

TROJAN TRIREMES

Non-ROV Device Design — Vertical Profiling Float (Rev. 4)

Carrollton High School | Carrollton, Georgia | 2026 MATE ROV Competition — Ranger Level

Overview

The Trojan Triremes Non-ROV Device is an autonomous vertical profiling float that collects water-column pressure, depth, and temperature data during the 2026 MATE ROV Competition. After launch, the float requires no operator input — it executes two complete vertical profiles under state-machine control, transmits real-time data to a shore-side laptop via Bluetooth LE, and waits for retrieval.

All components are housed in a 6-inch-diameter by 36-inch-long acrylic tube sealed at both ends. This is the fourth and final design iteration, incorporating an Arduino Uno controller, dual WYNK USB peristaltic pumps, a 4L catheter bag bladder, HM-10 Bluetooth LE communication, and shore-side monitoring via a laptop and secondary Arduino.

Housing and Physical Specifications

The float body is a 6-inch-diameter by 36-inch-long clear acrylic tube, sealed with O-ring end caps. The interior is organized by 3D-printed shelves that divide the tube into four functional compartments: battery bay, relay/switch bay, Arduino bay, and bladder bay.

Physical parameter	Value
Tube diameter	6 inches (152 mm)
Tube length	36 inches (914 mm)
Competition max diameter	18 cm — COMPLIANT
Competition max height	1 meter — COMPLIANT
Interior organization	3D-printed segmenting shelves (4 compartments)
Bladder	4L medical catheter bag (flexible, sealed)

Power System

The float is powered by two NiMH battery arrays wired to a combined 12V supply: six 1.2V DC cells in series (7.2V) and four 1.2V DC cells in series (4.8V), combined to deliver 12V to the main bus. A single 5.0A ATO-type blade fuse is installed within 5 cm of the battery positive terminal per ELEC-NRD-004. A 12V-to-5V automotive buck converter steps down the voltage to power the Arduino and pumps.

A 1-channel WiFi Smart Switch sits on the main 12V line and allows remote power control of the buoyancy system when needed. Full-load current was measured in both idle mode and active-pump mode to verify the 5.0A fuse rating per ELEC-NRD-005.

Device	Current draw (A)
Pressure sensor (Adafruit MPL3115A2)	0.00004
Arduino Uno	0.06
Pump In (WYNK peristaltic)	1.5
Pump Out (WYNK peristaltic)	1.5
HM-10 Bluetooth LE module	0.0085
Total current — pumps running (worst case)	3.06854 A
Maximum load amps (measured)	4.0 A
Fuse capacity (ATO blade)	5.0 A

Buoyancy Engine — Water-Transfer System

The float changes depth by transferring pool water in and out of an internal 4L medical catheter bag bladder, altering its average density relative to the surrounding water column. This replaced the original syringe-and-LEGO-gear-rack prototype, which could not reliably produce enough force at depth, and a PVC-bladder prototype that suffered from fitting failures.

Descent

- The intake WYNK USB electric peristaltic pump runs (controlled via relay channel 1). Pool water is drawn through a port in the end cap into the 4L catheter bag.
- Adding water mass increases the float's overall density above that of the surrounding water, producing a net downward buoyant force.
- The Arduino monitors depth from the MPL3115A2 sensor and cuts the intake pump when 2.5 m is reached.

Ascent

- The output WYNK USB electric peristaltic pump runs (relay channel 2). Water is expelled from the catheter bag back into the pool.
- Removing mass reduces density below that of water, producing a net upward force.
- A shallow-stop guard in the Arduino code cuts the output pump before the float reaches the surface (threshold: 40 cm depth), preventing the competition penalty for surface breach.

Interlock safeguard

The 2-channel 12V relay module operates in interlock mode — only one channel can close at a time. This hardware-level interlock prevents both pumps from running simultaneously. The Arduino state machine enforces the same constraint in software as a secondary layer of protection.

Sensors and Electronics

Controller — Arduino Uno

The Arduino Uno is the sole onboard controller. It runs the state-machine mission loop, manages pump sequencing via the relay module, polls the pressure/temperature sensor via I2C, logs data to an in-memory buffer, and manages Bluetooth LE transmission via the HM-10 module.

Pressure/altitude/temperature sensor — Adafruit MPL3115A2

The MPL3115A2 connects to the Arduino via I2C (SDA → A4, SCL → A5). Depth is calculated using the hydrostatic pressure formula: $\text{depth} = \Delta P \div (\rho \times g)$, where ΔP is the difference between live pressure and the surface pressure sampled at boot, ρ is 1,000 kg/m³ (freshwater) or 1,025 kg/m³ (EGADS saltwater at World Championship), and $g = 9.81 \text{ m/s}^2$. Surface pressure is stored in memory before deployment begins.

Wireless communication — HM-10 Bluetooth LE

The HM-10 module (3.6–6V; pins STATE / RXD / TXD / GND / VCC / EN) connects to the Arduino via SoftwareSerial on pins 10 (RX) and 11 (TX). Shore-side, a second Arduino receives the Bluetooth packets and passes data to a laptop running LightBlue or an equivalent serial Bluetooth terminal, which logs and graphs depth/temperature/pressure in real time. The HM-10 must be disconnected from pins 10 and 11 during code uploads to avoid upload conflicts.

1-channel WiFi smart switch

A 1-channel WiFi smart switch is installed on the main 12V line. This provides a remote power-isolation capability for the buoyancy system during pre-dive setup and safety checks, allowing the relay/pump circuit to be de-energized without opening the enclosure.

Component	Model/spec	Connection
Controller	Arduino Uno	Central hub
Pressure/temp sensor	Adafruit MPL3115A2	I2C — SDA→A4, SCL→A5

BLE radio	HM-10 (3.6–6V)	SoftwareSerial pins 10/11
Pump relay	2-ch 12V relay (interlock)	Digital output pins
WiFi switch	1-ch WiFi smart switch	12V main line (in-series)
Intake pump	WYNK USB peristaltic	USB — 5V rail via relay ch.1
Output pump	WYNK USB peristaltic	USB — 5V rail via relay ch.2
Bladder	4L medical catheter bag	Tubing from both pumps
Voltage regulator	12V→5V automotive buck conv.	Inline battery → pumps/Arduino
Battery array A	6× 1.2V DC NiMH (series)	Combined 12V main bus
Battery array B	4× 1.2V DC NiMH (series)	Combined 12V main bus
Fuse	5.0A ATO blade (<5cm from +)	Main 12V positive line

Shore station

The shore station consists of a 120V AC power source (standard outlet), a laptop running LightBlue or a serial Bluetooth terminal for real-time data logging and graphing, and a secondary Arduino that serves as the Bluetooth receiver bridge between the HM-10 module inside the float and the laptop's USB port.

Mission Profile Logic — State Machine

The Arduino Uno runs a finite state machine. All state transitions are triggered by depth readings from the MPL3115A2 sensor or elapsed-time timers. The float executes two complete vertical profiles fully autonomously after launch confirmation.

State	Action
IDLE / PRE-LAUNCH	Float at surface — surface pressure sampled and stored; one BLE data packet transmitted to shore laptop to confirm communication
DESCEND 1	Intake pump ON (via relay ch. 1) — pool water enters 4L catheter bag bladder, increasing density; descent toward 2.5 m
HOLD 1 (depth)	All pumps OFF — sensor data logged every 5 s for 30 s at 2.5 m
ASCEND 1	Output pump ON (via relay ch. 2) — water expelled from bladder; float rises. Shallow-stop guard cuts pump at ≤ 40 cm depth
HOLD 2 (shallow)	All pumps OFF — sensor data logged every 5 s for 30 s near surface
DESCEND 2	Second profile: intake pump ON; repeat descent to 2.5 m
HOLD 3 (depth)	All pumps OFF — sensor data logged every 5 s for 30 s at 2.5 m
ASCEND 2	Output pump ON; float rises. Shallow-stop guard prevents surface breach

HOLD 4 (shallow)	All pumps OFF — sensor data logged every 5 s for 30 s near surface
RECOVERY WAIT	All systems are idle. Manual button press on Arduino triggers bulk BLE transmission of all stored packets to the shore laptop for graphing.

System Integration Diagram (SID)

The SID below summarizes all power and data connections between float components. Gold lines represent 12V DC power; blue lines represent data/signal connections. Dashed blue lines represent water-transfer tubing between the pumps and the 4L catheter bag bladder (For Full Visual see full SID).

INSIDE ENCLOSURE		
POWER 6× 1.2V DC battery array (A) 4× 1.2V DC battery array (B) → 5.0A ATO blade fuse → 1-ch WiFi smart switch → 12V→5V buck converter	CONTROLLER Arduino Uno I2C → MPL3115A2 sensor SoftwareSerial → HM-10 BLE Digital out → 2-ch relay	ACTUATORS & BLADDER 2-ch 12V relay (interlock) WYNK intake peristaltic pump WYNK output peristaltic pump 4L catheter bag bladder
ABOVE WATER — SHORE STATION		
120V AC power outlet → Laptop → Secondary Arduino (BLE receiver bridge) → [Bluetooth LE wireless link] → HM-10 in float enclosure <i>The shore laptop runs LightBlue (or equivalent) to log and graph depth, temperature, and pressure data in real time during both vertical profiles.</i>		

Safety Compliance

The float's electrical safety design satisfies MATE competition requirements ELEC-NRD-003, ELEC-NRD-004, and ELEC-NRD-005:

- Battery chemistry: NiMH AA cells only — no lithium chemistry inside the enclosure, per MATE rules prohibiting lithium components underwater.
- Fusing: Single 5.0A ATO-type blade fuse installed within 5 cm of the battery positive terminal.
- Fuse sizing: Full-load current (3.069 A worst case) measured with both pumps modeled as running — confirms adequate headroom below the 5.0A rating.
- Overcurrent protection: The 12V→5V buck converter provides additional downstream current limiting for the pump circuit.
- WiFi smart switch: Allows remote isolation of the buoyancy system circuit during pre-deployment setup without opening the enclosure.
- Pump interlock: 2-channel relay hardware interlock + Arduino software state machine both prevent simultaneous pump operation.

- Shallow-stop guard: Code prevents float from ascending past 40 cm depth, avoiding the 5-point surface-breach penalty.
- Sealed enclosure: O-ring end caps with pressure testing before every float run. Two-person deployment and retrieval required per team JSEA.

Design Iteration Summary

#	Buoyancy	Controller/comms	Outcome
1	Syringe + LEGO gear rack + motor	Raspberry Pi 4B + 2.4GHz transceiver	Insufficient force at depth; gear alignment unreliable
2	Revised syringe; improved gear tolerances	Raspberry Pi 4B + transceiver	Improved but still inconsistent; syringe approach abandoned
3	PVC bladder + early pump prototype	Arduino Uno + prototype BLE	PVC fittings failures; bladder replaced with catheter bag
4 ✓	WYNK peristaltic pumps + 2-ch relay + 4L catheter bag ✓	Arduino Uno + HM-10 BLE + MPL3115A2 + WiFi switch ✓	CURRENT — pool tested; two-profile state machine verified

Full SID

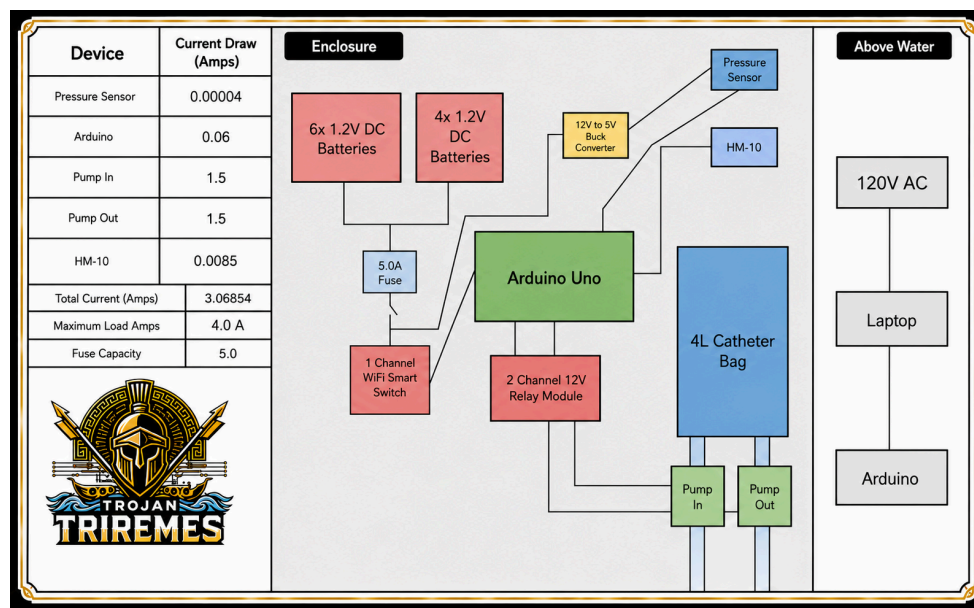


Figure 4 The System Integration Diagram (SID) of the Profiling Float