保良局顏寶鈴書院
Po Leung Kuk Ngan Po Ling College
HONG KONG, CHINA

Ranger Class

2025 MATE ROV Competition

Buoyancy Engine (Non-ROV Device)

Dolphin Specifications	
Largest Diameter	95 mm
Device Height	464 mm
Total Weight	1.51 kg

Dolphin, our vertical profiling float, consists of a transparent acrylic tubing with an outer diameter of 80 mm (5mm thick) and length of 250 mm. Since this tubing was initially designed for computer water-cooling, both ends of the tube can be twisted off easily. This ensures a watertight seal while also allowing for easy maintenance and upgrades. Custom 3D-printed holsters were designed to house and install different electrical components.

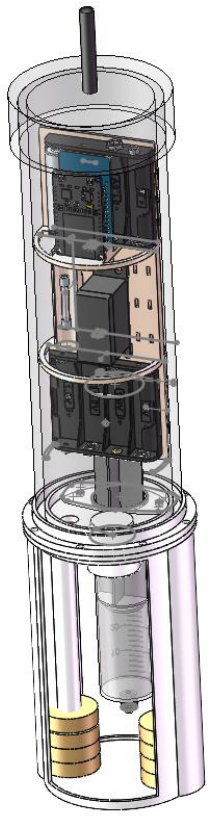


Figure 1: 3D Model of ***Dolphin***

All components are managed by an *ESP32 DevKit V1* microcontroller. The ESP32 series were the strongest contender during the selection process due to its user-friendly wireless protocol – ESP-NOW. The specific choice for the *DevKit V1* is due to its adequate balance between cost and computing strength. A custom PCB is used to organize and integrate components.

The buoyancy engine operates using a 100 ml syringe connected to a servo. This servo uses gears to convert rotational into translational movement. The ESP32 would control the servo, which pushes/pulls the syringe to displace surrounding water to adjust its buoyancy.

Since our device was originally positively buoyant, through Archimedes principle, we calculated the water displacement provided and add masses accordingly. Below are the results to our calculations (upward is to be taken as positive.

$F_b = \rho V g$	**Original net force (no water in syringe)**	**Net force after water being taken in**
	$F_{net\ (original)} = F_{buoyancy} - F_{weight}$ $= (997 \times 0.00153 \times 9.81) - (1.51 \times 9.81)$ $= +\mathbf{0.18N}$	$F_{net\ (new)} = F_{net\ (original)} - F_{syringe}$ $= (0.18) - (0.04 \times 9.81)$ $= -\mathbf{0.21N}$

Dolphin uses an MS5837_02BA depth sensor to monitor and log depth data. A simplified PID control system regulates the linear actuator to maintain the float within a specified depth. The controller would push or pull the syringe depending on the current depth of ***Dolphin***. For example, if ***Dolphin*** exceeds the target depth, the system activates the syringe to expel water, inducing ascent, and vice versa.

When ***Dolphin*** remains within the target depth, the ESP32 initiates a timer. If the duration exceeds the required 45 seconds, the linear actuator fully expels water from the syringe, forcing the float to surface.

Whenever the float finishes a vertical profile and reaches the surface, the microcontroller in the float (connected to a waterproof antenna for strength amplification), transmits data packets via the ESP-NOW protocol to the ESP32 station onshore. These packets include the team number, dive/surface time, and recorded depth data.

To address the power demands of the system, power is supplied by 2 sets of 4 alkaline AA batteries connected in parallel, providing 6VDC supply at 1.5A nominally. The batteries are separated from the electronics compartment to enable easy replacement without disrupting the core components. It is hooked onto the side of the PVC enclosure using a piece of laser-cut acrylic.

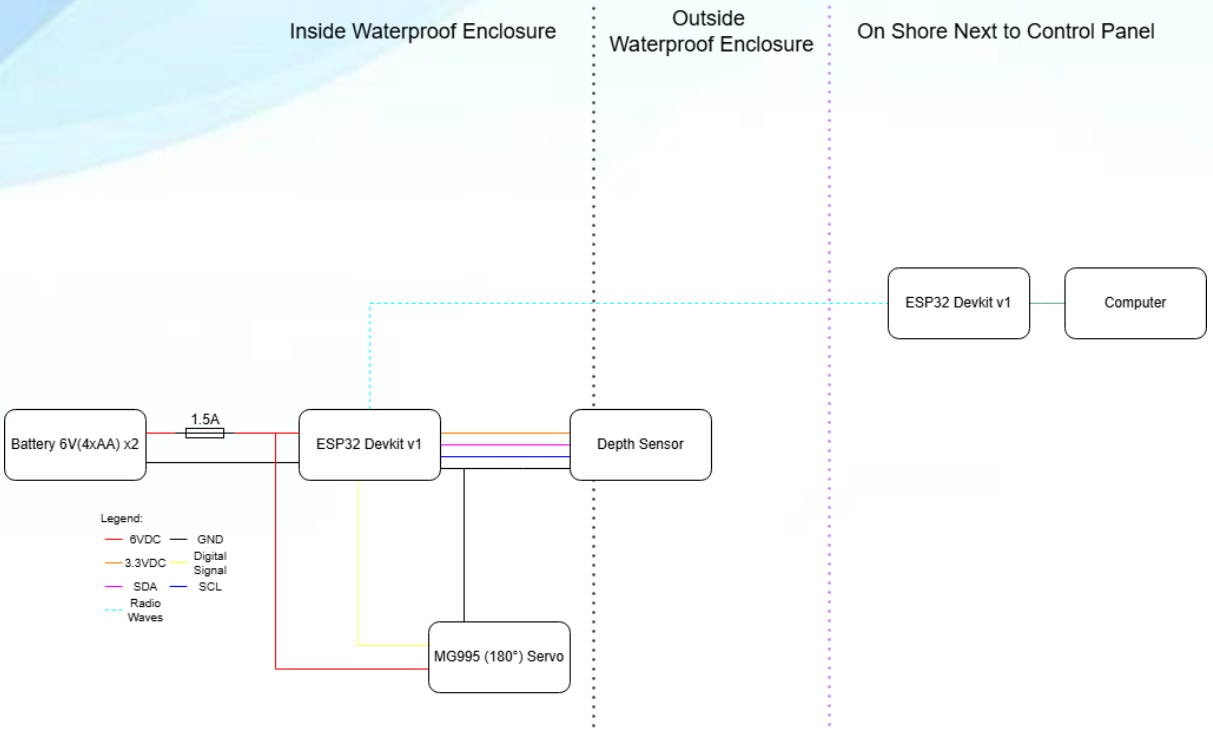
Between the battery box and the electronics is a wire with a 0.5A cartridge fuse (See SID for fuse calculations). It is plugged into a cartridge fuse holder (Figure 3), which is connected 4cm from the positive end of the power.

Figure 2: 4 AA Battery Box

Figure 3: Fuse used (500mA)

A custom PCB (printed circuit board) was designed to integrate all the electronics seamlessly. It is housed inside a 3D-printed electronic holster, situated at the top of the float.

System Integration Diagram (SID)



Maximum Current Calculations

Servo	994mA
ESP32	160mA
Depth Sensor	22mA
Total (Maximum Current Draw)	**1176 mA**

Fuse Calculations

Full Load Amps (FLA) in Water (servo on)	1176 mA
Full Load Amps (FLA) in Water (servo idle)	282 mA
Fuse Selected (Cartridge Fuse)	**1500 mA**