Station 173

UC DAVIS COLLEGE OF ENGINEERING

Autonomous Underwater Vehicle

Cyclone RoboSub

Leadership: Peter Webster, Jason Pieck, Anjani Gadkari, Nidhi Vadulas, Dilraj Gill, Luna Park, Jacob Marinas, Nico Holasek, Allen Cooke, Mohammad Ayub Hanif Saleh, Zenyn Ethridge, Luci Masselink, David Kou, Aditi Anand, Aubri Lee
Advisors: Shima Nazari PhD, Abhigyan Majumdar

About Us

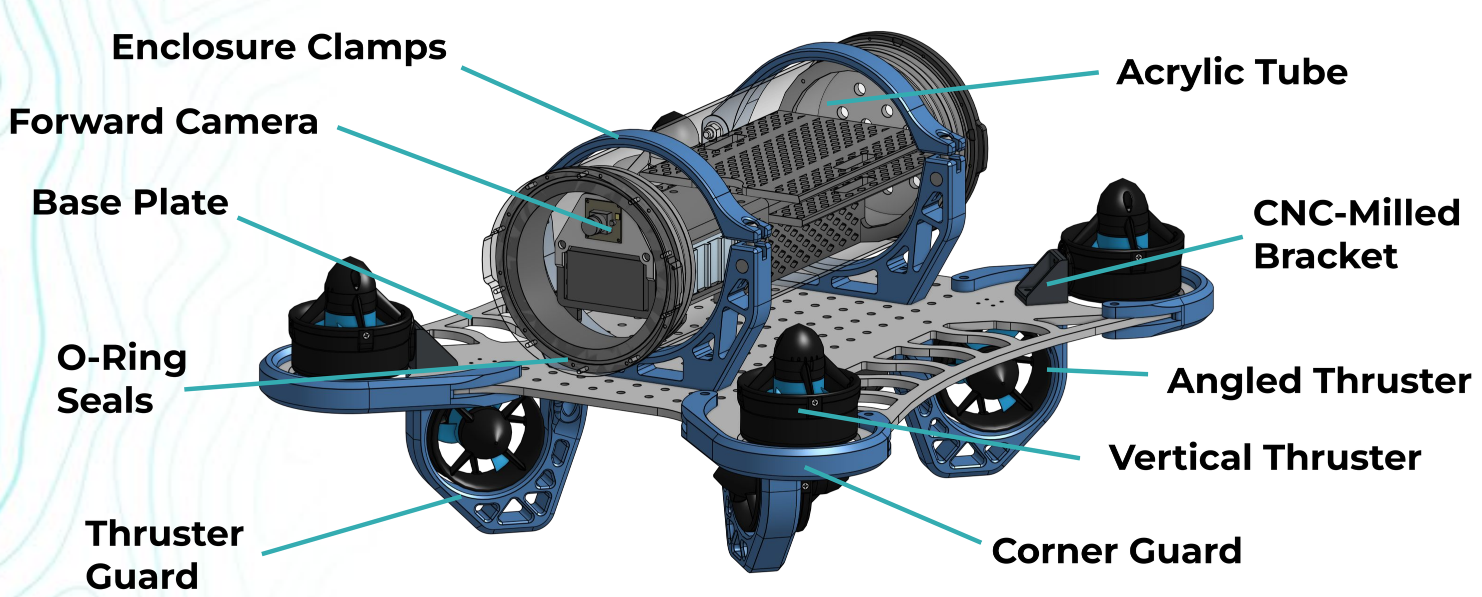
Cyclone RoboSub, founded in 2023, is an engineering student design team at UC Davis developing an autonomous underwater vehicle (AUV). Our interdisciplinary team of 30+ students is organized into three divisions and six sub-teams, each tackling different aspects of this project.

RoboSub Competition

Teams from around the world compete with custom AUVs which complete tasks such as manipulating objects, maneuvering around obstacles, and firing torpedoes. Our team has prioritized navigation-based tasks, eliminating the need for precise manipulation. Cyclone RoboSub will be competing for the first time this year where we will debut our vehicle!

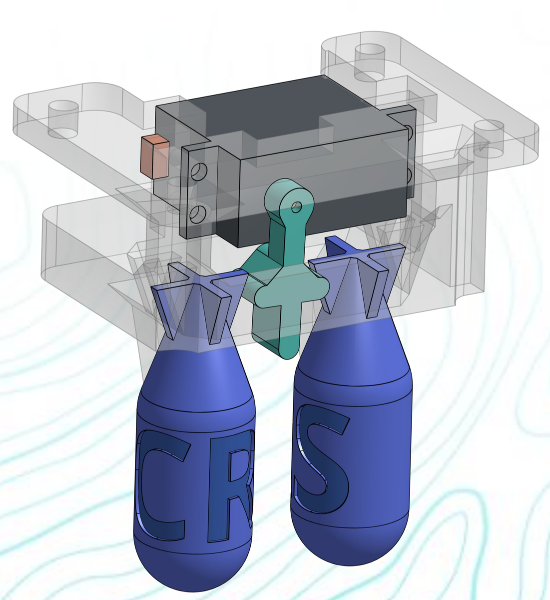
Vehicle Design

Our chosen thruster configuration allows for six degrees of freedom while its symmetry simplifies vehicle control and maneuverability. Designed to be neutrally buoyant and have a low center of mass, the vehicle naturally corrects errors in positioning. All electronics are housed in an acrylic tube with Blue Robotics WetLink penetrators to connect cables to the external environment.



Manipulation

We designed servo-actuated mechanisms to release two small droppers into a bin during competition runs. The AUV centers itself over the bin using a downward facing camera and computer vision.



Software Controls

The vehicle relies on a combination of sensors to determine its depth, heading, and position within the pool. All data and commands are sent over a ROS network and mission planning is handled by the Executive Main Loop which is written in C++.

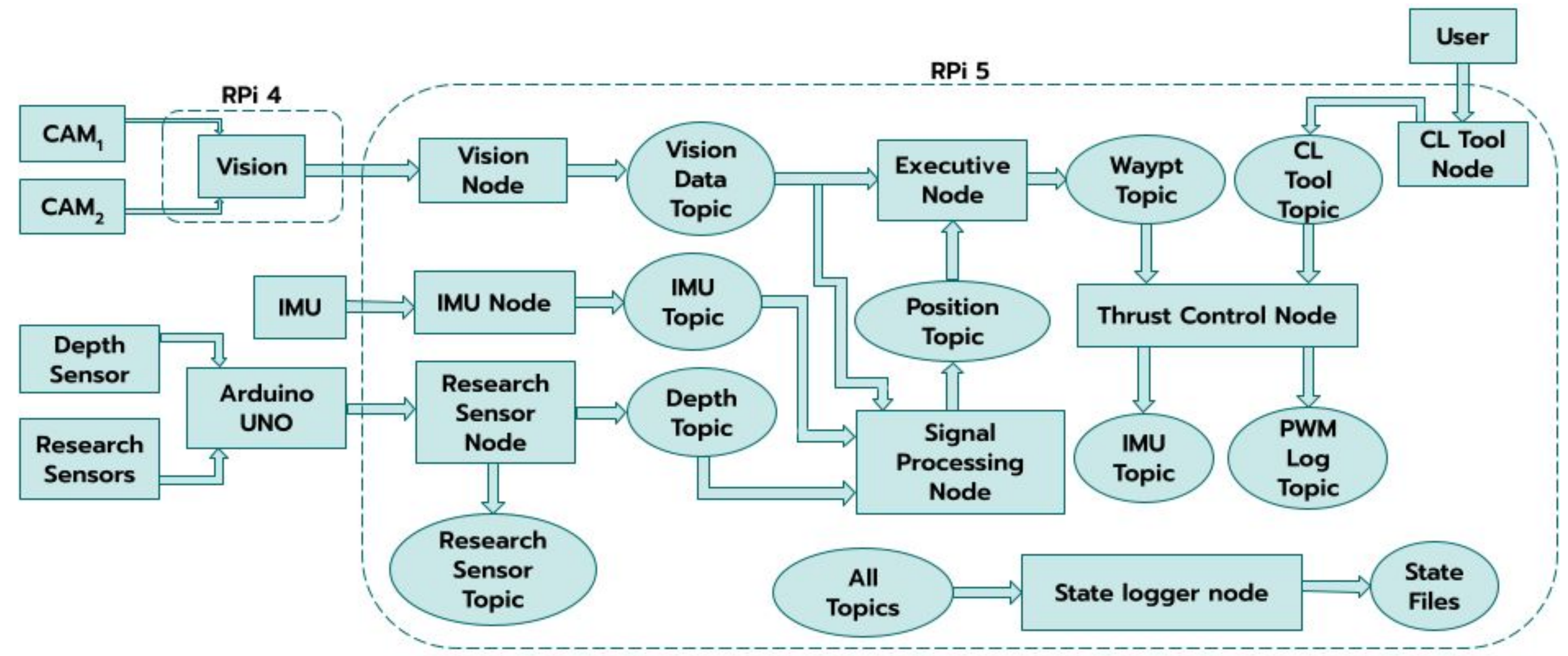


Figure 1: ROS Communication Flowchart

Dynamics Modeling

The control scheme is built in MATLAB Simulink which generates trajectories and regulates PID feedback based on a built dynamic model and waypoints. The model accounts for the AUV's 6-axes of freedom, buoyancy, drag, and vectored thruster configuration. The parameters are measured and validated based on IMU data collected during underwater testing.

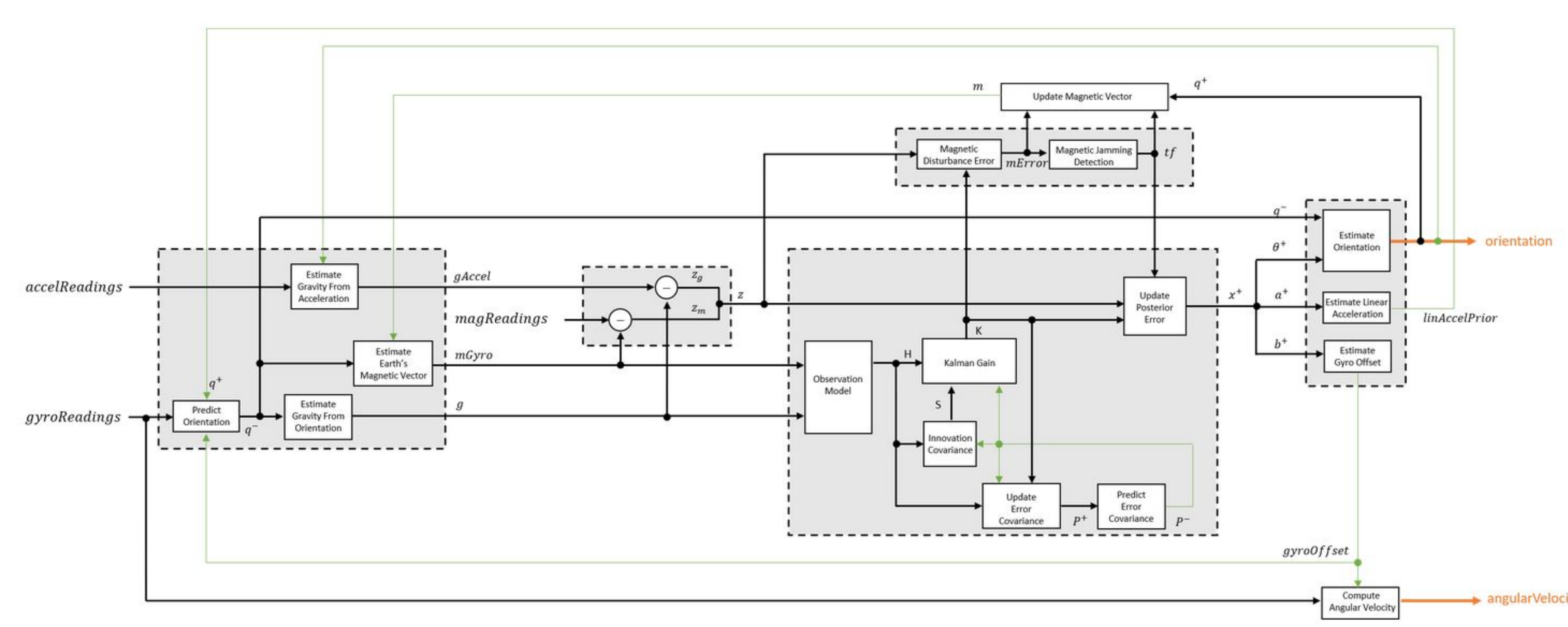
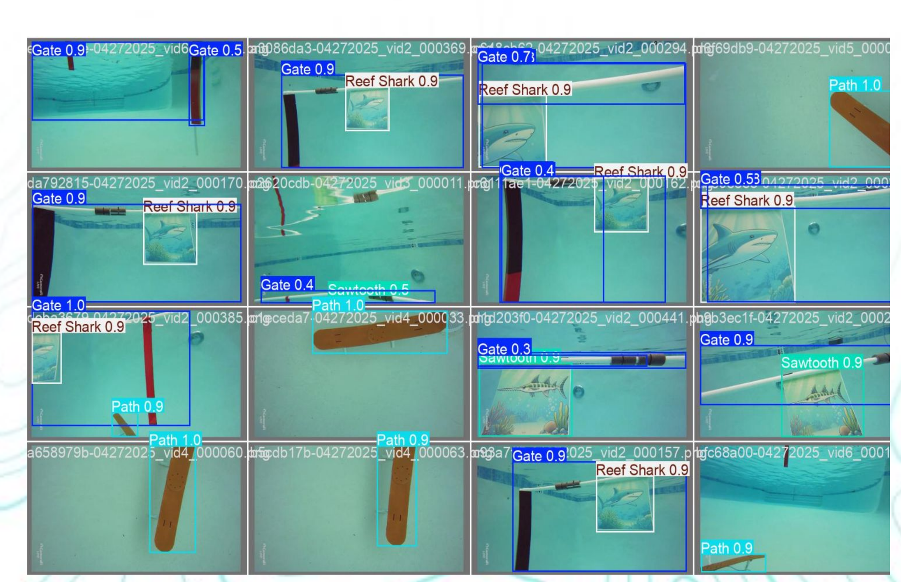


Figure 2: Simulink Block for Sensor Fusion and Motion Estimation

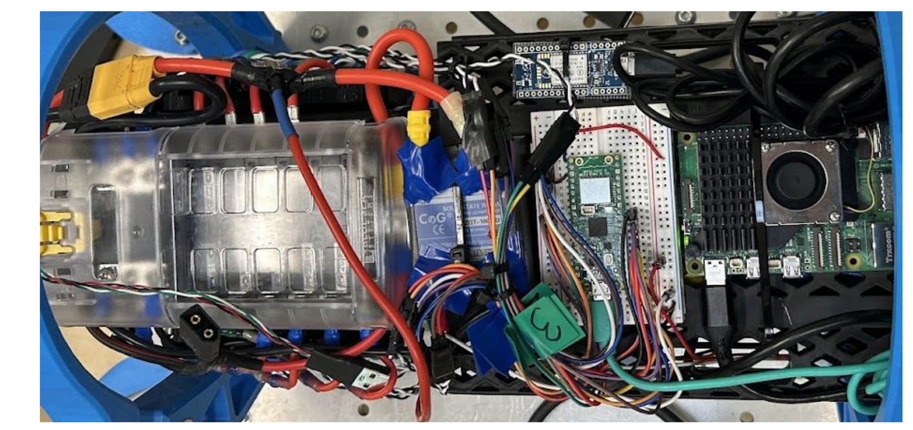
Vision

Two cameras provide the vehicle with feeds that run through a YOLO vision model, to identify objects of significance. The downward facing camera allows for positioning the dropper, while the forward facing camera determines which side of the start gate the vehicle passes through. Identifying objects along the course help the robot track its position within the pool.



Electrical System

The vehicle is powered by a single 16V Lithium Polymer (LiPo) battery which supplies power to the AUV's computers, sensors, and thrusters. Electrical components are precisely mounted to a 3D-printed internal structure to maximize volume within the tube and efficiently route wires between components. A custom PCB distributes 5V of power from the buck converter to low-voltage components.



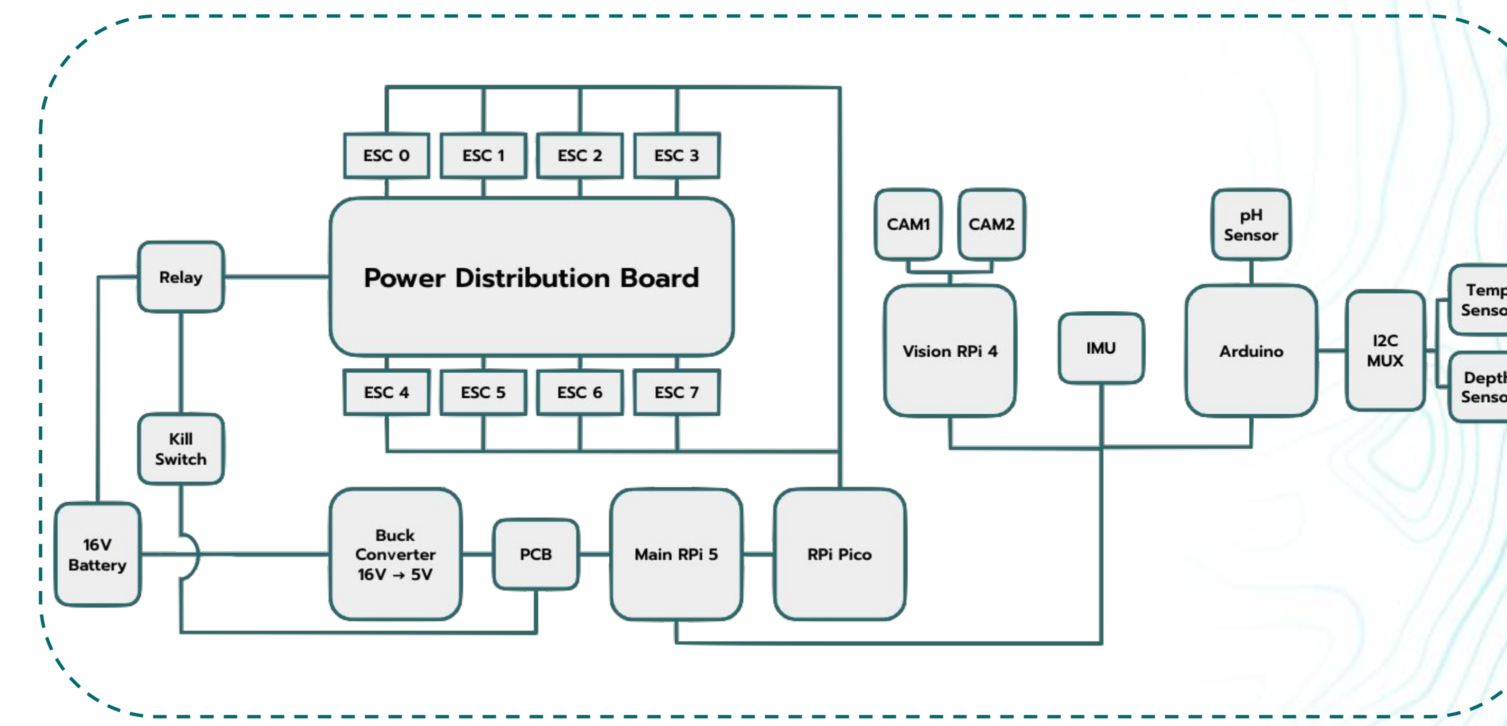
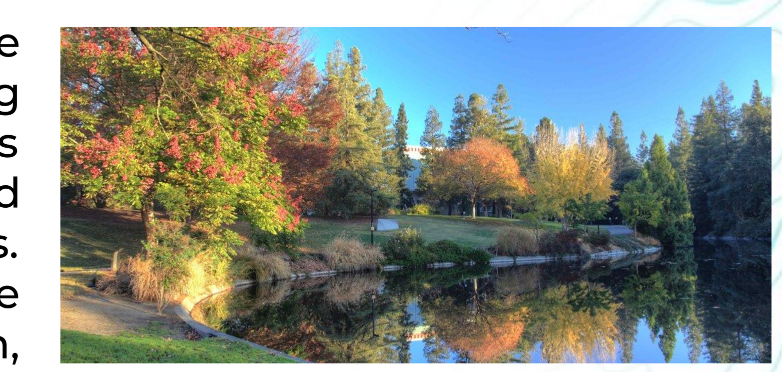


Figure 3: Electrical Schematic

Research

Beyond the competition, Cyclone RoboSub is currently contributing to environmental research efforts through field deployments and interdepartmental collaborations. Equipped with sensors to measure temperature, pH, dissolved oxygen, and depth, the vehicle can collect environmental data while taking two transects along the UC Davis Arboretum. We are also exploring opportunities to contribute to marine science research at the Bodega Marine Lab.



Acknowledgements

We would also like to thank all of our highly dedicated team members, including but not limited to Aishwarya Tawade, Albert Zheng, Alice Roy, Andrew Li, Brandon Santamaria, Danny Kwong, Hannah Kench, Hunter Ward, Josh Cook, Kaitlyn Hahn, Kekoa Olive, Kory Haydon, Lemar Argand, Naia Dalal, Nathaniel Fregoso, Ruby Stanton, Ryan Mathur, Sawyer Morgan, Sherry Lei, Tanishq Dwivedi, William Barber

Text

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Teams from around the world compete with custom AUVs which complete tasks such as manipulating objects, maneuvering around obstacles, and firing torpedoes. Our team has prioritized navigation-based tasks, eliminating the need for precise manipulation.

Four vertical thrusters and four 45° horizontal thrusters allow for six degrees of freedom. The symmetric thruster layout simplifies vehicle control and maneuverability. Designed to be neutrally buoyant and have a low center of mass, the vehicle naturally corrects errors in positioning.

All electronics are housed within an acrylic tube with Blue Robotics WetLink penetrators to connect cables to the external environment. The tube remains fixed by hinged clasps printed from weather-resistant PETG filament. The thrusters are mounted to a baseplate using CNC-milled aluminum brackets.

The vehicle is outfitted with servo-actuated mechanisms designed to release two small droppers into a bin during competition runs. The AUV centers itself over the bin using a downward facing camera and computer vision.

The vehicle relies on a combination of positioning systems and dynamic control. The Inertial Motion Unit (IMU) and the Doppler Velocity Logger (DVL), respectively, provide acceleration and velocity data to the robot. These data sets are merged and sorted using a Kalman filer, allowing the system to accurately track the robot's position down to the centimeter. The vehicle also relies on multiple pressure sensors and an automatic heading and referencing system (AHRS) to track depth and heading.

The Executive Main Loop makes a series of decisions throughout a competition run based on active sensor and vision feedback. Sensor feedback is used for mission planning and PID control. The executive main loop commands the thrusters by assigning PWM values to eight electric speed controllers (ESCs) which modulate the thruster outputs.

The vehicle relies on a combination of positioning systems and dynamic control to accurately track its position. It also utilizes multiple pressure sensors and an automatic heading and referencing system (AHRS) to track depth and heading.

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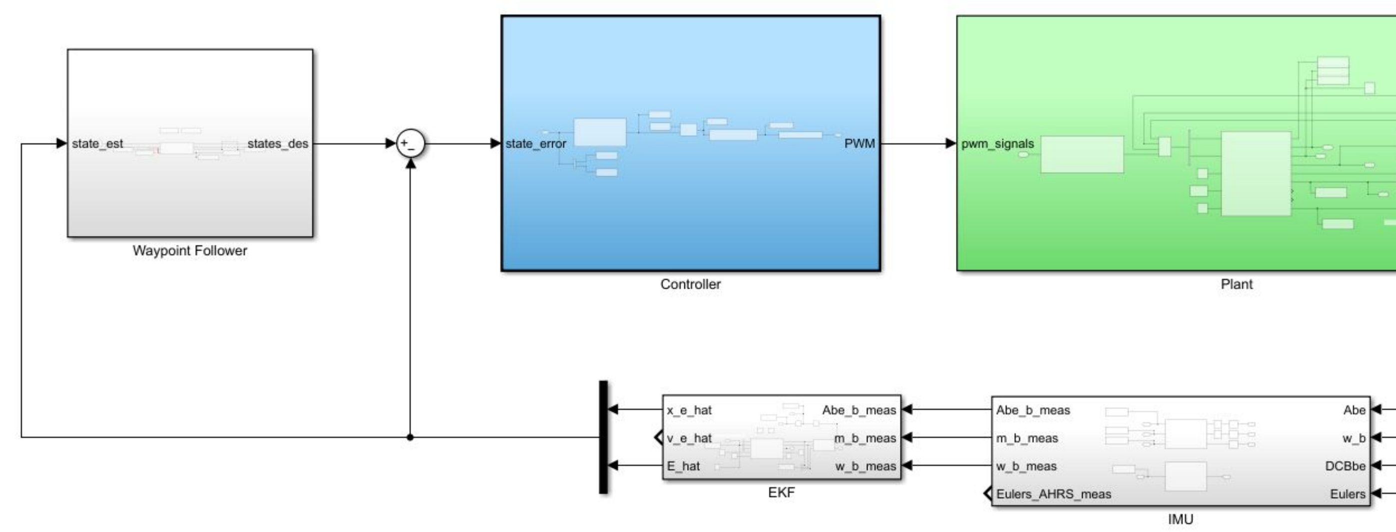
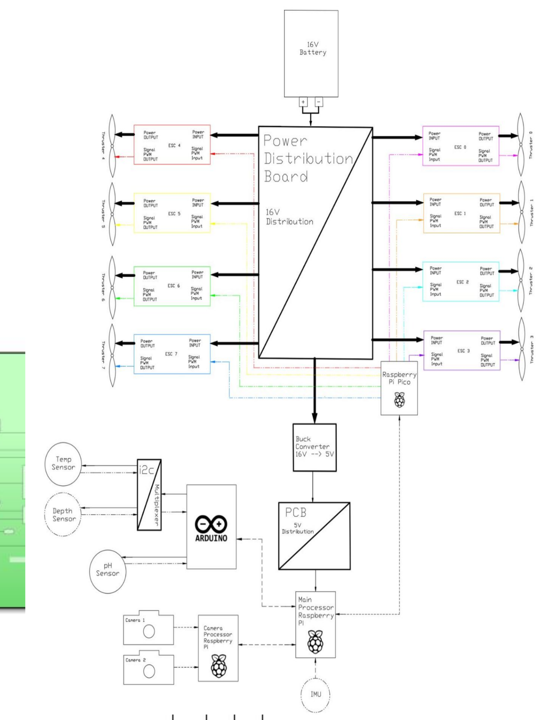
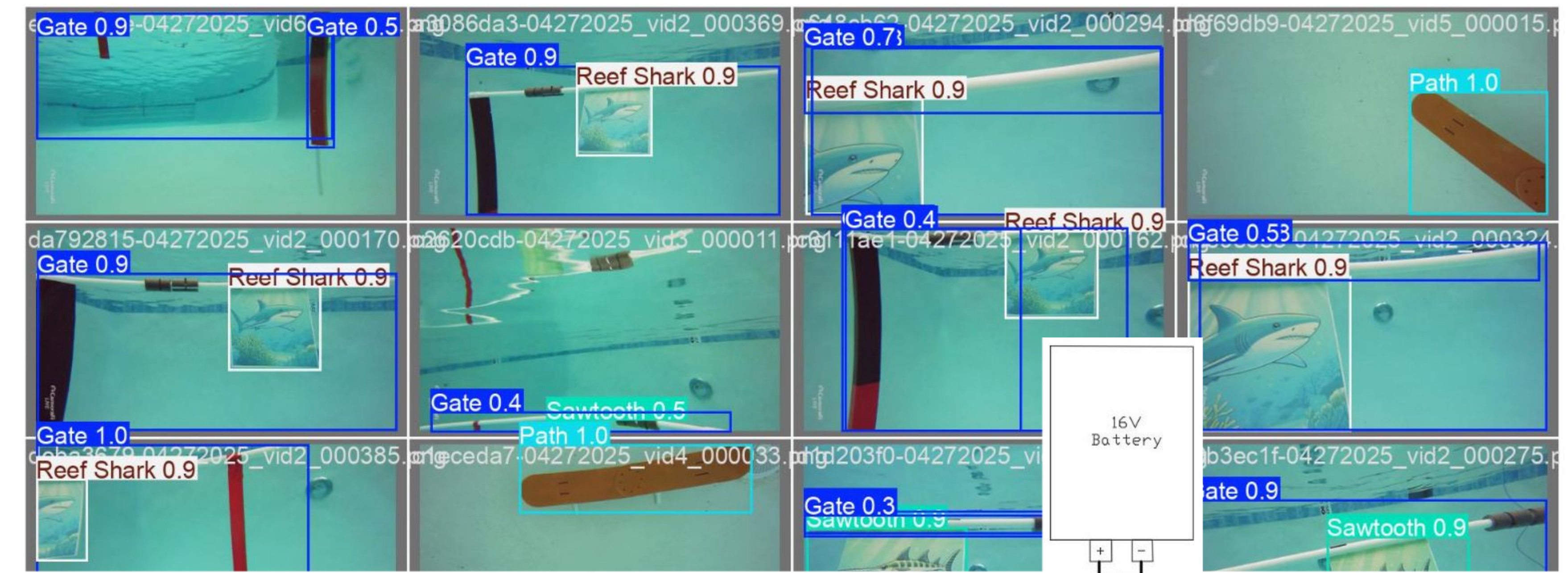
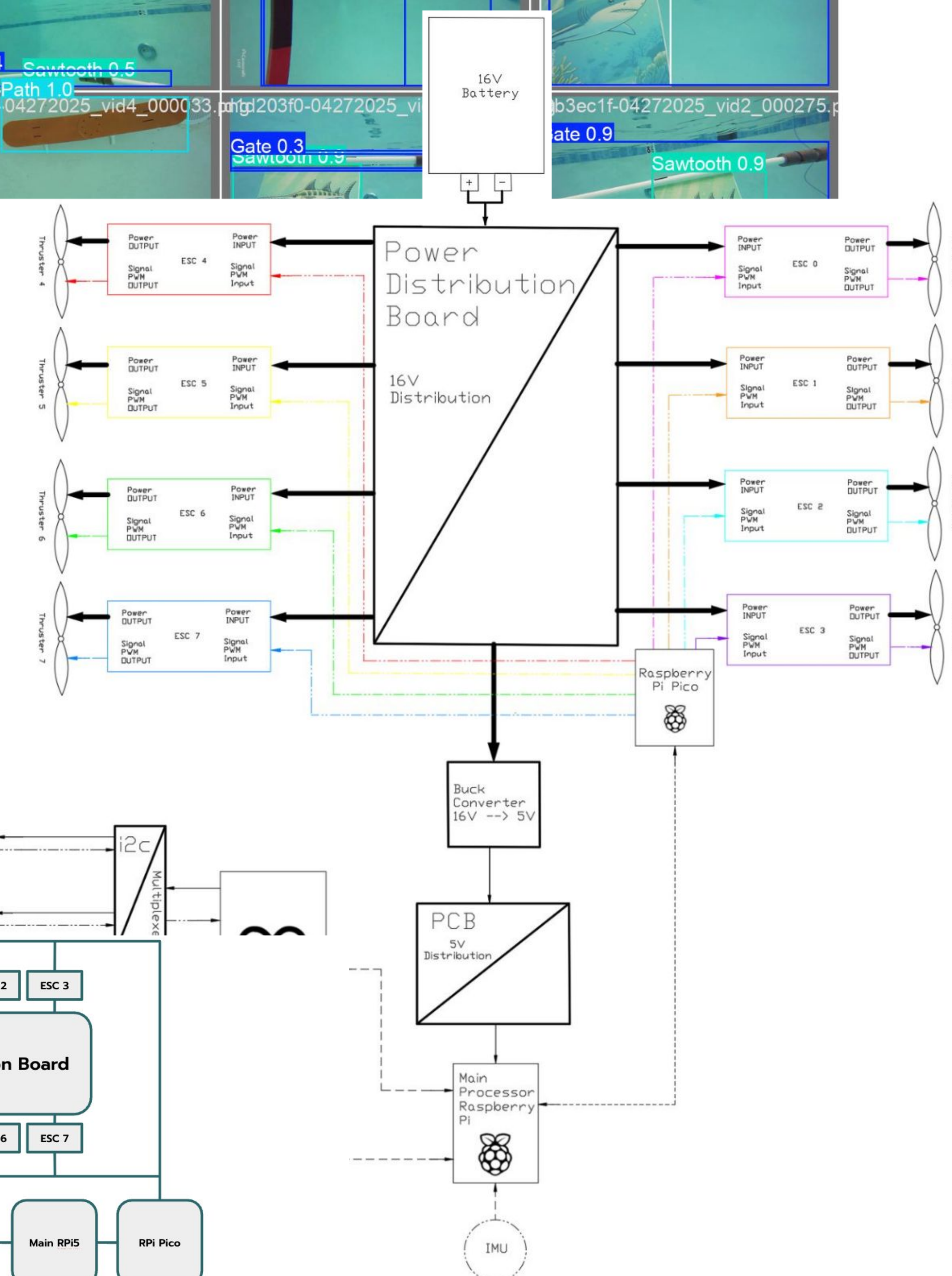
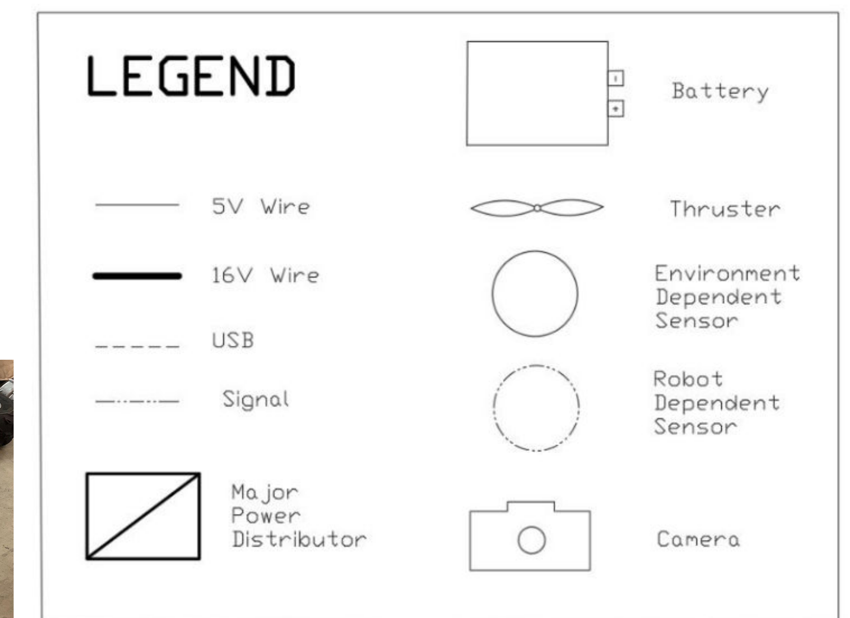
Images


Waypoint Follower
Controller
Plant
EKF
IMU






16V Battery
Power Distribution Board
16V Distribution
Raspberry Pi Pico
Buck Converter 16V --> 5V
PCB
5V Distribution
Main Processor Raspberry Pi
IMU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16V Wire
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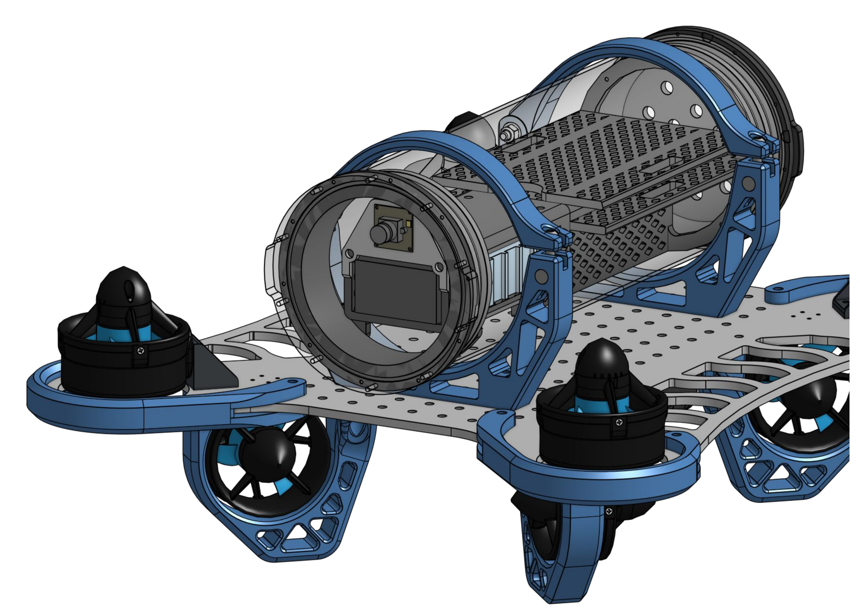
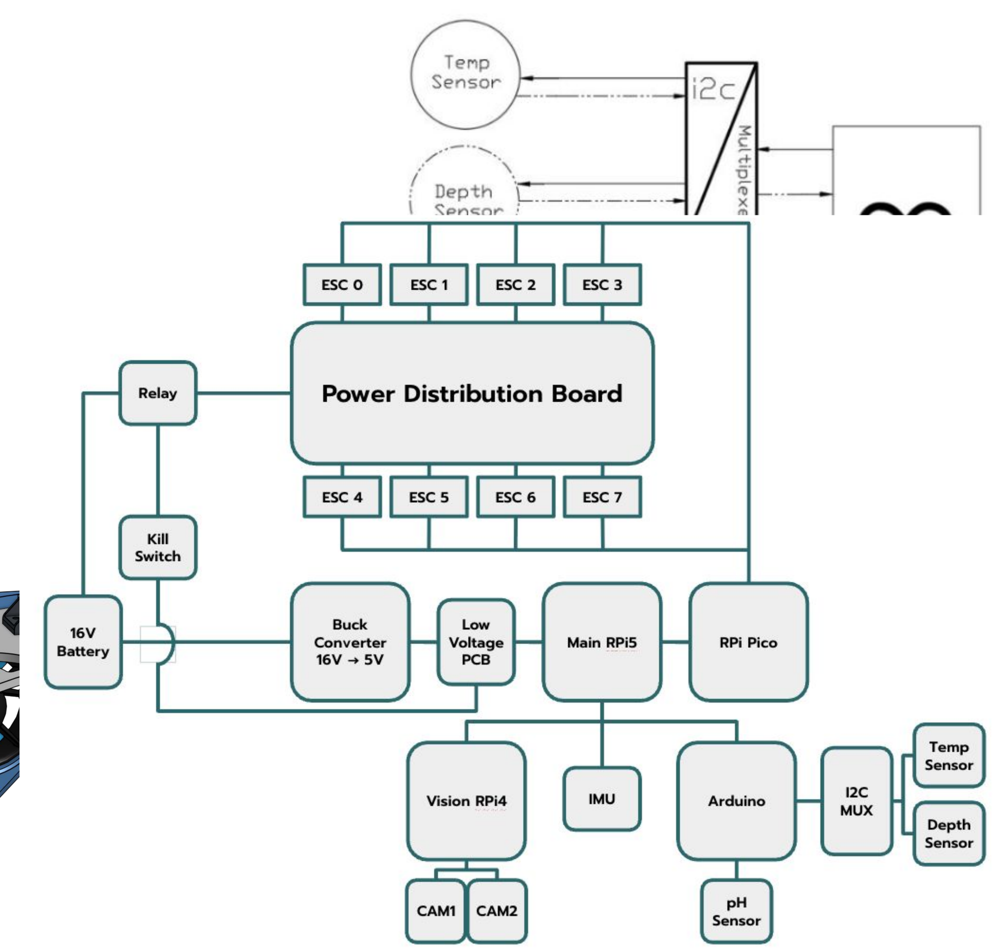
Signal
Major Power Distributor
Battery
Thruster
Environment Dependent Sensor
Robot Dependent Sensor
Camera

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Depth Sensor
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ESC 2
ESC 3
Power Distribution Board
ESC 4
ESC 5
ESC 6
ESC 7
Relay
Kill Switch
16V Battery
Buck Converter 16V → 5V
Low Voltage PCB
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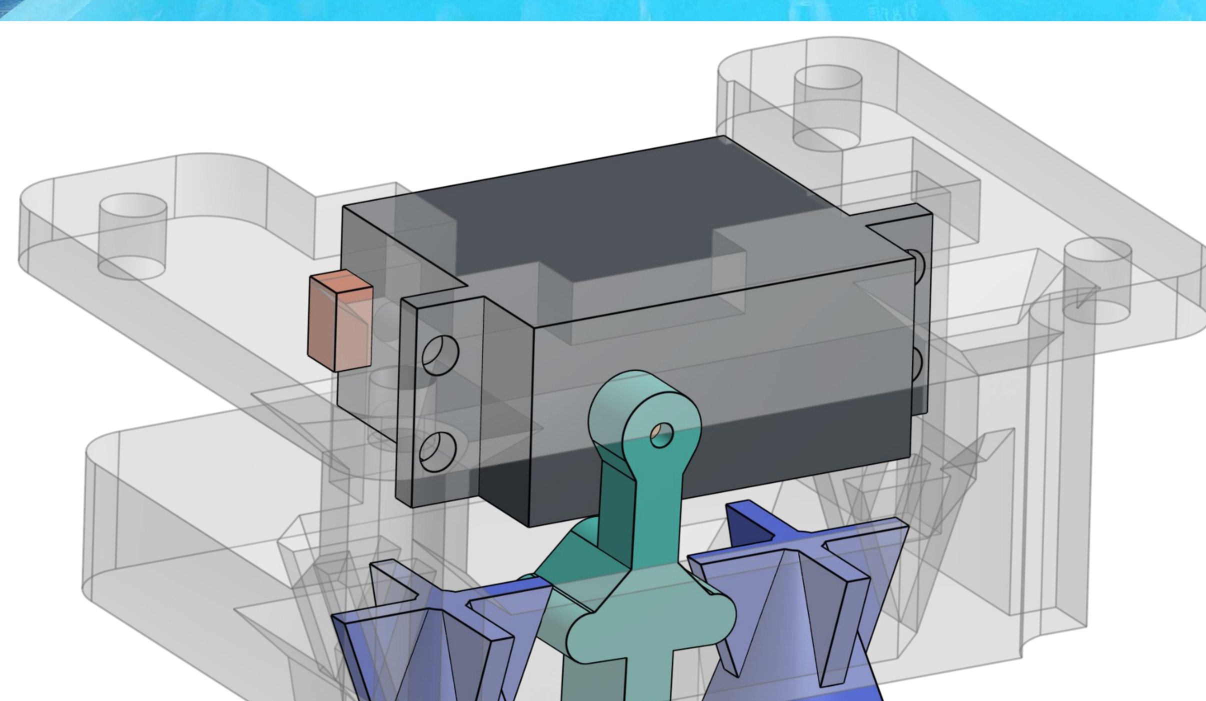
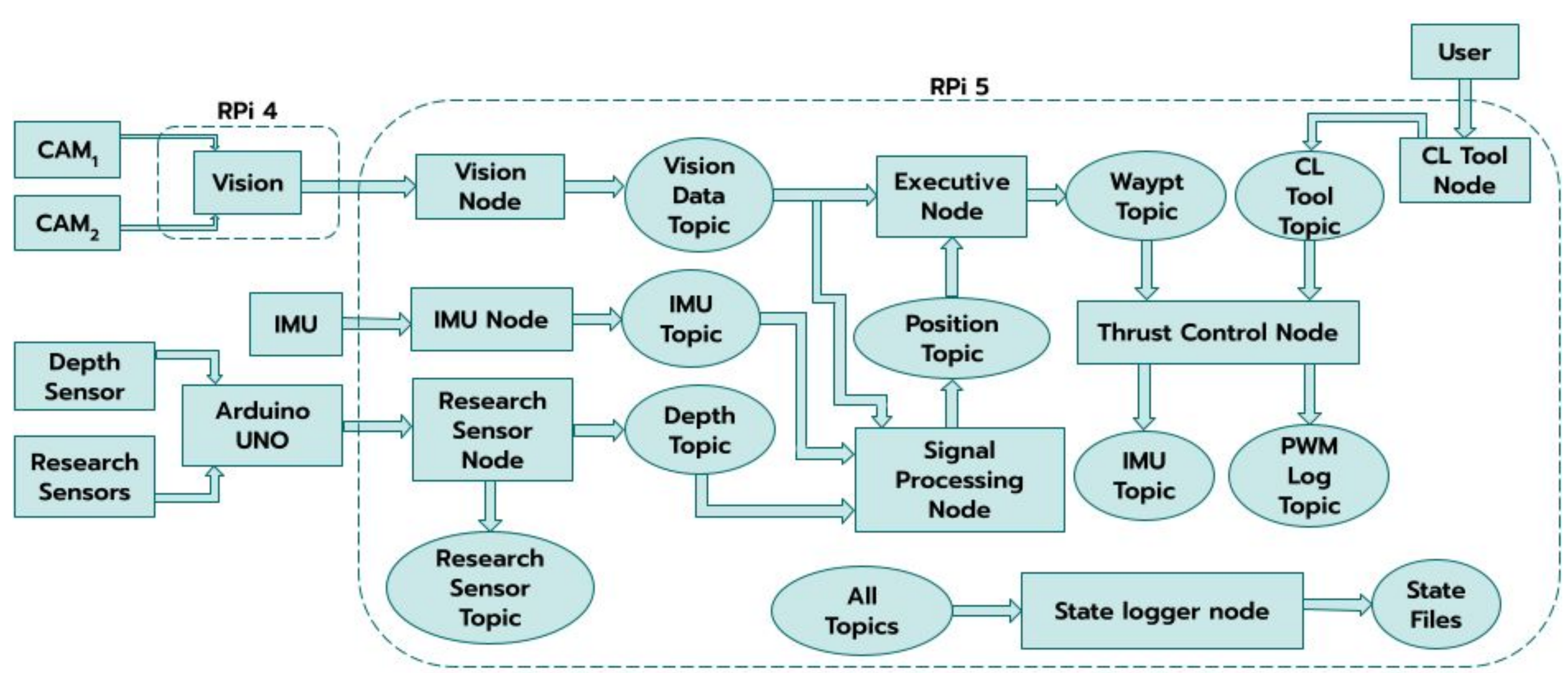
RPi Pico
Vision RPi4
IMU
Arduino
I2C MUX
Temp Sensor
Depth Sensor
CAM1
CAM2
pH Sensor

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RPi 5
User
CAM_1
CAM_2
Vision
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Vision Data Topic
Executive Node
Waypt Topic
CL Tool Topic
CL Tool Node
IMU
IMU Node
IMU Topic
Position Topic
Thrust Control Node
Depth Sensor
Arduino UNO
Research Sensors
Research Sensor Node
Depth Topic
Signal Processing Node
IMU Topic
PWM Log Topic
Research Sensor Topic
All Topics
State logger node
State Files


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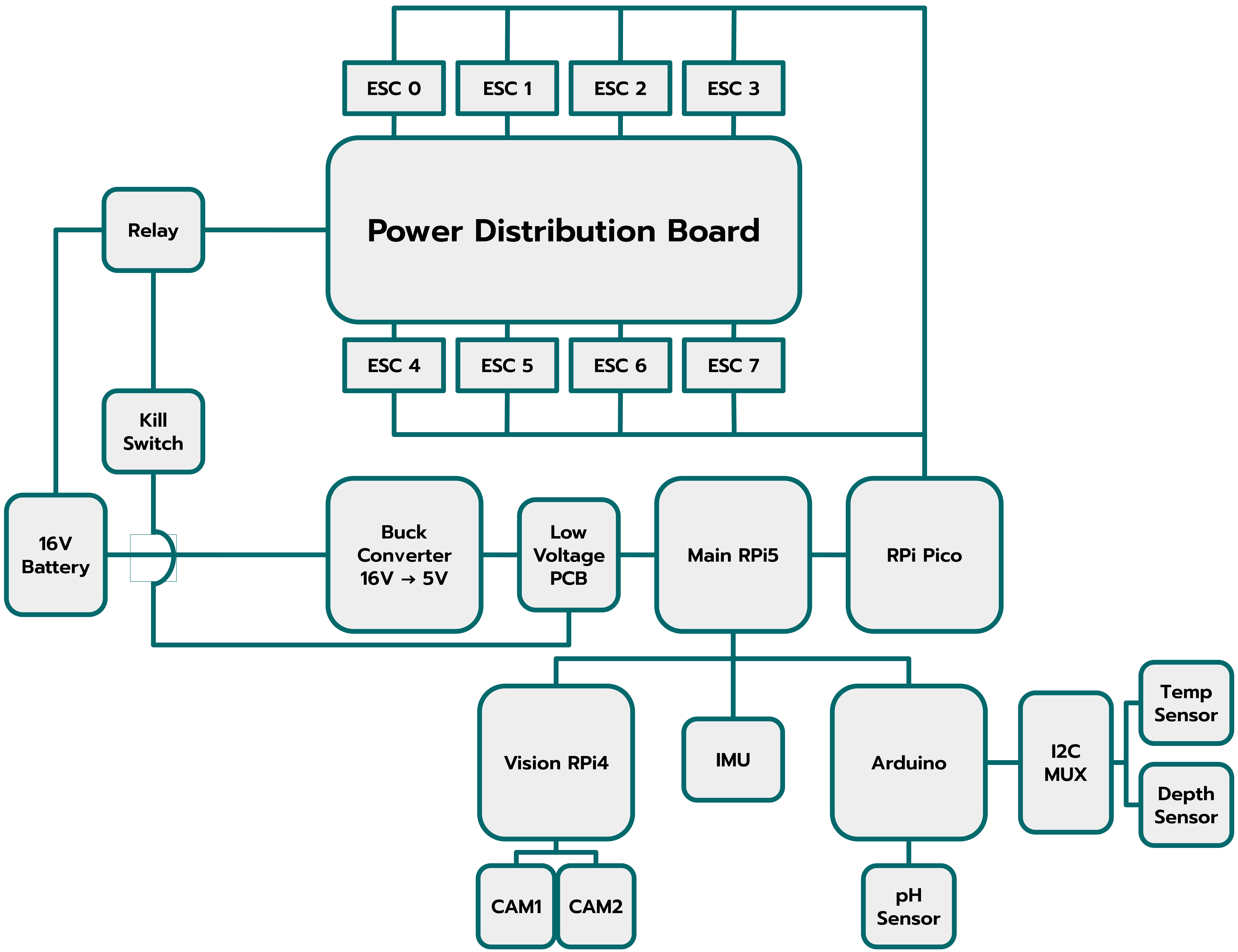
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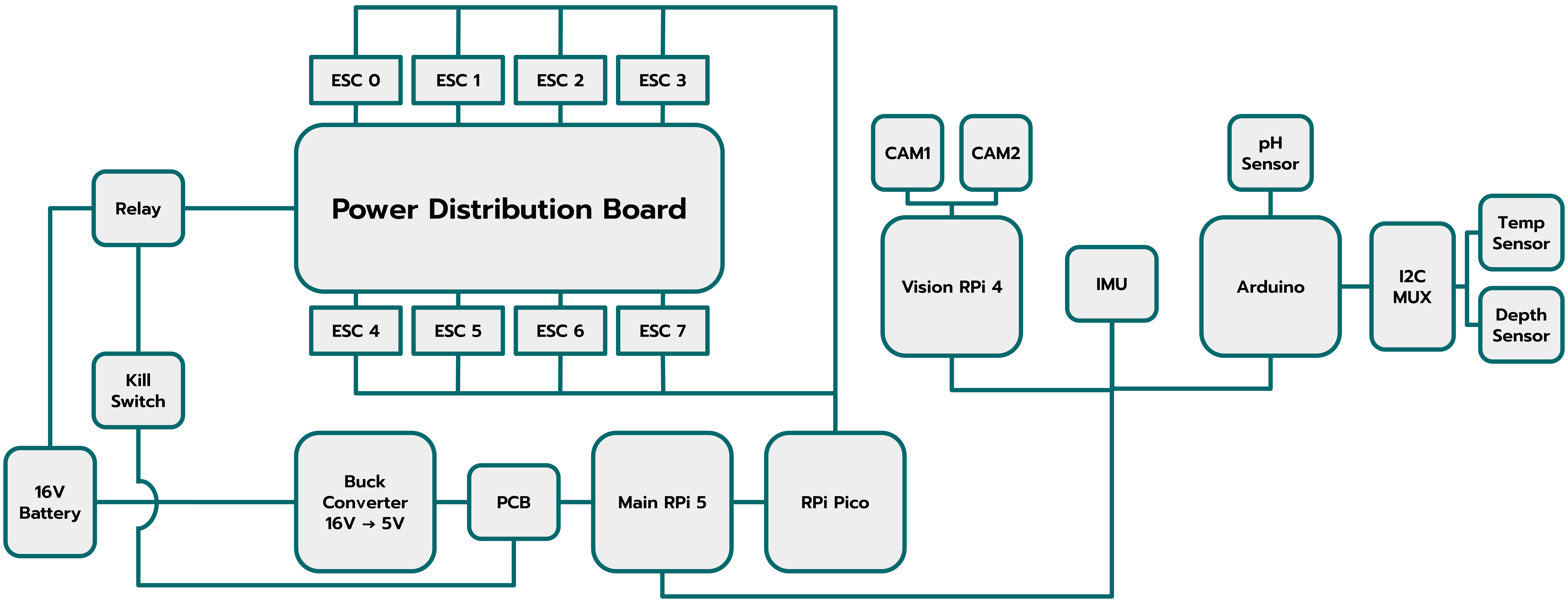
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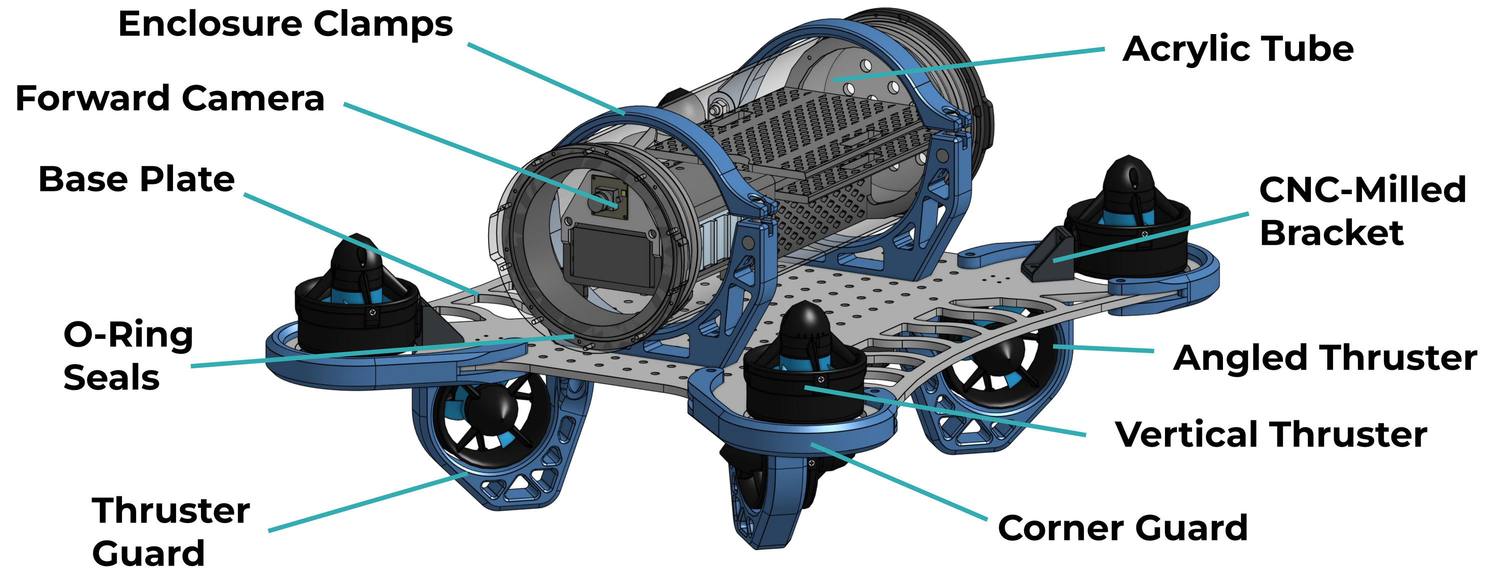
Enclosure Clamps
Acrylic Tube
Forward Camera
Base Plate
CNC-Milled
Bracket
O-Ring
Seals
Angled Thruster
Vertical Thruster
Thruster
Guard
Corner Guard