Two Robots, One Mission: Talos & The SS Flip Barker

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***Abstract*—For RoboSub 2025, The Ohio State University's Underwater Robotics Team (UWRT) focused on enhancing system resilience, autonomy, and multi-vehicle coordination. Building on Talos' proven foundation, the team introduced the SS Flip Barker, a compact, ballasted AUV designed to assist with *Ocean Cleanup* and enable inter-vehicle acoustic communication. Talos received upgrades including a new downward-facing stereo camera, redesigned internal cages, and an integrated pressure testing and leak detection system. Real-time control learning further improved autonomy and reliability. With parallel task execution enabled by this dual-platform strategy, UWRT aims to maximize task coverage, flexibility, and robustness in RoboSub 2025.**

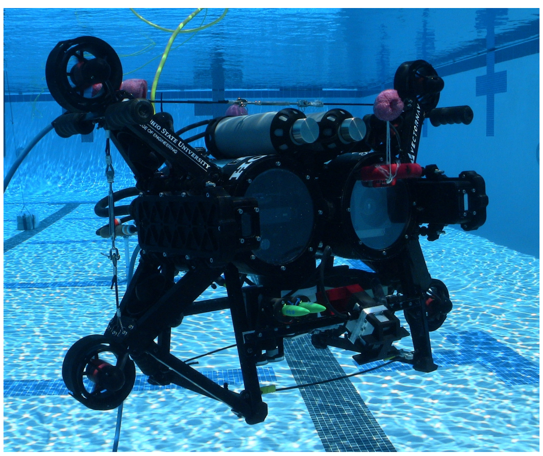

Fig. 1: Talos

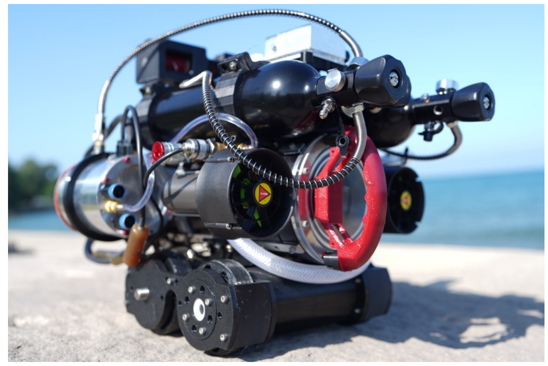

Fig. 2: The SS Flip Barker

I. Competition Strategy

A. General Strategy

UWRT's RoboSub 2025 competition strategy centers around creating a set of vehicles capable of earning all available points: the refined competition vehicle Talos (Fig. 1) and the newly developed SS Flip Barker (Fig. 2). This approach involves making Talos feature-complete while developing the SS Flip Barker (SSFB) specifically for *Ocean Cleanup*. Talos was enhanced with hardware and software for intervehicle communication, downward vision for *Drop a BRUVS*, and acoustic pinger identification to achieve the Random Pinger points. Meanwhile, the SSFB was equipped with intervehicle communication capabilities, a manipulator, and a ground-based locomotion system to effectively complete *Ocean Cleanup* while Talos performs other tasks.

B. Course Strategy

- **Collect Data**: Talos and the SSFB start joined together, execute the coin-flip decision, then Talos carries both vehicles through the start gate using vision-guided navigation and passes beneath the frame. On the return leg, now operating independently, Talos disables Doppler velocity log (DVL) feedback to perform the required flips before re-enabling for normal navigation.
- **Pinger & Deployment**: Talos navigates to *Tagging*, samples acoustics data from the pinger, then navigates to *Ocean Cleanup*, deploys the SSFB onto the table, and takes a second acoustic sample. Using both samples, Talos determines which pinger is active. If the *Ocean Cleanup* pinger is active, Talos uses IVC to notify the SSFB to begin table cleanup, then completes the remaining tasks. If the pinger at *Tagging* is active, Talos returns to complete *Tagging*, then uses IVC to notify the SSFB to start *Ocean Cleanup*.
- **Navigate the Channel**: Talos uses the first three channel poles to establish a reference plane, aligns to that plane and maintains a steady heading and depth as it traverses the channel.
- **Drop a BRUVS**: The downward-facing camera locates the correct half of the target panel, Talos positions itself over the panel and releases both droppers in a single pass.
- **Tagging**: Vision and navigation-filter feedback guide Talos into alignment with the correct *Tagging* aperture. Once roll, pitch, yaw and position meet stability criteria the system fires the torpedo into the designated hole.
- **Ocean Cleanup**: While Talos performs remaining tasks, the SSFB operates on the table surface, collecting debris with its manipulation system. After acquiring each object, the SSFB orients toward the correct octagon direction, surfaces, and sorts the debris into the appropriate bins.
- **Return Home**: Using its forward-facing vision model, Talos locks onto the rear face of *Collect Data*, passes

under the gate, then surfaces to complete the competition run.

II. Design Strategy - Talos

A. New Rail/Cage System

After two years of competition, Talos showed significant wear from frequent assembly and disassembly. The original slider rails were secured with short screws that engaged only three or four threads. Over repeated installations, the threads began to strip, compromising both rail retention and hull integrity. To address this, the internal mounting scheme was completely redesigned for easier access and minimal impact on the hull.

The new rails are press-fit between existing hull segments, as shown in red in Fig. 3. Removable cages now slide securely into these static rails without fasteners, simplifying installation, and maximizing internal volume. Each rail includes an internal channel to protect new leak-sensor wiring.

The rail orientations were designed to provide an unobstructed view for the downward-facing camera (DFC). The DFC is mounted directly against the hull surface, reducing the optical distortion of the curved shell. A custom quick-connect slide-in adapter provides a hands-free electrical interface between the DFC and its removable cage, minimizing handling of fragile components and streamlining maintenance.

The redesign also addressed FOG connectivity issues. After breaking the original fragile pin connectors during cage assembly, a robust pogo pin interface was developed using a 3D-printed three-plate assembly (Fig. 17). This layered structure ensures proper pin alignment and compression while enabling repeatable installation within the camera cage system.

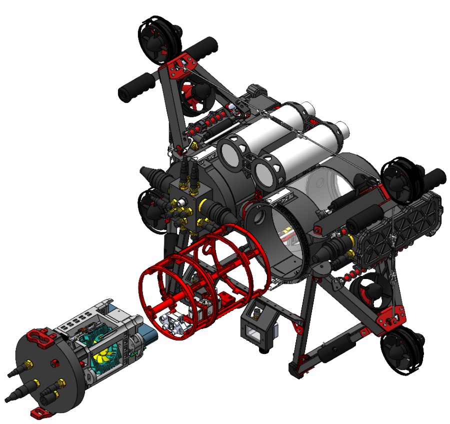

Fig. 3: Exploded CAD assembly of the new rail/cage system

B. DFC

The previous DFC, a custom Raspberry Pi-based solution, was replaced by a ZED X Mini [1]. The ZED offers higher depth accuracy and provides a comprehensive Software Development Kit (SDK) that simplifies hardware and software integration. This allows both onboard cameras to share the same perception and localization workflow for greater code modularity and reuse. Its smaller footprint reduces overall weight and eliminates the need for a dedicated housing.

C. Controls

To improve testing efficiency and accommodate mechanical modifications, UWRT implemented a reinforcement learning algorithm to tune the AUV's open-loop control system. This algorithm estimates control inputs using the Controller Scale subsystem, which performs basic stability analysis to assess the system's average force output. This helps determine whether Talos has reached a steady state, and evaluates overall stability.

The resulting data is passed to the Open Loop Control Learner. Once specific criteria are met for updating the control estimate, a new estimate is generated and applied. The AUV then responds to this updated input, providing physical feedback that is analyzed again by the Controller Scale. This iterative loop continues, progressively refining the control parameters.

After successful implementation and validation, the team was able to eliminate the need to manually retune open-loop values after every mechanical change. This allowed for immediate testing following modifications. Over time, the system self-optimizes during AUV operation and achieves a more stable control configuration than manual tuning can provide. It also persistently saves tuning data for future tests.

This implementation also enabled additional features. The stability analysis was used for automatic drag tuning and provided timing inputs for the AUV's behavior trees. These improvements significantly enhanced the AUV's ability to aim and fire torpedoes reliably from a distance. A block diagram of the complete control system is presented in Fig. 10.

D. Autonomy

Talos' behavior-tree-based autonomy system [2] entered its fourth competition cycle in 2025 with two tasks receiving targeted upgrades. The *Tagging* task now uses real-time controller feedback such that torpedoes only launch once the vehicle's position and attitude settle within predefined limits. *Drop a BRUVS* integrates the new DFC to drive an expanding square-spiral sweep of the pool floor. When the vision system detects the target and position confidence exceeds a set threshold, the tree transitions to the controller-assisted alignment action, followed by the release of the droppers.

E. Intervehicle Communication (IVC)

To facilitate wireless underwater communication between the AUVs, UWRT developed an acoustic inter-vehicle communication solution. This system was built around a frequency-shift-keying (FSK)-based communication protocol with data being received by an Aquarian Audio H1c [3] hydrophone.

For data transmission, UWRT designed a custom underwater transmitter tailored for robust, low-cost performance and seamless integration with the driving circuitry. A prototype was made using parts from an off-the-shelf loudspeaker, but its large size and limited corrosion resistance demonstrated a more refined solution was necessary. To that end, the team developed a transmitter featuring a flooded-core architecture, eliminating the need for pressure seals. This design, shown in

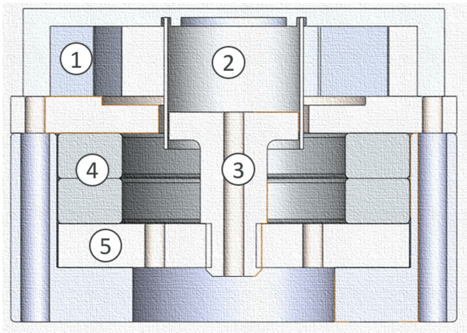

Fig. 4: IVC transmitter system diagram

1: Interchangeable plastic or metal head
2: Metal voice coil and bobbin
3: 406 Stainless steel magnetic circuit
4: Samarium Cobalt permanent magnets
5: 6061 Aluminum Structural Enclosure

Fig. 4, ensures consistent operation at any depth by preventing pressure differentials across the transmission head.

At the heart of the flooded core lies a custom inductor wrapped around an aluminum bobbin, functioning as a voice coil. The magnetic core was designed using samarium cobalt magnets, chosen for their exceptional corrosion resistance.

The listening electronics system receives a pre-amplified hydrophone signal and processes it through several gain and filtering stages. An adjustable gain allows the system to be tuned for its expected environment, then the signal passes through a three-stage analog band-pass filter tuned to the chosen communication band. A multiple-feedback analog filter topology was chosen for its high resonance and low sensitivity to component value tolerance, making the device more robust to varying environmental factors. These filters were designed using TI's Filter Designer Webkit [4]. After filtering, the signal is read by the built-in analog-to-digital converter (ADC) on an RP2040 microcontroller.

The base transmission frequency is generated by the microcontroller using its timer Application Programming Interface (API). This signal is initially a square wave, so it is converted into a near-perfect sinusoidal signal by an 80 dB/dec analog low-pass filter with a cutoff frequency of 25 KHz. After filtering, the signal is amplified to a higher voltage using a high-power operational amplifier (OPA548F). The high-power signal is then propagated by the underwater acoustic transmitter.

F. Acoustics

Pinger detection uses the same hydrophone and low-noise preamplifier as the inter-vehicle communication system. For acoustics, the output is routed into separate processing chains. After amplification, the waveform passes through four separate multi-stage analog band-pass filters tuned to the competition pinger frequencies. These filters remove out-of-band noise while preserving the ping waveform.

The filtered signal is sampled by the RP2040's onboard ADC at fixed intervals. Firmware scans each buffer for peak amplitude and forwards that information to the primary computer. This peak amplitude is then used to determine the location of the pinger by comparing samples around both possible pinger locations.

G. Zenoh RMW Integration

Throughout the previous year, the team experienced several issues with the Robot Operating System (ROS) [5] that links together the vehicle's software subsystems. These difficulties mainly stemmed from the unreliability of the default ROS middleware (RMW), FastDDS. UWRT decided on a more reliable approach, Zenoh [6], as its chosen RMW implementation. Zenoh RMW is capable of handling large amounts of traffic, performs efficient network discovery, and provides more reliable inter-process communication. To make Zenoh compatible with the Micro-ROS protocol, which communicates with the electronics system, UWRT created a custom middleware implementation for the Micro XRCE-DDS agent; it forwards the incoming Micro-ROS traffic directly to the ROS Client Library, allowing it to select and use any valid RMW implementation to communicate to the rest of the ROS network. This middleware facilitates switching the Micro-ROS agent between FastDDS and Zenoh, which is critical for validating the new RMW.

III. Design Strategy - The SS Flip Barker

Following the previous RoboSub competition, UWRT developed a dual-vehicle strategy centered on maximizing task coverage and operational efficiency. The team envisioned a second vehicle that would accompany Talos through the start gate, enabling inter-vehicle communication points while providing specialized capabilities for specific tasks. The initial design concept featured an actively ballasted AUV that would maintain position without actuators, thus having no reliance on a DVL or other localization techniques.

As the team's testing strategy evolved, UWRT recognized an opportunity to optimize development efficiency by specializing each vehicle for different mission components. This insight led to the innovative SSFB design: a hybrid vehicle that combines underwater operation with ground-based mobility. The SSFB strategically uses its ballast system to settle onto the surface of *Ocean Cleanup*, then employs its drivetrain to manipulate and sort objects into their respective bins. This approach enables parallel task execution, allowing both vehicles to operate simultaneously and maximize points by reducing mission time. The hybrid design also provides the advantage of terrestrial testing and validation, ensuring robust performance when deployed underwater.

A. Hull Design and Sealing

The SSFB employs a single-hull design that houses all power systems, actuator controls, compute infrastructure, and the complete sensory suite. The main hull was recycled from UWRT's 2015 ROV *Jaws 2*, demonstrating the team's commitment to sustainable engineering practices. Both the lid and sealing lens bracket were completely redesigned to accommodate stereo vision capabilities and ensure seal robustness.

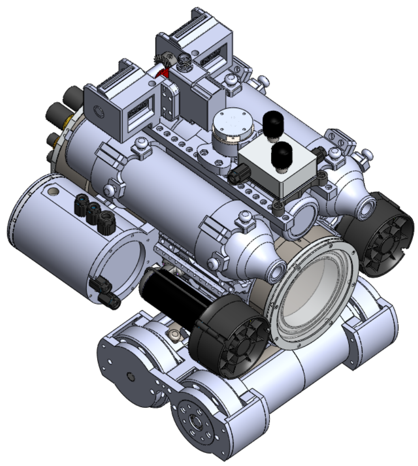

Fig. 5: CAD model of the SS Flip Barker

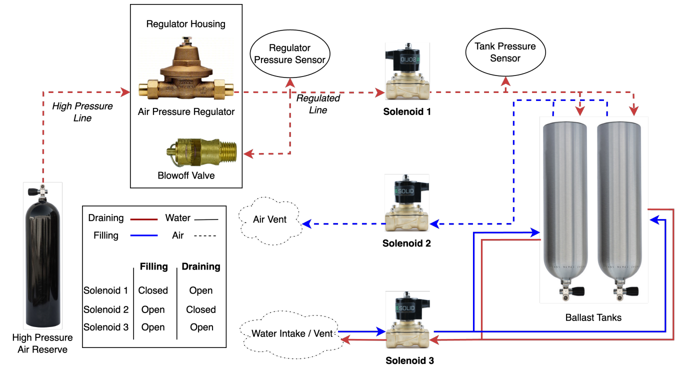

Fig. 6: Active ballast system diagram

The hull features front and back double O-ring seals [7] for enhanced watertight integrity. The SSFB incorporates both physical leak sensors and pressure testing capabilities, providing redundant safety measures critical for reliable underwater operation.

B. Ballast System Architecture

The SSFB utilizes an active ballast system, allowing the vehicle to maintain underwater station-keeping without continuous thrust.

The system sources compressed air from a high-pressure tank, which is regulated to an operating pressure of approximately 40 psi through a sealed regulator housing. This pressure reduction expands the available air volume and reduces operational pressures on downstream components. At operating pressure, the AUV can fully cycle the ballast system approximately fifteen times before requiring a refill.

System safety incorporates multiple redundant monitoring and protection elements:

- Two removable manual pressure gauges monitoring both the source tank and the regulated line pressures
- Three electronic pressure gauges providing electronic monitoring of the regulated line and tank pressures
- Two blow-off valves positioned in the regulator housing and on the regulated line for overpressure protection

A detailed diagram of the ballast control system can be seen in Fig. 6

This control architecture enables advanced operational modes including depth maintenance for qualification and neutral buoyancy for towing. During *Ocean Cleanup* execution, the system maintains a slight negative buoyancy, allowing the AUV to rest on the table, while preventing damage to the task.

C. Drivetrain System

A diagonal drive system powers the front-right and back-left wheels with 0.8 hp combined output, while unpowered caster wheels at the front-right and back-left positions provide stability. This configuration minimizes mechanical complexity while maintaining vehicle maneuverability. The reduced footprint maximizes camera field of view for object detection during *Ocean Cleanup*. The motorized wheels utilize lip seals [8] with buffer fluid for underwater operation, enabling the drivetrain to function both on land and underwater.

D. Thruster Configuration

A pair of brushed auxiliary thrusters complement the drivetrain system, allowing the vehicle to operate both as a surface-driving robot and as a free-swimming AUV. The thrusters assist with ground mobility, allowing for forward motion without applying force on the table surface. Additionally, they aid in recovery if the vehicle becomes stuck during *Ocean Cleanup*.

E. Noodle Winch

UWRT's novel "Noodle Winch" system allows the SSFB to extend and retract a buoyant object fixed to a string, enabling the robot to surface in the octagon while remaining on *Ocean Cleanup*. The servo-driven winch features custom worm gears designed to prevent cable tangling during deployment and retrieval operations, ensuring reliable connection management throughout the mission.

F. Attachment System

The attachment system enables coordinated transit and tolerant attachment between the SSFB and Talos using an electromagnet-based coupling mechanism. An electric lifting magnet with 135N holding force mounted on Talos couples to a ferromagnetic stainless steel plate (416 alloy) mounted on the rear hull of the SSFB.

To prevent rotational forces from breaking the magnetic connection, mechanical hard points on Talos transfer torque loads through a structural ring encircling the SSFB's hull. This distributed load path ensures that Talos can maneuver the combined system without breaking the magnetic circuit.

G. Manipulation System

The manipulation system employs a dual-servo actuated claw mechanism designed specifically for *Ocean Cleanup* object handling. The claw assembly utilizes two independent rack-and-pinion gear systems, each driven by dedicated servos, to provide precise control over gripper positioning and actuation.

The first servo raises and lowers the entire claw, while the second opens and closes it. This dual-axis architecture allows the manipulator to accommodate objects of varying heights, maintain clearance from the table surface, and deliver the fine-grained control needed for reliable grasping and placement into designated bins.

The claw hands feature 4-inch Dragon Skin 20 [9] silicone grippers with integrated spikes to maximize grip effectiveness across diverse objects. The compliant design conforms to irregular geometries while maintaining sufficient grip force, securing object retention during manipulation and transport operations. A CAD model of the manipulation system can be seen in Fig. 7.

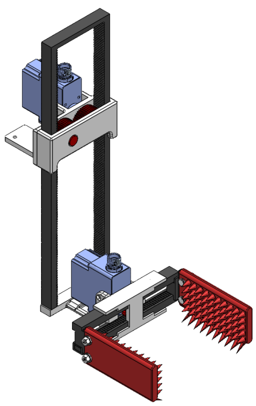

Fig. 7: Manipulation System

H. Software System

The SSFB leverages Talos' proven software architecture with a customized controller to minimize development time while ensuring system reliability. Minor modifications to the simulator, behavior trees, and RViz interface accommodate the vehicle's unique drivetrain and ballast system.

The SSFB control system employs a proportional-integral-derivative (PID) controller for heading regulation, selected for its straightforward implementation and tuning characteristics. Given the vehicle's operational constraints on the table surface, the system forgoes closed-loop position control in the X and Y axes. Instead, it utilizes a throttle-based approach where external systems can modulate forward motion while the PID controller maintains directional stability. This hybrid control strategy enables the autonomy system to execute precise movements relative to task elements such as bins and objects, providing the control necessary for effective *Ocean Cleanup* manipulation.

The SSFB autonomy system operates through coordinated behavior trees that activate upon receiving IVC commands from Talos. The execution sequence begins with systematic object detection using the pretrained YOLO11 [10] segmentation vision model, which classifies objects by type and color before retrieval. The drivetrain then maneuvers the vehicle to the targeted object, where the claw mechanism secures it. The vehicle subsequently rotates to the correct direction, as specified by Talos using IVC. SSFB then surfaces using the noodle winch system, and locates the corresponding bin to deposit the object. This cycle continues until all objects are properly sorted.

I. Battery System

The SSFB reused Talos' smart battery system in its entirety, providing proven undervoltage, overvoltage, and overcurrent protection, cell balancing, and temperature monitoring via the existing Battery Management System board. The total battery system delivers a nominal pack energy of 148Wh at 5S voltages, housed inside the main hull. Due to space constraints, no external charging port was added, so the hull must be opened to access the pack. For additional safety in the event of battery failure, a pressure-relief valve was added to prevent catastrophic pressure buildup.

J. Primary Electrical System

The SSFB's primary electrical system retains much of Talos' design philosophy. Employing a distributed control architecture, each board runs its own RP2040 microcontroller communicating over CAN [11] communication protocol. This approach simplified integration with legacy circuitry. The system is comprised of the IVC board plus three SSFB-specific boards:

- PoHalf, the main power distribution board that regulates voltages from battery power
- H-Bridge, which drives two Seabotix thrusters, two drivetrain motors, and three servo motors
- Nano Hat, which connects the Nvidia Jetson Orin Nano to the CAN network and the Inertial Measurement Unit (IMU).

High-power external devices each received their own SubConn connection on the back lid, but size constraints prevented separate connectors for every device. To solve this, a single 12-pin connector was routed to the regulator housing. The housing now serves as a junction box for LEDs, pressure monitors, and solenoids. The complete electrical system architecture is illustrated in Fig. 11.

IV. Testing Strategy

UWRT implemented a comprehensive testing program that validated all vehicle systems from individual components through full mission scenarios. The approach maximized development efficiency through parallel testing strategies, with Talos undergoing pool testing for navigation and underwater tasks while the SSFB's land-capable design enabled extensive dry testing without competing for limited pool time.

The team discovered that intensive, extended testing sessions were most effective, providing operators sufficient time to identify and resolve bugs while refining autonomous behaviors. Bi-weekly testing at the Ohio State Recreation and

Physical Activity Center dive well provided valuable ”competition run” environments that frequently exposed system-level issues and informed critical decisions such as adopting rmw_zenoh_cpp as the ROS2 middleware.

Key testing protocols included rigorous pressure testing and leak detection, vision system calibration using playback methodologies, and inter-vehicle communication validation across various acoustic environments. To ensure test readiness, the team implemented a comprehensive multi-day pre-test checklist with clearly-defined responsibilities for technical leads, which successfully identified issues like unplugged cables and software misconfigurations before pool sessions.

A. Vision System Testing and Validation

The ZED X Mini downward-facing camera required comprehensive stereo calibration validation using MATLAB’s calibration toolbox [12] with checkerboard targets at multiple distances and angles shown in Fig. 8. The curved hull geometry introduced additional optical distortion challenges that necessitated specialized calibration procedures to account for refraction effects through the cylindrical viewing window. UWRT developed a playback-based testing methodology using pre-recorded stereo footage, enabling iterative camera calibration and YOLO11 model refinement without requiring additional pool time. The testing involved playing back the stereo feed to check depth and object detection accuracy across the operational range while identifying and compensating for hull distortion artifacts introduced by the curved interface.

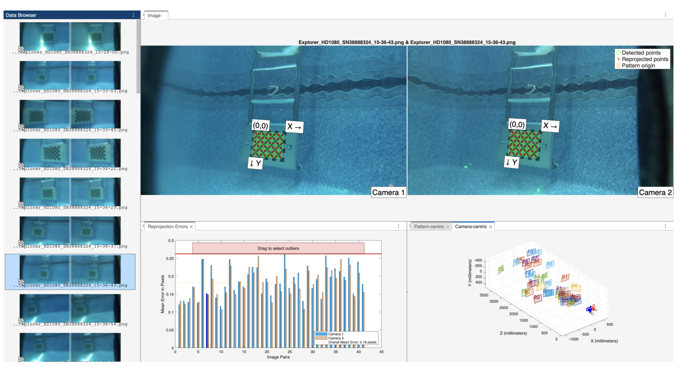

Fig. 8: Matlab Stereo Camera Calibration

B. Pressure Testing and Leak Detection

Building on lessons learned from hull sealing issues, comprehensive pressure testing became central to UWRT’s validation strategy to ensure watertight integrity. The system employs a rigorous testing protocol using the onboard IMU for pressure monitoring and internal circuit boards for temperature sensing to calculate moles of air in the hull using the ideal gas law.

The test begins by sampling ambient air to establish a baseline, then lowering the hull pressure by 0.05 bar using a hand pump. Once this state is reached, the system continues recording pressure and temperature data. For five minutes, this value is monitored for significant change, which would signal a leak. If no leak is detected, a cover is fitted to indicate the vehicle is pressure-ready. The test uses negative gauge pressure for operator safety, avoiding the risks associated with positively pressurized containers.

C. Acoustics Testing

UWRT validated the acoustic pinger detection system through simulation and physical testing. The simulation framework included simulated pingers and calculated time difference of arrival (TDOA) between hydrophones using estimated speed of sound and fourth-order Runge-Kutta [13] position estimation. Gaussian noise injection tested gradient descent and Levenberg-Marquardt [14] algorithms under realistic conditions.

Physical testing evaluated system performance against thruster noise, pool vibrations, and unwanted frequencies using a dunk tank with Blue Robotics T200 [15] and Seabotix BTD 150 [16] thrusters operating alongside pingers. Pool vibration was further tested during routine pool sessions without thrusters. The pre-amplifier’s high-pass filters successfully rejected both interference sources. Frequency selectivity was validated using a benchtop function generator, confirming the acoustic board’s band-pass filters effectively isolated target frequencies while rejecting out-of-band signals.

V. Conclusion

UWRT’s dual-vehicle approach for RoboSub 2025 combines Talos’ comprehensive upgrades with the SSFB’s specialized *Ocean Cleanup* capabilities to enable parallel task execution and maximize point acquisition. Key innovations include integrated leak detection, reinforcement learning-based control tuning, and a custom inter-vehicle communication system that enables coordinated autonomous operations underwater. The modular design philosophy across both platforms facilitates rapid testing and provides a foundation for future competition cycles. With Talos optimized for comprehensive task coverage and the SSFB specialized for *Ocean Cleanup* operations, UWRT is positioned to demonstrate effective multi-vehicle coordination in RoboSub 2025.

VI. Acknowledgments

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Finally, we recognize our team members whose technical expertise and commitment brought these systems to fruition, and RoboNation for their continued stewardship of the RoboSub competition.

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APPENDIX A: COMPONENT LIST

TABLE I: Talos' Component Specifications

Component	Vendor	Model/Type	Custom/Purchased	Cost	Purchase Year
Acoustics Housings		Aluminum 6061, Polycarbonate	Custom	$98.00	2024
Algorithms: Autonomy		BehaviorTree.CPP v3	Custom		
Algorithms: Localization/Mapping		Extended Kalman Filter/Custom mapping system	Custom		
Algorithms: Vision		YOLO11	Custom		
AUV Chassis		Talos, Aluminum 6061	Custom	$900.00	2023
Battery	MaxAmps	Li-Po 8000 5S2P 18.5v	Purchased	$599.98	2023
Buoyancy Control	Blue Robotics	Subsea Buoyancy Foam; R-3312	Purchased	$70.00	2023
Camera	Stereolabs	Zed X	Purchased	$624	2025
Communication Network		CAN Bus	Custom		
Converter	TDK-Lambda	I6A4W020A033V	Purchased	$68.34	2022
CPU	Nvidia	Jetson AGX Orin	Purchased	$2,374.00	2022
Doppler Velocity Log (DVL)	Nortek	DVL1000	Sponsored	$15,000.00	2018
Hydrophones	Aquarian Audio	H1C	Purchased	$400.00	2018
Inertial Measurement Unit (IMU)/Compass	Vectornav	VN-100-T	Sponsored	$1,300.00	2022
Fiber Optic Gyro (FOG)	Fitzoptica	VG103S-2LND	Purchased	$2,870.00	2024
Microcontrollers	Raspberry Pi	RP2040	Purchased	$0.07	2021
Motor Control	APD	80F3	Sponsored	$245.00	2022
Open Source Software		ROS2/OpenCV/Pico-SDK/BTCPP			
Programming Languages		C/C++/Python/MATLAB			
Smart Battery Housings	Xometry	Aluminum 6061, Polycarbonate	Custom	$634.00	2023
Thrusters	Blue Robotics	T200	Purchased	$1,432.00	2021
Waterproof Connectors	MacArtney	MC/HP/D Series	Purchased	$4,000.00	2015-2023
Waterproof Main Housing	Xometry	Aluminum 6061, Polycarbonate	Custom	$2,233.00	2021
Downwards-Facing Camera	Stereolabs	Zed X Mini	$639.99	2024	
Task Mechanism Servo	Hiwonder	Hiwonder HTD-45-H	Purchased	$24.99	2024
Waterproof Servo Housings	BlueTrail Tobotics	SER 2000 Underwater Servo Kit	Purchased	$215.00	2024
Transmitter			Custom	$68.53	2025
Pressure Valve	IkeLite	1/2" Pressure Value	Purchased	$125.00	2024

TABLE II: The SS Flip Barker's Component Specifications

Component	Vendor	Model/Type	Custom/Purchased	Cost	Purchase Year
Acoustics Housings		Aluminum 6061, Polycarbonate	Custom	$50.00	2024
Algorithms: Autonomy		BehaviorTree.CPP v3	Custom		
Algorithms: Localization/Mapping		Extended Kalman Filter/Custom mapping system	Custom		
Algorithms: Vision		YOLO11	Custom		
Battery	MaxAmps	Li-Po 8000 5S2P 18.5v	Purchased	$300	2023
Buoyancy Control		Active Ballast / 3D printed	Custom		
Camera	Stereolabs	Zed X Mini	Purchased	$639.99	2025
Communication Network		CAN Bus	Custom		
Converter	TDK-Lambda	I6A4W020A033V	Purchased	$68.34	2022
CPU	Nvidia	Jetson AGX Nano	Purchased	$499.00	2024
Hydrophones	Aquarian Audio	H1C	Purchased	$200.00	2018
Inertial Measurement Unit (IMU)/Compass	Vectornav	VN-100-T	Sponsored	$1,300.00	2022
Microcontrollers	Raspberry Pi	RP2040	Purchased	$0.07	2021
Motor Control	TI	DRV8243HQRXYRQ1	Purchased	$19.15	2022
Open Source Software		ROS2/OpenCV/Pico-SDK/BTCPP			
Programming Languages		C/C++/Python/MATLAB			
Waterproof Connectors	MacArtney	MC/HP/D Series	Purchased	$2,000.00	2015-2023
Waterproof Main Housing		Jaws2, Aluminum	Custom		2015
Thrusters	Seabotix	BTD 150	Purchased	$695.00	2013
Regulator	Harris Welding Supplies	25GX-145-590-3000550	Purchased	$97.00	2025
Pressure Valve	IkeLite	1/2" Pressure Value	Purchased	$125.00	2024
Drivetrain Motors	LeTkingok	T-ZFY60-127	Purchased	$74.97	2024
Task Mechanism Servo	Hiwonder	Hiwonder HTD-45-H	Purchased	$24.99	2024
Waterproof Servo Housings	BlueTrail Tobotics	SER 2000 Underwater Servo Kit	Purchased	$215.00	2024
Transmitter			Custom	$68.53	2025
Regulator Housing	Xometry		Custom	$550.00	2025
Active Seals	RapidDirect		Custom	$639.00	2025

Appendix B: Software Diagram

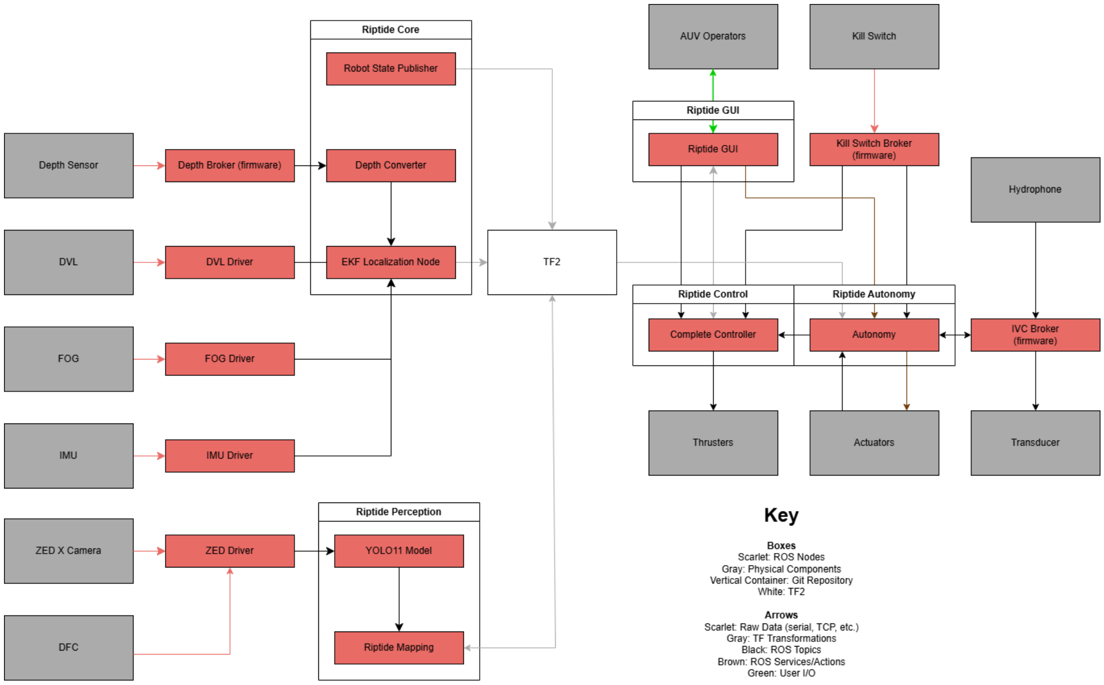

Fig. 9: Software Diagram of Talos

Appendix C: Control System Diagram

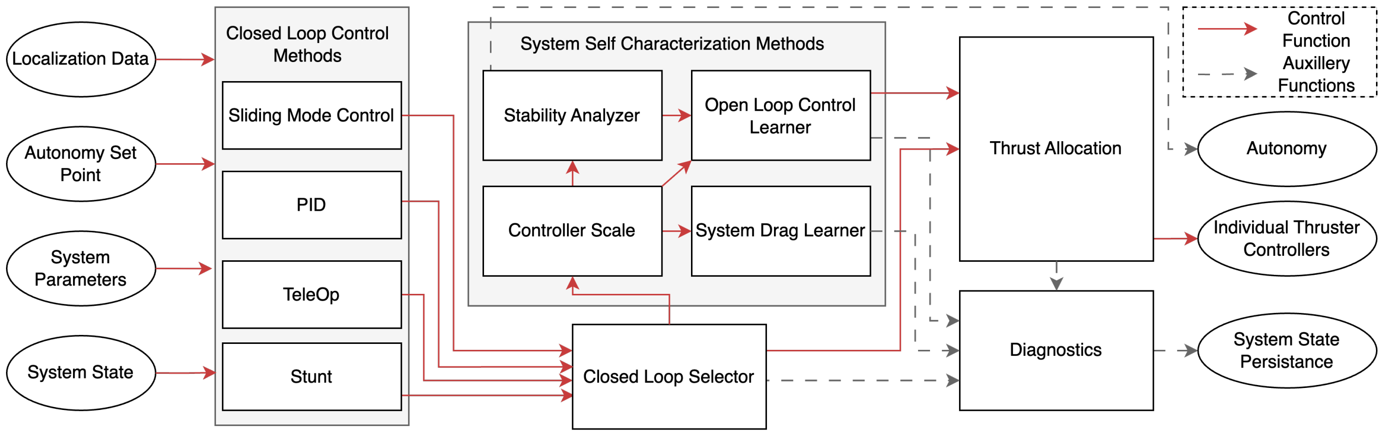

Fig. 10: Block diagram of the control system

APPENDIX D: ELECTRICAL BLOCK DIAGRAMS

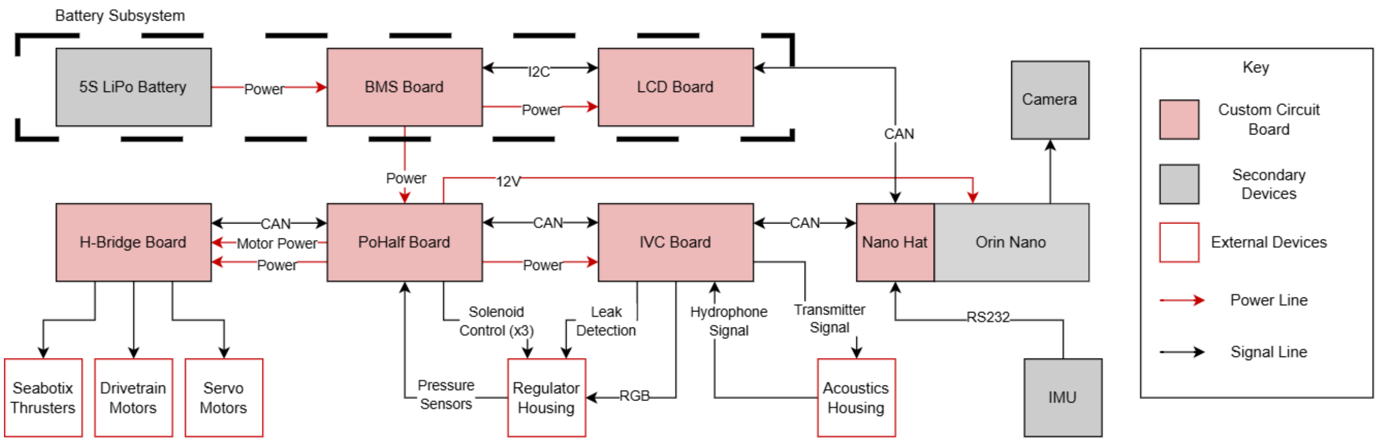

Fig. 11: The SS Flip Barker electrical system block diagram

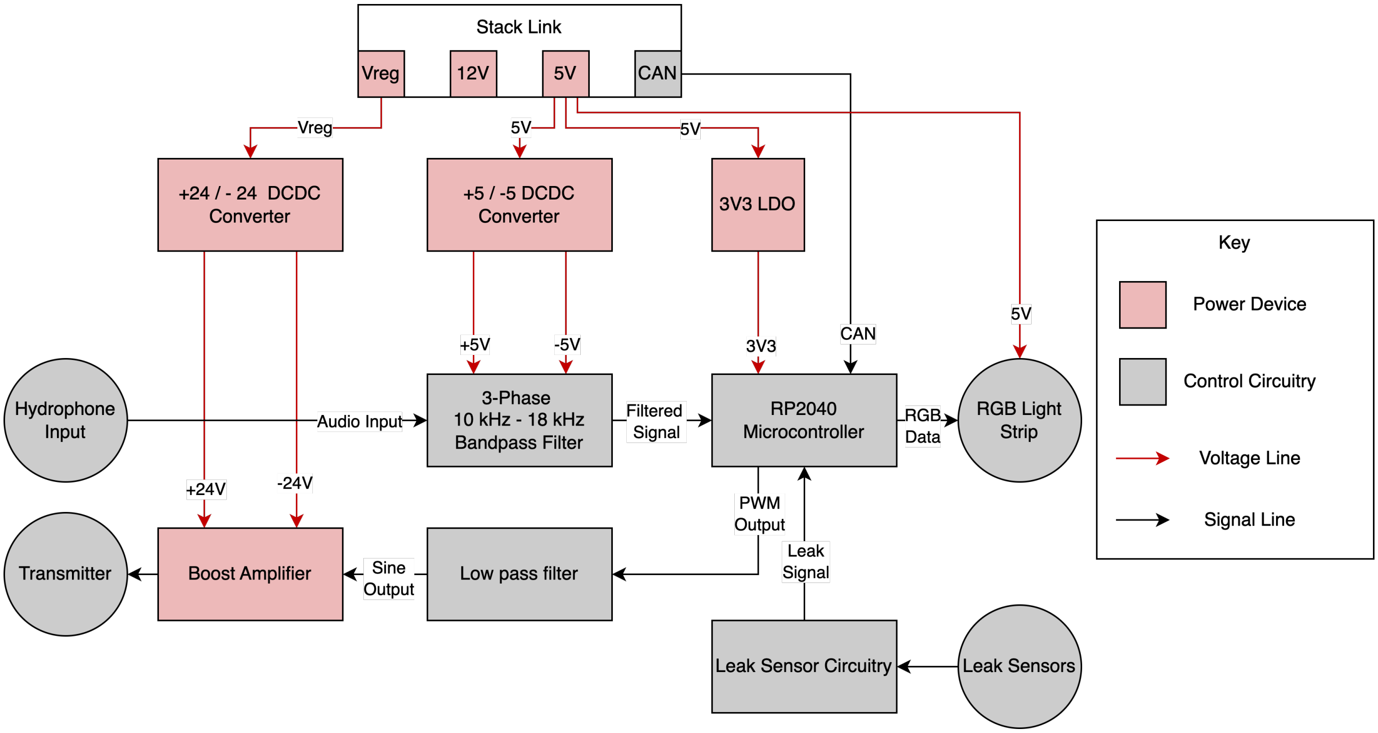

Fig. 12: IVC Board Block Diagram

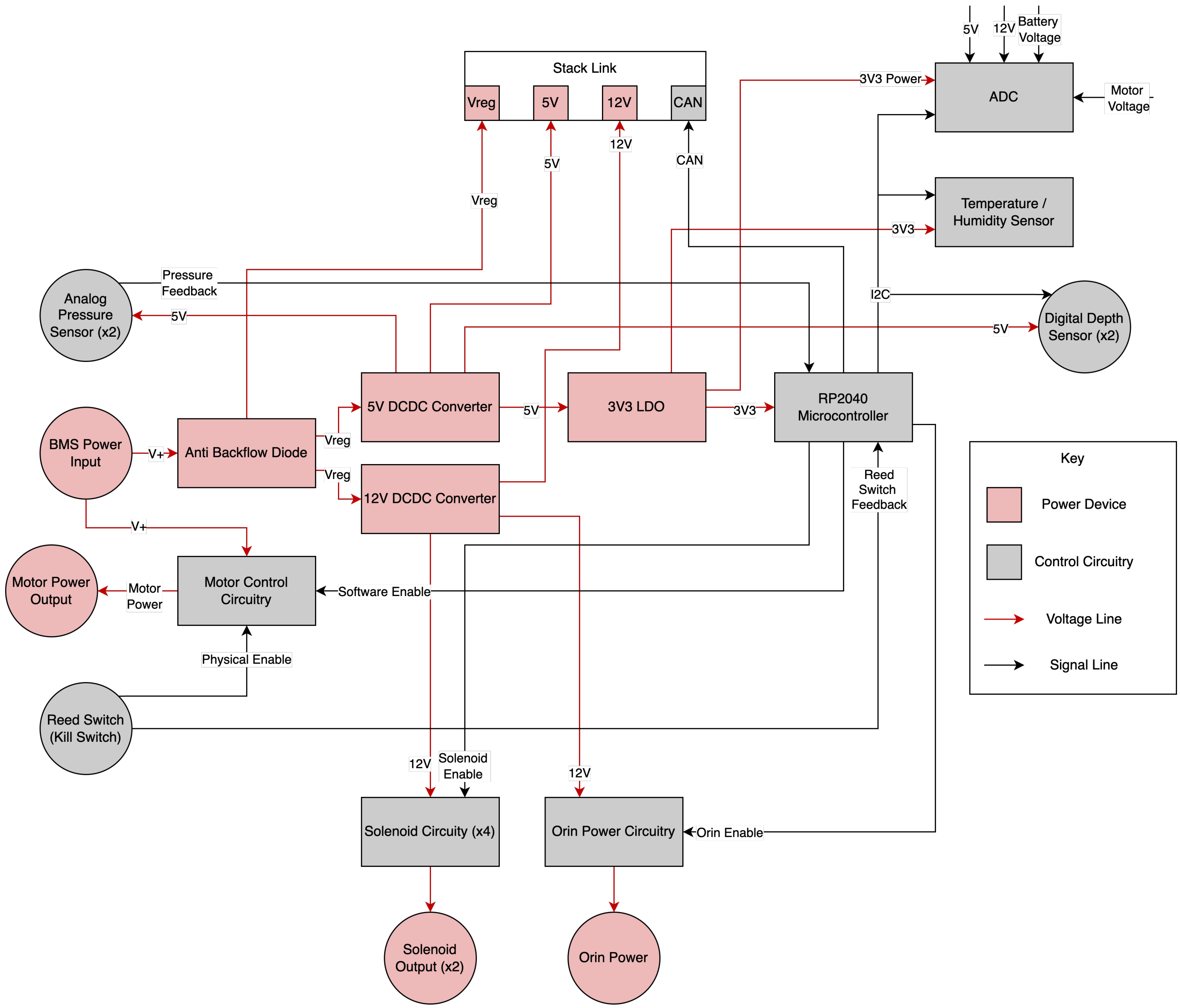

Fig. 13: PoHalf Board Block Diagram

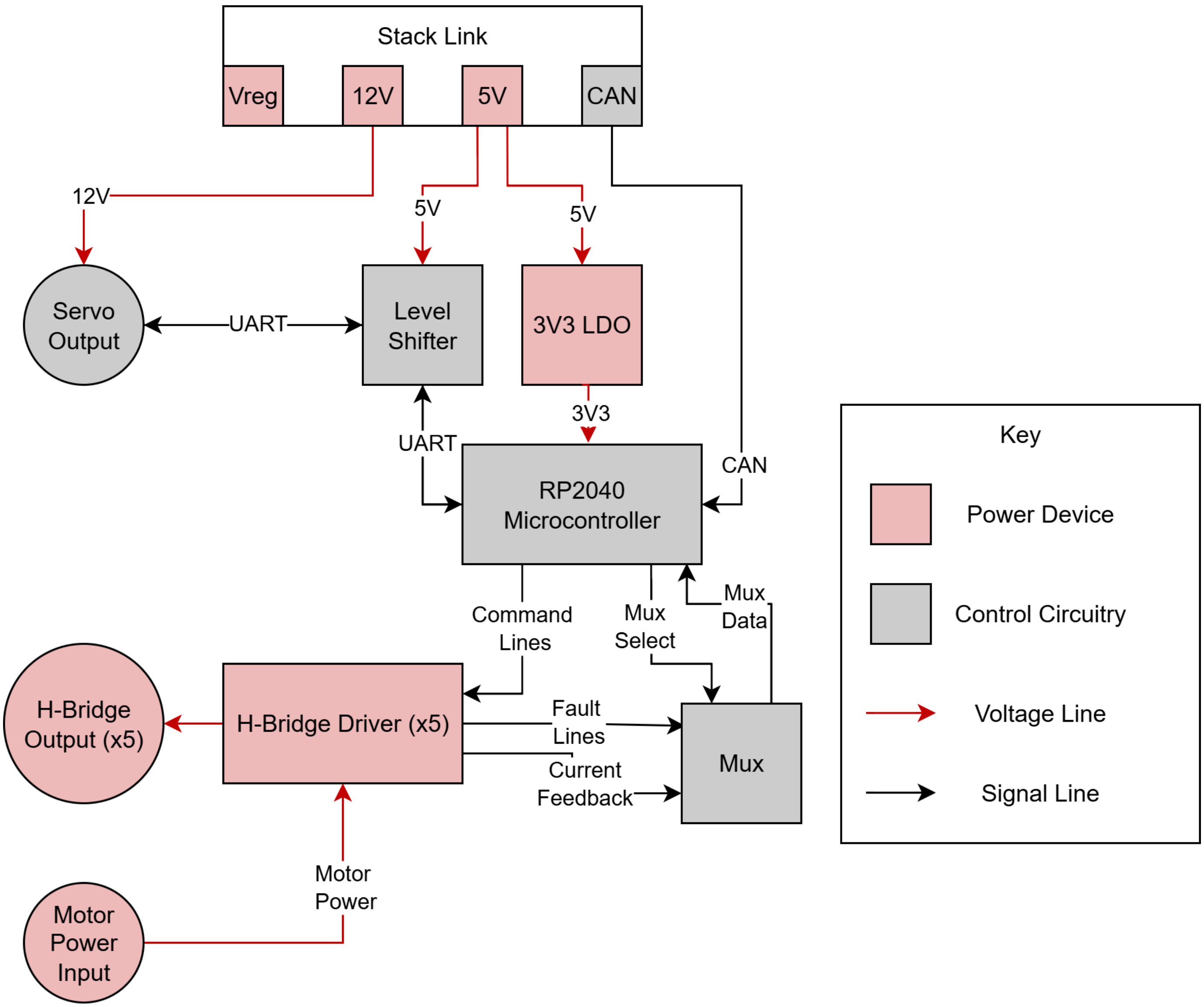

Fig. 14: H-Bridge Board Block Diagram

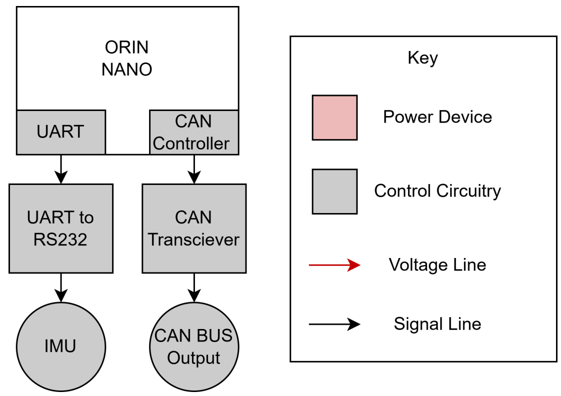

Fig. 15: Nano Hat Diagram

APPENDIX F: FOG CALIBRATION

Fig. 16: FOG calibration rig with temperature-controlled enclosure and stepper-motor turntable

Last summer, the team added a fiber-optic gyroscope (FOG) to Talos to improve yaw accuracy and counteract magnetic and acceleration disturbances. Because the FOG's 24-bit ADC output drifts with temperature, we designed a custom calibration rig: a temperature-controlled enclosure mounted on a stepper-motor turntable. By precisely rotating the FOG at known rates and temperatures, we generated a 3-D calibration surface mapping ADC output and temperature to true angular velocity.

Appendix G: FOG Mount

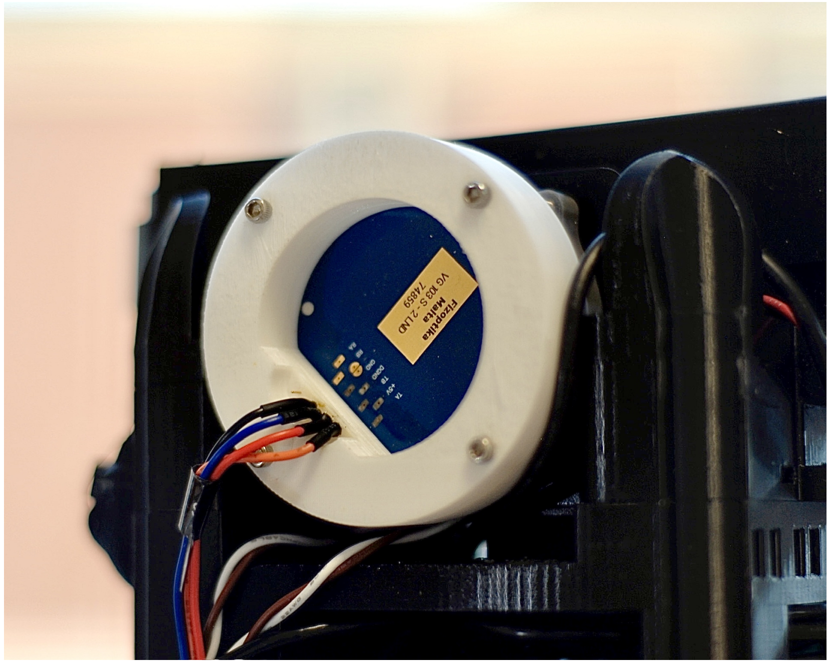

Fig. 17: 3D printed FOG mount with pogo pin interface

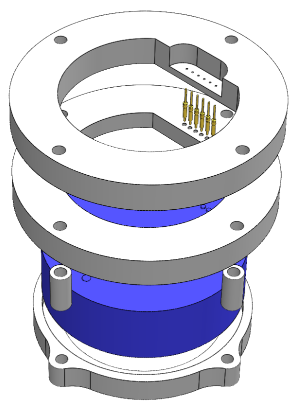

Fig. 18: FOG Mount Exploded Assembly

The FOG originally had a connector system which relied on thin, exposed pins that were very fragile/sensitive. The pins were broken during the assembly of the new cage. The team managed to create a solution that safely repaired the gyro but also provided more protection than it originally had before.

The new mounted housing for the FOG was re-designed to utilize a new pogo pin interface. The new mount consists of a 3D printed assembly, printed with a 0.2mm nozzle to ensure a precise fit, consisting of three plates. The top two plates hold the pins; the lower of the two, positioned directly above the FOG, aligns the bodies of the pins with the FOG's contact pads; the top plate supports the soldered connections between the pins and wires, and holds the pins in place. The bottom plate, separated from the other two by standoffs, secures the FOG and mounts the entire assembly within the camera cage. This layered structure ensures the correct pin height and compression, enabling consistent electrical contact, while also allowing for repeatable and safe removal and installation in the camera cage