CWRUbotix

2025 Non-ROV Device Design

Monitoring and Mitigating the Impacts of Climate Change on Our Water World

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The CWRUbotix 2025 *Shrimp* vertical profiling float uses a linear piston driven by a motor and lead screw to control its buoyancy, with excess internal vertical space to house its battery and control electronics.

The main body of the float is made from high-pressure hard polycarbonate tubing with three aluminum support rods extending from the endcap, on which are mounted the battery, electronics, and the motor and piston assembly. The endcap holds a 25mm diameter pressure release plug, two penetrators, and a radio antenna, while a central plate secured on the main support rods holds the motor and piston assembly. The endcap is constrained to the top of the tube with two latches and sealed with two NBR o-rings. The piston uses two x-rings to form a water-tight seal against the tube as it moves up and down to adjust the vehicle's buoyancy. The float weighs 2.7 kg, with a minimum volume of 2500 cm^3 when the piston is fully retracted and a maximum volume of 2900 cm^3 when the piston is fully extended (specific gravity of 1.08 and 0.90 respectively).

Figure 1: CAD render

The endcap, pressure release plug, and piston were all machined in-house using lathes and mills (see *Figure 2*). The piston is made from 316 stainless steel for its corrosion resistance and high density which lowers the float's center of mass to improve its stability, while the remainder of the machined components are made from 6061 aluminum for its lightweight and easy machinability. The o-ring and x-ring sizes were calculated to achieve ideal compression of the rings to ensure a reliable watertight seal. The latch wings on the endcap and clamp pieces on the motor plate were cut in-house with a waterjet, and the motor and piston plates, latch ring, and battery holder are all made from 3D printed PETG.

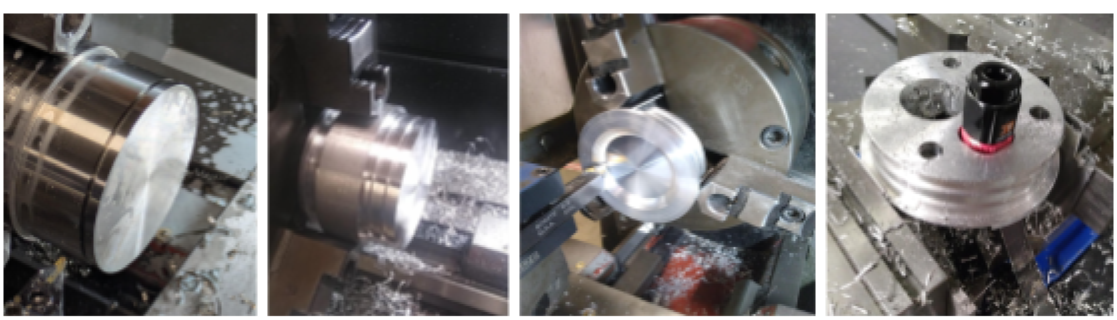

Figure 2 (left to right): machining the x-ring grooves on the piston after turning it down to the desired diameter; machining the o-ring grooves on the end cap after turning it down to the desired diameter; machining the counter bore on the top of the end cap; checking the fit of the penetrator nut in the hole we had just milled for it.

To prevent the piston from rising too far up and crashing into the motor, there is a limit switch mounted to the support rod which the float uses to determine the highest point of the piston travel. Should the piston overextend, it will simply run off of the leadscrew and remain held by extra tube length, and thus cannot be fully expelled to allow ingress of water and will therefore remain watertight and positively buoyant, allowing it to be easily retrieved should this happen.

To support our goal of developing all hardware in-house, we designed a custom float control board (*Figure 3*) that integrates all essential functionality onto a single PCB. The board includes a microcontroller that manages communication, motor control, power regulation, and it features built-in I^2C support to simplify software integration. It includes a motor driver for precise actuation, a 3.3V regulator for stable power delivery, and a LoRa radio module to enable reliable wireless communication with the surface computer. By consolidating these features into one compact, purpose-built board, we not only streamlined wiring and reduced system complexity, but also enhanced maintainability and aligned with our broader objective of reducing reliance on third-party hardware.

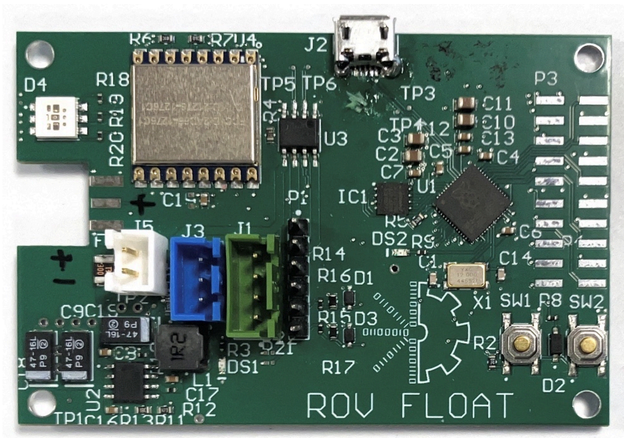

Figure 3: float control board

The float is piloted by an Arduino sketch which communicates with the surface on 877 MHz. The sketch represents a state machine that manages the different stages of the vertical profile (see *Figure 3*). The state machine initially transmits specially formatted singleton packets for judging. On being commanded over radio, the float begins a PID loop to position the float at a depth of 2.5m. Our PID loop was designed and tested in Matlab Simulink (*Figure 3*). Depth data is collected over the course of the profile and transmitted in “chunk” packets (constrained by the maximum LoRa packet size) upon reaching the surface. See *Figure 4* for the binary structure of these packets.

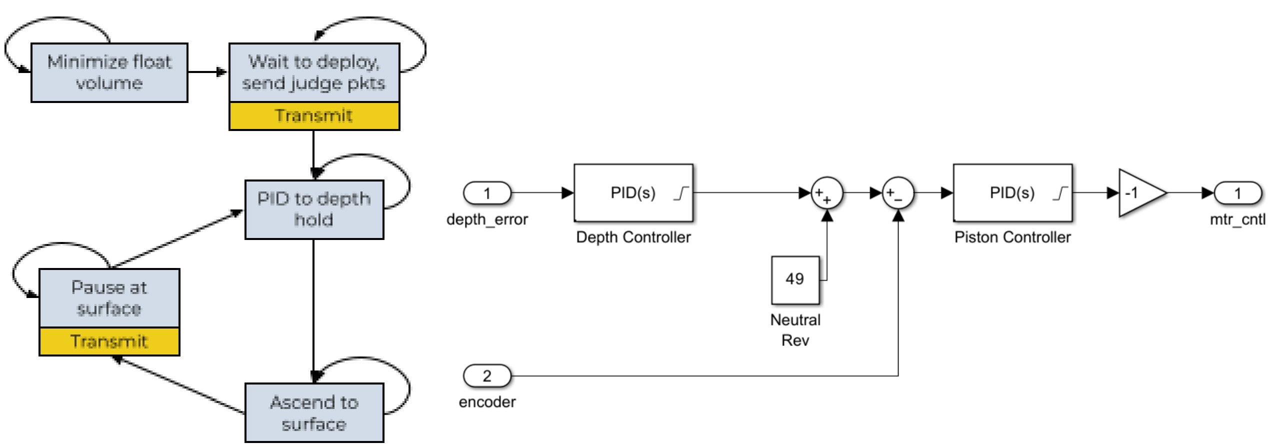

Figure 4: float state machine (left) and PID loop (right)

<table>
<tr><td colspan="2">Team Number
1 byte</td><td colspan="2">Profile Number
1 byte</td><td colspan="2">Payload Chunk
1 byte</td></tr>
<tr><td colspan="3">Time (ms from boot)
4 bytes</td><td colspan="3">Depth
4 bytes</td></tr>
<tr><td colspan="3">Time
4 bytes</td><td colspan="3">Depth
4 bytes</td></tr>
<tr><td colspan="6">*(continue to 31 time/depth pairs)*</td></tr>
</table>

Figure 5: chunk packet structure