RoboSub 2026 Technical Design Report

University of Rhode Island (URI Hydrobotics)

Akira Hall, Christopher McRae, Cooper Jones, Elias Newall-Vuillemot, Julian Tamayo, Julie DesAutels, Junrong Liu, Lilah Saunders, Logan Rekowski, Naomi Gitelman, Piero Navarro

***Abstract*—Team URI Hydrobotics is deploying Tardigrade V3, an updated model of previous year's iterations. This year we aim to create a reliable and navigation-based system that is easier to troubleshoot, adapt, and manipulate.**

I. COMPETITION STRATEGY

A. General Strategy

Our main objective for RoboSub 2026 is to focus on completing navigation based tasks. This allows our team time to build and experiment with computer vision, localization, and autonomy while also maximizing task points with our vehicle structure.

B. Course Approach

The vehicle path plan is to begin with *Coin Flip*, then the *Gate* task (with "style"), navigate to *Slalom*, attempt the surface component of *Octogon*, then complete *Return Home*.

In order to follow this strategy, the AUV is required to identify and navigate to tasks reliably. Our team has decided to focus on utilizing our computer vision to navigate and complete tasks, supplemented by an IMU and sonar for stationkeeping and object avoidance. As the AUV heavily relies on computer vision and lacks a DVL, attempting "style" points through the gate and the *Octagon* task are labelled as "stretch" goals.

1) Collecting Data – Gate

The gate task is first completed to ensure points can be earned. Tardigrade will first attempt *Coin Flip* by submerging and completing a full 360 degree scan of the environment using computer vision and an echosounder to identify the gate location, where the AUV will navigate through.

2) Avoid Debris – Slalom

After completing the gate task, Tardigrade will detect the path marker using its downward-facing camera. The front camera is used to identify and navigate in between the pipes.

3) Resupply - Octagon

Navigating to and surfacing in the octagon is one of our "stretch" goals and will only be attempted if the Tardigrade succeeds reliably in initial attempts of the previously mentioned tasks. As the vehicle is not equipped with a system to detect the acoustic pinger in the center of the octagon, our computer vision subsystem will be used to try and identify the task. If the octagon and hanging images are detected, the vehicle will approach the area and center itself in the octagon then surface. As this method is complex and unreliable, the return home task may be attempted instead.

4) Return Home

If Tardigrade successfully surfaces in the octagon, it will resubmerge and attempt to return back through the gate. The CV subsystem will be used to identify the other tasks and navigate towards and through the gate. If the octagon task is not attempted, Tardigrade will navigate around or through the slalom, keeping the pipes on one side of the AUV until the gate or path marker is identified, passing back through the gate.

C. Reflect on Design

Since much of our focus this past year has been on refining basic operations and navigation, the majority of our design work has been on improving and overhauling core systems.

II. DESIGN STRATEGY

The goal for this year's design was to improve ease of operation and deployment by examining the existing hardware and identifying areas of improvement. We noticed we were spending a significant amount of time preparing the vehicle for operation due to the cumbersome nature of the existing platform, which was not designed with expandability in mind. This year we aimed to refine our existing design through implementing upgrades and quality of life improvements that increase the ease of use and deployability.

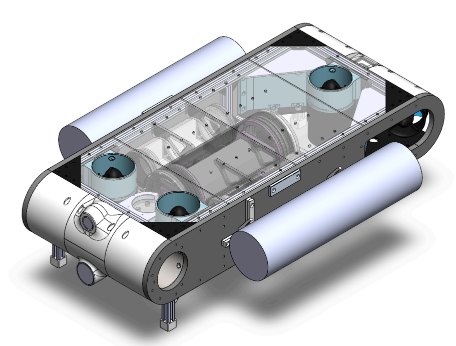

Fig 1. Tardigrade Render.

A. Mechanical Highlight: "Water Wings"

During previous competitions, our team noticed that many teams, including ourselves, needed to add extra buoyancy foam to their AUV during water testing to adjust their ballasting. The addition of this foam can often be cumbersome, limiting access to key components on the interior and exterior of the AUV. In our case, the internal foam was limiting repeated access to our computer bottle. We decided a more reliable and effective solution would be to implement permanent buoyancy tubes, "water wings", then add weights to ballast the AUV, rather than adding foam.

The "water wings" are made up of hollow side mounted black ABS tubes, with PVC endcaps sealed to the ends with purple plumbers glue. These tubes are mounted to the sides with laser cut acrylic crescent brackets and aluminum hose clamps, held to the side of the AUV by milled aluminum bar stock. Overall, our team has found the "water wings" to be a much more space efficient, reliable, and elegant solution to our previous problems with ballasting the AUV.

B. System Highlight: Switches Assembly

With our focus on redesigning Tardigrade for usability we upgraded the system for our kill switch and tether. Our previous system consisted of two cables hanging out the back of the AUV, so we decided this system needed a design overhaul, aiming to have a single contained unit to house everything we needed. Furthermore, this design overhaul creates an opportunity to add more features, specifically a dedicated start button, a wake switch to turn on the AUV, and a waterproof LED Display to indicate distress states.

The switches assembly consists of a 3D printed PETG box that the buttons and cables come out of, with a clear resin fairing mounted on the top that the LEDS can shine out of. The inside of the Box is epoxied to waterproof all of the components. Additionally three cables with Blue Trail Engineering connectors come out of the back of the box to connect to the computer bottle.

C. Electrical Highlight: Custom PCBs

Another focus for this year's design was improving the internal mounting of the electronics system. To clear up space in the pressure housing, we decided to design two custom PCBs to achieve a higher level of integration. We first designed a hat for our on board Raspberry Pi that provides connectors for common GPIO and I2C peripherals, such as sensors. Then we designed an improved ESC stack that replaces our cumbersome kill switch solution (a large high current contactor) with discrete power MOSFETS[1], which can sink up to 49A, while integrating our Raspberry Pi Pico Microcontroller, used for generating PWM signals for our ESCs, directly onto the board. These two PCB designs eliminate much of the wiring complexity that was found in Tardigrade's previous iteration.

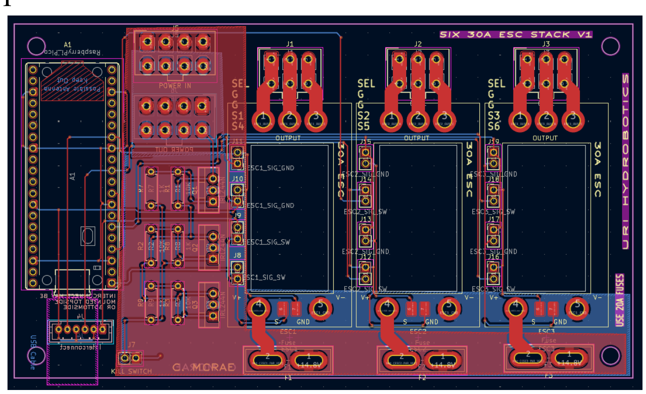

Fig 2. ESC stack PCB design.

D. Software Highlight: AVOE

One of the main issues with the previous iteration of Tardigrade was the software stack. Last year's software solution lacked the refinement and flexibility that we expect from AUV middleware. So, we have prioritized working on a new software stack for this year. The Autonomous Vehicle Operating Environment (AVOE) is a fully custom and open source (source available on our GitHub repository [2]) robotics middleware solution for AUVs being developed by our team. It has been designed for simplicity, flexibility, and high performance and has been the center of Tardrigrade's control software. One of our goals for this year's software was to rely less on hardcoded, vehicle specific software routines which we have achieved through AVOE's generalized approach to building a control suite which can be used for future AUV designs.

III. TESTING STRATEGY

A. Hardware Testing

Prior to integrating new components into the system, each part is individually tested for functionality. This is to ensure that nothing will break or destroy the current system, and to help in the troubleshooting process. Bench testing Tardigrade's electronics was an important part of our testing strategy as in-water testing opportunities were limited. We conducted a thorough testing process to verify the functionality of all onboard systems including sensors, networking, killswitch, and thrusters. Failure of any of these systems promptly launched an investigation into the underlying issue.

B. In-water Testing

Throughout the year, the team has prioritized water testing as frequently as possible. Before any deployment, a test plan is developed to maximize efficient use of time. Tardigrade is first prepared and bench tested, then deployed, then a post test evaluation is conducted.

1) Preparation

To prepare the AUV, the system is first pressure tested to check for any leaks. The system is then tested outside of the water to ensure there are no poor connections and that each component is functioning properly. A plan is developed for the type of testing being completed, including the amount of time spent in the water and how it is being used.

2) In Water

Once the AUV is deployed, the testing plan is followed. Team members monitor the AUV in the water during its run, and any observations or issues are noted.

3) Post Testing

After the AUV is recovered from the test, it is dried and returned to the lab. Issues noted during testing that require further adjustments to the software or vehicle are added to the task list.

ACKNOWLEDGEMENTS

We would like to thank our faculty advisor, Dr. Mingzi Zhou and our graduate advisor, Jason Noel for their continued guidance and support. Without the support of The University of Connecticut-University of Rhode Island Navy STEM Coalition, our club would absolutely not be where we are today. We would like to thank them for their continued financial support for our RoboSub travel, as well as guidance with professional workshops and community outreach events. We would also like to thank all of our sponsors, who are listed in Appendix A.

REFERENCES

[1] IRFZ44NPBF HEXFET® Data Sheet. https://www.infineon.com/assets/row/public/documents/24/49/infineon-irfz44n-datasheet-en.pdf?fileId=5546d462533600a40153563b3a9f220d

[2] *URI Hydrobotics* "Autonomous Vehicle Operating Environment," https://github.com/URI-Hydrobotics-Team/AVOE

APPENDIX A. SPONSORS

URI COE and OCE Department — For providing lab space, equipment access, academic assistance, and financial support.

Navy STEM Coalition — For sponsoring the travel logistics for the RoboSub competition.

Cadence — For providing software licenses and funding for our PCB design.

RISE UP — For providing access to their makerspace as well as financial support.

BAE Systems — For providing financial support.

SolidWorks — For providing software licenses for our mechanical design work.

APPENDIX B. COMPONENT SPECIFICATIONS

Component	**Vendor**	**Model/Type**	**Specs**	**Cost (if new)**
Front Camera	DWE	exploreHD 3.0	400m ~82 FOV	$300
Downward Facing Camera	Microdia	Arducam IMX298	180 FOV	$50
Thrusters	Blue Robotics	T200	Brushless Motor	$1320
Batteries	Blue Robotics	Lithium-ion	15.6Ah and 18Ah	$760
Echosounders	Blue Robotics	Ping-1D	Single-Beam sonar	$700
Raspberry Pi	Raspberry Pi	Raspberry Pi 4B	4GB RAM	$65
Nvidia Jetson	Nvidia	Jetson Nano Orin	8GB RAM	$250
IMU	Adafruit	BNO055	9-DOF Fusion	$40
Pressure Sensor	Blue Robotics	Bar30	2mm Resolution	$85
Leak Sensor	Blue Robotics	SOS Leak Sensor		$35
ESC	Blue Robotics	Basic ESCs	Speed Control	$240
Computer Bottle	Blue Robotics	Locking Series	5” inner diameter	$200
Battery Bottle	Blue Robotics	Locking Series	3” inner diameter	$150
Bulkhead Connectors & Cables	Blue Trail	Cobalt Series	Dry-Mate	$1250
Raspberry Pi	Raspberry Pi	Pico 2	RP2350	$5
Power Switch	Blue Robotics	Waterproof switch	1000 m, 5A, 26 VDC	$28
LED Button	DigiKey	AVP22MAIBCE 0DT5A04	1 A, 24 VDC, Piezoelectric	$80