropper System

The dropper system has been redesigned this competition cycle to prioritize a smaller marker as to eliminate the loss of points due to weight. The system uses two in-house machined waterproof solenoid enclosures to actuate the mechanism. To reduce costs, these were reused from last year.

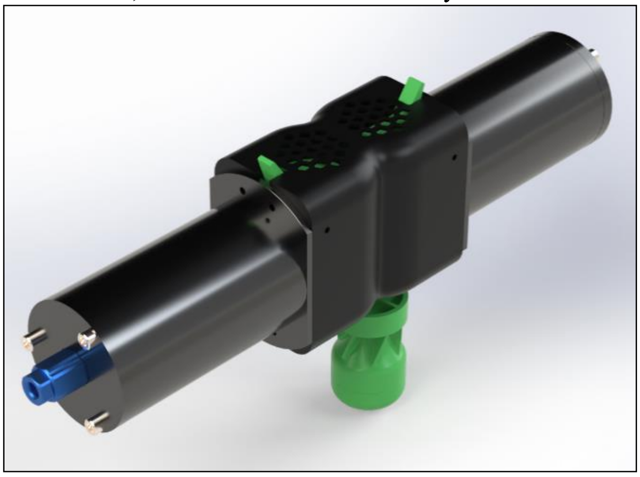

Figure 6: Dropper System

To improve the system, adding mechanical advantage to the system was critical in ensuring that the markers could be released reliably. By having the solenoid act at the end of a rotating lever, this allowed the introduction of an automatic reset upon reload as well as a manual release lever.

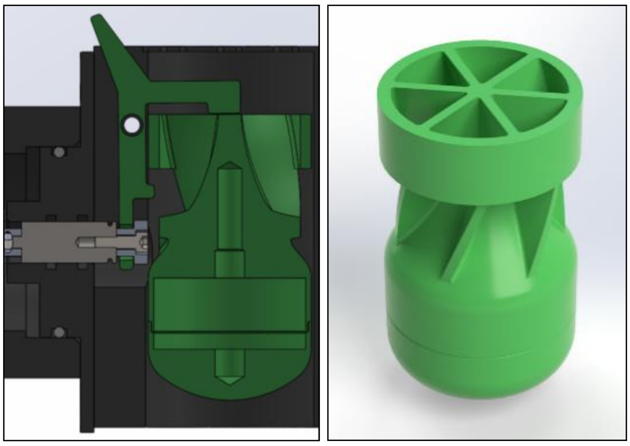

Figure 7: Dropper Release Mechanism and Marker

The marker itself was designed with a perfectly vertical drop path in mind. For this reason, the marker was designed with a heavy rounded nose and rifled fins. This transfers the center of pressure behind the center of mass creating a dynamically stable object. With the added rotation of the body upon descent, the straightest possible fall path is achieved.

B. Snappy Electrical Improvements

1) Mower Board

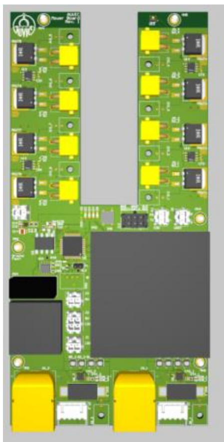

Figure *8*: Mower Board in Altium

1) Mower Board

The Mower board was scoped to include power distribution and motor control signals, with configurable protections and telemetry included. This was made possible using integrated circuits (ICs) which integrate telemetry and communication, primarily through inter-integrated circuit (I2C). The previous system was largely analog and used discrete gate drive circuitry.

a) Battery Monitoring System (BMS)

The scope included a rudimentary BMS which would track cell and top-of-stack voltages, and battery current. This included voltage and battery protections that controlled low-side MOSFETs. Due to cost constraints, the PCB was brought up by hand, and the BMS was not included due to difficulties soldering fine pitch components. The BMS will be introduced later as a standalone PCB, that will be assembled by the manufacturer.

b) 5V and 12V outputs

The Mower board incorporates through-hole off-the-shelf (OTS) converters for 5V and 12V outputs, which provide power to auxiliary systems. OTS converters were used to accelerate development time and ensure safety of upstream and downstream components. The 5V and 12V outputs each have a digital current sensor which provides voltage, current, and power data over I2C for diagnostics.

c) Motor Outputs

The motors are driven by Blue Robotics Basic ESCs (ESC) that are controlled via PWM signals from the Mower board microcontroller (MCU) [2]. The MCU also controls the turn on and turn off of the ESC power through a hot-swap controller IC. The hot-swap controller has an analog section to enable fast turn off in the case of overcurrent, overvoltage, undervoltage, and the pass MOSFET maximum power being exceeded. The hot-swap controller IC has a separate digital section, which is responsible for reporting data such as voltage, current, and power for diagnostic purposes via I2C.

d) Ground Fault Detection

Ground fault detection was implemented using our aluminum frame as a seawater probe, which is connected to an isolated circuit. This allows us to determine if any current is coming through the frame, indicating that an external device(s) such as a motors or solenoid is no longer watertight. The issue may then be investigated and maintenance performed before a major failure occurs.

e) Humidity and Temperature Sensors

The humidity sensor also integrates a temperature sensor which will measure ambient conditions inside the enclosure. The humidity sensor is intended to serve as a form of protection to detect if water is inside the enclosure, or a small leak is occurring which may not trigger other protections. The temperature sensors are placed around the board to ensure that we are not reaching high levels of heat on certain components. All sensors communicate over I2C. This allows us to connect all sensors and telemetry to only two MCU pins, allowing us to have a greater range of diagnostic data sources than in previous years.

2) Batteries

The previous batteries were 6S lithium polymer (LiPo) batteries which were ageing and not well suited to the updated electrical system. The 22.2V nominal voltage was too high for the thrusters and was being stepped down through a buck converter; this limited our maximum power output and created additional limitations. The 12 amp-hour capacity could support a long run-time; however, the enclosures were unwieldy and the extra run-time was not used in practice. The new system uses 4S LiPo batteries. These are smaller, have lower capacity, and have lower voltage. This greatly simplified the electrical system, as the motors and some auxiliary components may be run directly from the batteries; the removal of the buck converter also increased efficiency.

3) Firmware

As there was a redesign on the main electrical boards, the firmware required an update as well. Some of the firmware from the previous system could be reused on the Mower board. A key design principle for firmware this year was to make it easy to interpret and use for any programmer without extensive study into the STM32 firmware or the schematic of the mower board. Additionally Micro-ROS was added to the firmware to allow easier integration with ROS2 on the NVIDIA jetson.

a) Pin Declarations

The previous and current electrical boards both use STM32 chips. This meant some firmware from the previous systems could be reused by simply updating pin declarations and making some minor register address changes in the firmware.

b) Abstraction

As part of the design goal to make the firmware more intuitive, the ported functions were changed to be easier to use. This meant improving modularity for organization and readability. Additionally, the functions were moved to a higher abstraction level to facilitate future updates.

c) Micro-ROS and FreeRTOS

A better interface between the NVIDIA Jetson and the electrical system was desired; this was achieved through the use of FreeRTOS and micro-ROS.

AUVIC's embedded components run FreeRTOS on the vehicle's STM32F4 series microcontroller, providing real-time task scheduling for time-critical operations such as thruster PWM output, actuator control, and sensor polling. micro-ROS is layered on top of FreeRTOS via the rclc client library, enabling the MCU to exist in the ROS 2 Humble ecosystem as a node. The micro-ROS Agent, running on the Jetson, bridges the MCU's topics over UART into the main ROS 2 DDS allowing higher-level subsystems like the controller, behavior tree, and state estimator nodes to publish and subscribe to MCU-side topics and vice versa. This architecture enforces a clean separation of concerns: the MCU owns all real-time hardware interaction and low-level actuation, while the Jetson handles compute-intensive workloads like perception, state estimation, and mission planning, with the micro-ROS bridge serving as the communication boundary between the two layers.

d) New Hardware Features

New features present on the Mower board also had to be accounted for. The motor, 5V, 12V, and Jetson outputs allow for various parameters to be tracked such as voltage, current, power, and temperature. The firmware had to be updated to allow communication via an I2C bus with all the respective ICs for interpreting data.

4) Wiring Harness

In previous years maintenance and upgrades to the wiring harness have been largely pushed to the backburner. Shorted wires, loose connections and an oversized wiring harness were a few issues caused by the lack of quality wiring harness. Additionally, the system struggled with being overly complex, making it so only experienced electrical members could assemble the wiring harness. To mitigate these issues the wiring harness was thoroughly planned out at the start of the year to be reliable, modular, safe, and easy to understand.

a) Wiring

Each connection has its own clearly labelled wire with polarized connections to minimize the likelihood of any shorts or wiring mistakes. Keyed connectors may be investigated in the future to improve this further.

b) Mower Board Design

The Mower board was designed with wire management in mind. The pitchfork design allows motor output wires to route through the middle of the support structure and avoid getting in the way of the mechanical enclosure. Where budget allowed, PVC wires were replaced with silicone wires due to increased flexibility and longevity. Some issues persisted or became apparent because of the new design. Routing all the wires into the center of the submarine created a lot of noise in the signal lines beside the power lines. Adding some shielding, using differential signaling, and moving to more digital communications should help with the signal-to-noise ratio in the future.

C. Snappy Software Improvements

The software system builds off the progress from the 2025 competition, porting some of the Python code into C++. The system is written on top of ROS2 Humble to handle parallel processing and inter-process communication. It is split into 4 main subsystems: mission planning, computer vision, state estimation, and control.

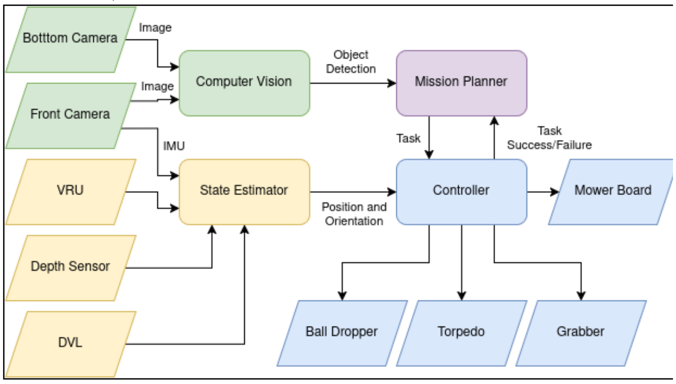

Figure 8: Software Architecture

1) Mission Planner

The mission planner is the high level decision maker that defines the order in which to perform tasks. For this competition cycle, the software team has decided to use BehaviourTree.CPP to define the mission and handle the interfacing with the other subsystems. BehaviourTree.CPP was chosen since it has well-supported ROS2 compatibility and interfaces with Groot2, a graphical representation of the behaviour tree, allowing for quick iteration during testing and at competition.

2) Computer Vision

The computer vision system on board snappy is what allows snappy to know where it is in the water and what it is seeing. It receives a continuous stream of both the depth and color camera feed. Upon arrival a message synchronizer, then the color feed gets letterboxed and normalized to ensure accurate object detection. This year our computer vision stack is running a YOLO26s model on a TensorRT node. This allows snappy to leverage the Jetson Orin Nano's graphics card to perform the object detection/run the inference model. By doing this more CPU space can be freed for other important ros2 nodes. Once objects are detected they are parsed, have bounding boxes placed around them, and an object specific function gets called to measure its distance before publishing to the mission planner. All our computer vision data is gathered from previous pool tests, current pool tests at competition and from custom blender renderings to allow for a robust data set in different lighting conditions to improve accuracy.

3) State Estimation

The state estimator has seen significant improvements since RoboSub 2025. Previously, AUVIC's vehicle utilized a depth sensor and vertical reference unit (VRU) for position and orientation estimation. This year, the team has added an inertial measurement unit (IMU) and doppler velocity log (DVL), providing the ability for much more accurate readings. With these sensors, the state estimator uses the extended Kalman filter (EKF) algorithm to fuse the readings and provide an estimate of the position and orientation.

4) Control

The control node is responsible for taking instructions from the mission planner, and determining the steps required to achieve that goal. The control node takes the current state from the state estimator, along with a desired target state given by the mission planner, generates a trajectory from the two states, and passes them into a PID loop. The output of this PID loop determines the magnitudes of the thrusters which are sent to the motor/power board.

III. Testing Strategy

Throughout the development of this year's vehicle, everything was tested thoroughly to make sure that it was functional to the best ability. Starting with the mechanical team, the testing started with interference analysis in SOLIDWORKS to make sure that each physical component had a properly defined operational region. This also allowed the team to check the theoretical buoyancy and mass of the fully assembled vehicle.

After each waterproof enclosure was machined, a thorough vacuum and dunk test was completed verifying the functionality of each system. With a bare-bones chassis, battery enclosures, and main enclosure tested, system integrations were able to begin.

At the same time, the electrical team was testing individual circuits during the population of the new PCB. This allowed the board to be integrated with the real system seamlessly knowing each small-scale system was functional.

In parallel, software worked to test and build the code base on which the competition plan could be constructed. This involved communication protocols, data pipelines, navigation systems as well as a micro-ROS implementation.

The largest test was a full system integration test. The test started a week out from a scheduled pool test. This involved wiring up each of the thrusters to the controllers, test firing each to make sure communication was possible. The complete system was once again vacuum tested before being placed in the pool. During the pool test, the most basic tests were completed first, buoyancy was stabilized using weights, and a submersion was undertaken. This gave way to simple motion instructions such as forwards, backwards, and individual thruster firings.

With a bare-bones system test complete, the goal of future tests is to slowly integrate new systems and features making sure that each additional component is stable and operational before adding the next.

Each of the torpedo, dropper, and claw mechanisms underwent individual bench testing procedures, verifying actuating force, watertightness, and gripping strength. The first system to be integrated is the dropper system. The dropper was the simplest mechanism and the first task prioritized after the slalom making the test vital. The test will include dropping multiple items of varying shape, determining where in the camera view the item will land as well as the preferred hydrodynamic reaction of the marker.

Next, the claw system will be integrated into the vehicle. With this being the most complex in terms of software implementation, it was placed as a second priority. This test will include camera view verifications, and testing opening and closing while submerged. A main point will also be to figure out at what distance the depth camera reads the claw. This will allow the team to successfully align the claw with objects and the table.

Lastly, the torpedo system testing will be conducted. Another vacuum test of each solenoid enclosure will be done, followed by a system integration test in the pool. This will include a test of firing speed, trajectory, as well as repeatability of firing.

A new LCD screen is being implemented in this year's build, creating a new way of getting diagnostics and monitoring battery voltages. This system will allow the team to be confident that all systems are functioning correctly during each of these tests.

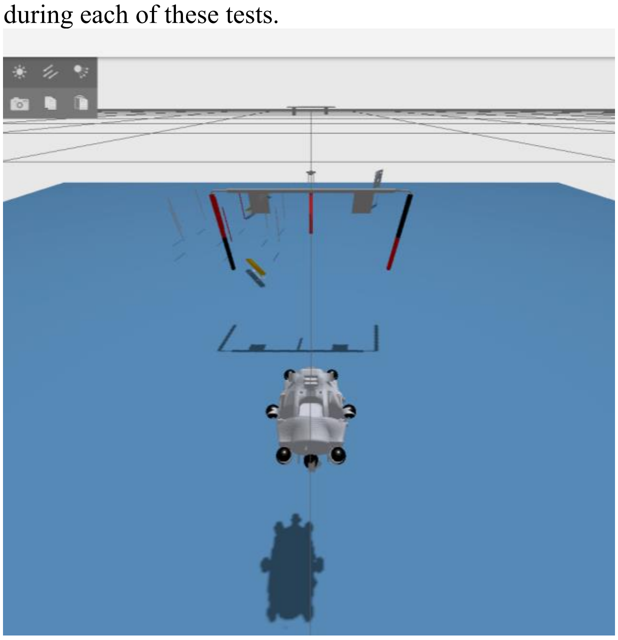

Figure 9: Gazebo Simulator

During times when AUVIC cannot test Snappy in a pool, the team uses a simulation for sensor and movement testing. The simulator used for testing features a complete model of the AUV with corresponding thruster placement, the full course layout for testing navigation, and full hydrodynamic and buoyancy simulation. AUVIC uses Gazebo Fortress to achieve this simulation and interfaces with the ROS2 software system.

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REFERENCES

[1] O-Ring Guide, https://www.parker.com/content/dam/Parker-com/Literature/Praedifa/Catalogs/Catalog_O-Ring-Guide_PTD5712-EN.pdf (accessed May 27, 2026).

[2] "Basic ESC (Electronic Speed Controller) for Thrusters and Brushless Motors,"*Blue Robotics*. https://bluerobotics.com/store/thrusters/speed-controllers/besc30-r3/

[3] Quaternion kinematics for the error-state Kalman filter Joan sol`a, https://www.iri.upc.edu/people/jsola/JoanSola/objectes/notes/kinematics.pdf (accessed May 28, 2026).