Robot Ecosystem for Monitoring Climate Change

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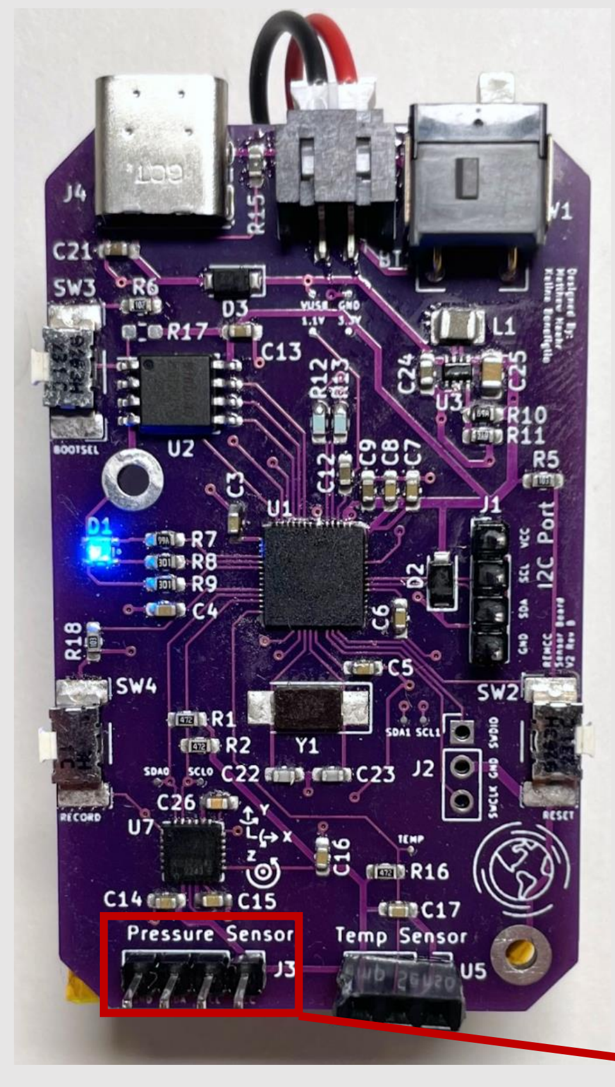
Abstract

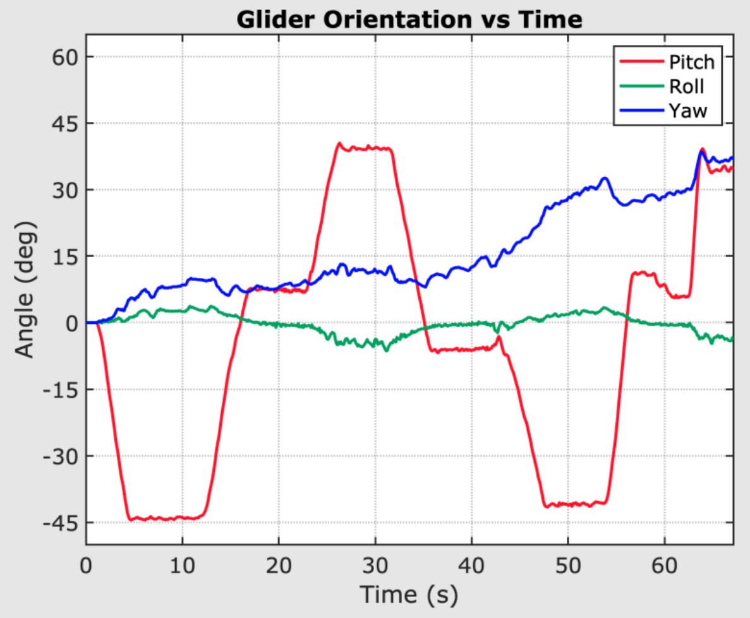
The effects of climate change are far-reaching and difficult to accurately predict. We designed an underactuated underwater glider with a closed-loop fluidic controller; a soft hydrostatic pressure sensor; and a custom sensor board that measures temperature, pressure, and orientation. Our proof-of-concept designs are incorporated into a low-cost, power efficient underwater glider that is easy to customize and fabricate. **When deployed, the glider will monitor the thickness of an ice sheet while collecting data on essential ocean variables.** Our approach seeks to provide physical oceanographers with inexpensive tools that allow for collecting spatially distributed data sets with the end-goal of predicting sea levels more accurately than currently possible, and ultimately suggest timelines for installing countermeasures to combat floods.

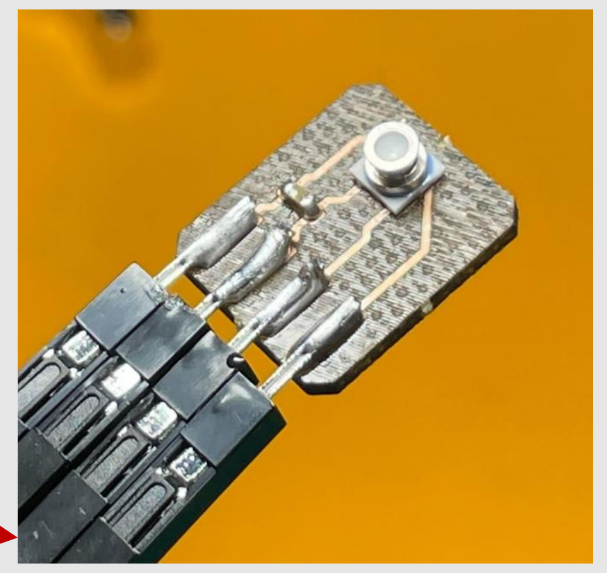
Electronic circuit

For data collection, the key parameters to collect were the glider velocity, pressure and the temperature around the glider though out its deployment. Low cost and availability were among the key selection criteria used. A single cell LiPo battery is used to power the sensor board.

	Component	Cost	Features
Microcontroller	Raspberry Pi RP2040	$1	I2C, SPI, UART, USB
Pressure sensor	TE Connectivity MS5837-30BA	$12.46	0-3MPa (5 kPa)
Temperature sensor	Maxim/Analog Devices DS18B20	$2.35	-55 ºC to 125 ºC, (0.0625 ºC)

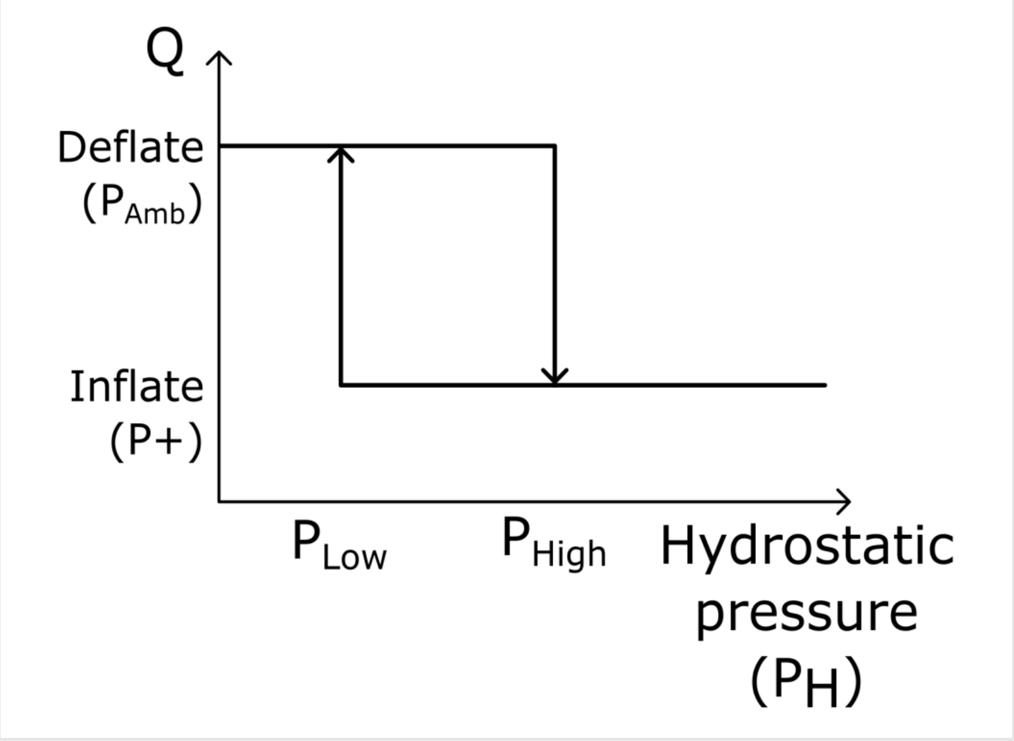


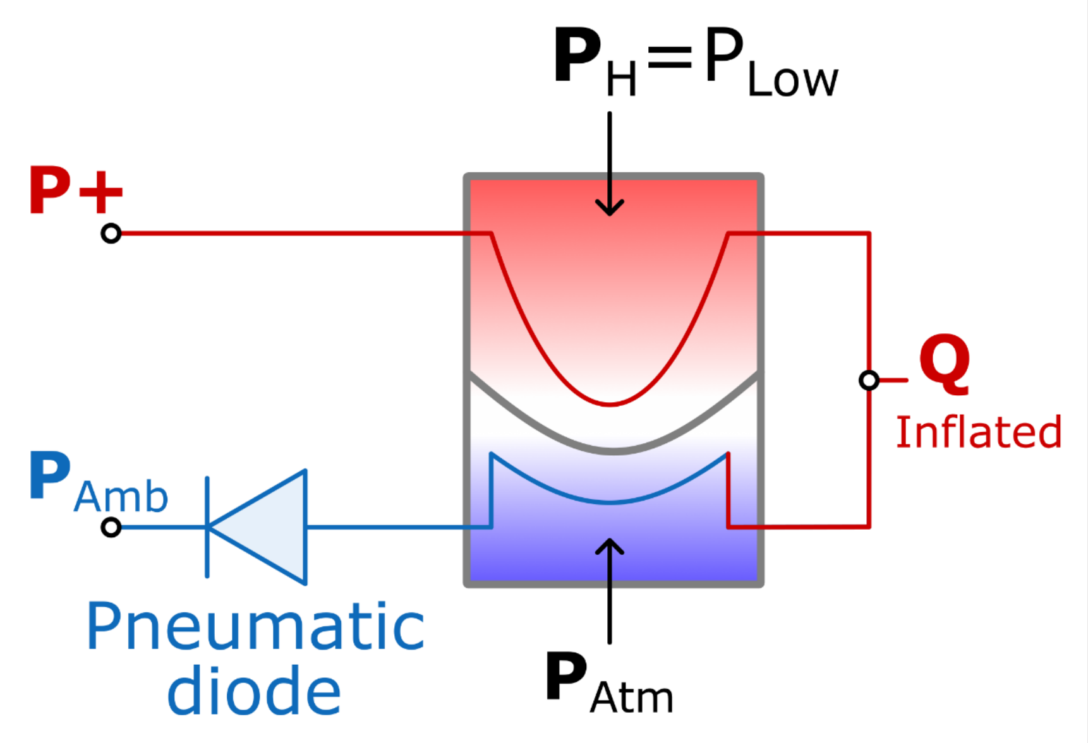


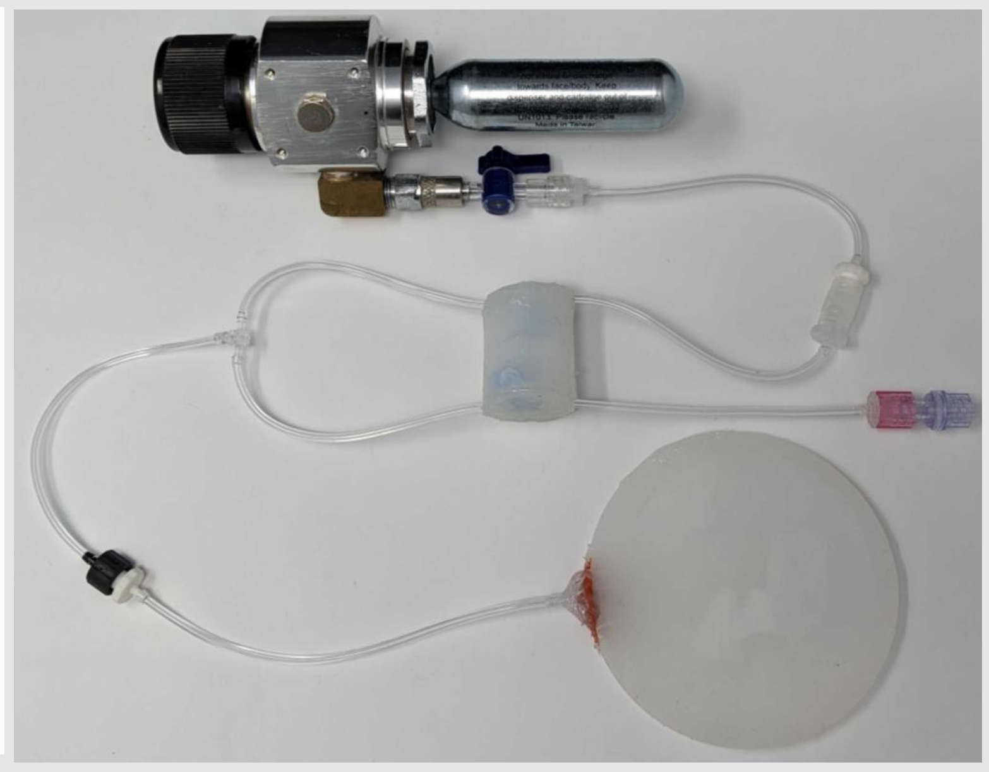


Fluidic circuit

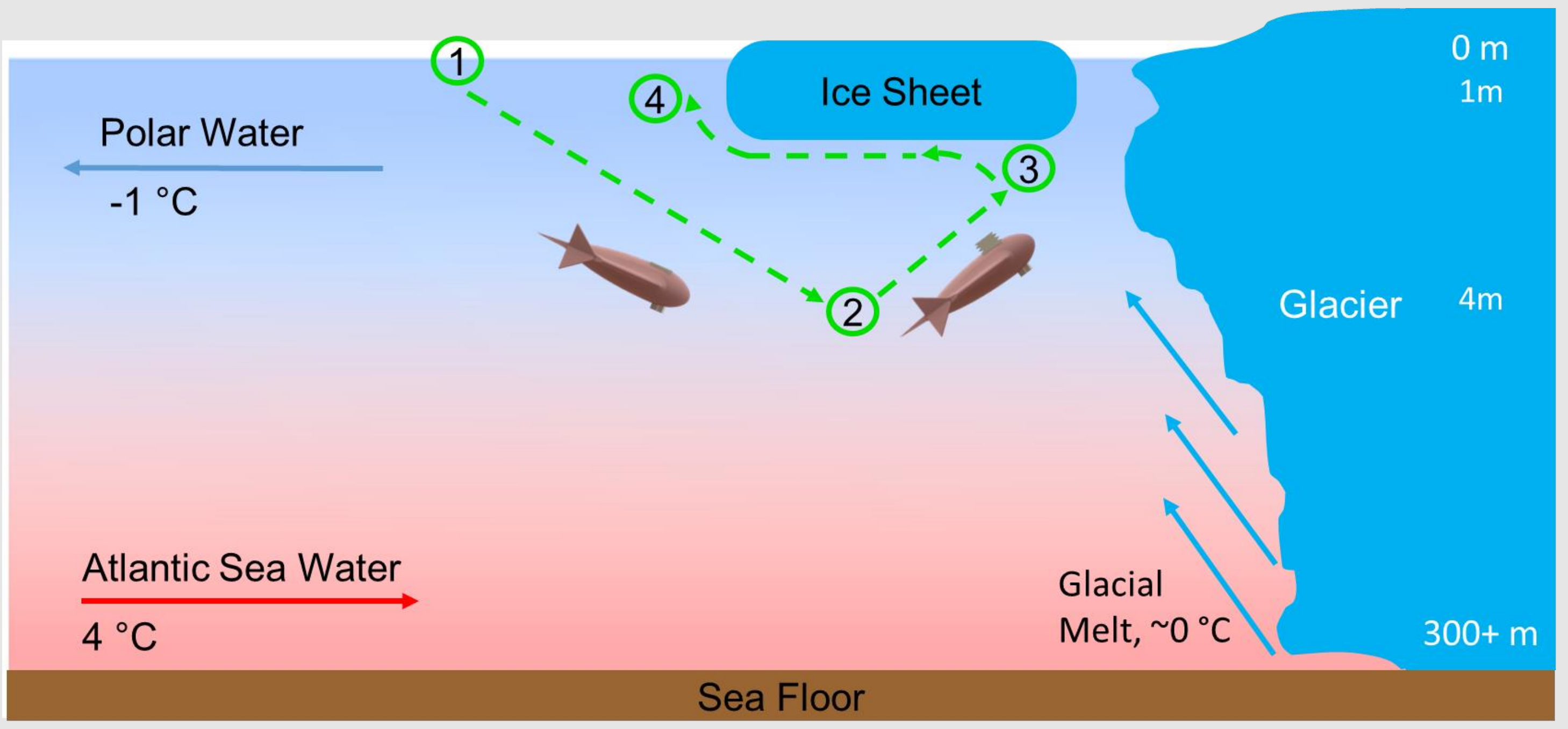
Our fluidic circuit is based on the soft bistable valve configured as a hydrostatic sensor. It is implemented as a bang-bang controller. When above 4m depth the soft hydrostatic sensor kinks the pressure line from the onboard CO_2 and the swim bladders are not inflated. Once the glider reaches 4m depth the membrane flips and the CO_2 inflates the swim bladder. Once the glider is above 1m depth the hydrostatic pressure will decrease enough to allow the membrane to flip back to and the pressure in the swim bladder will vent through the pneumatic diode.







Ice sheet thickness monitoring

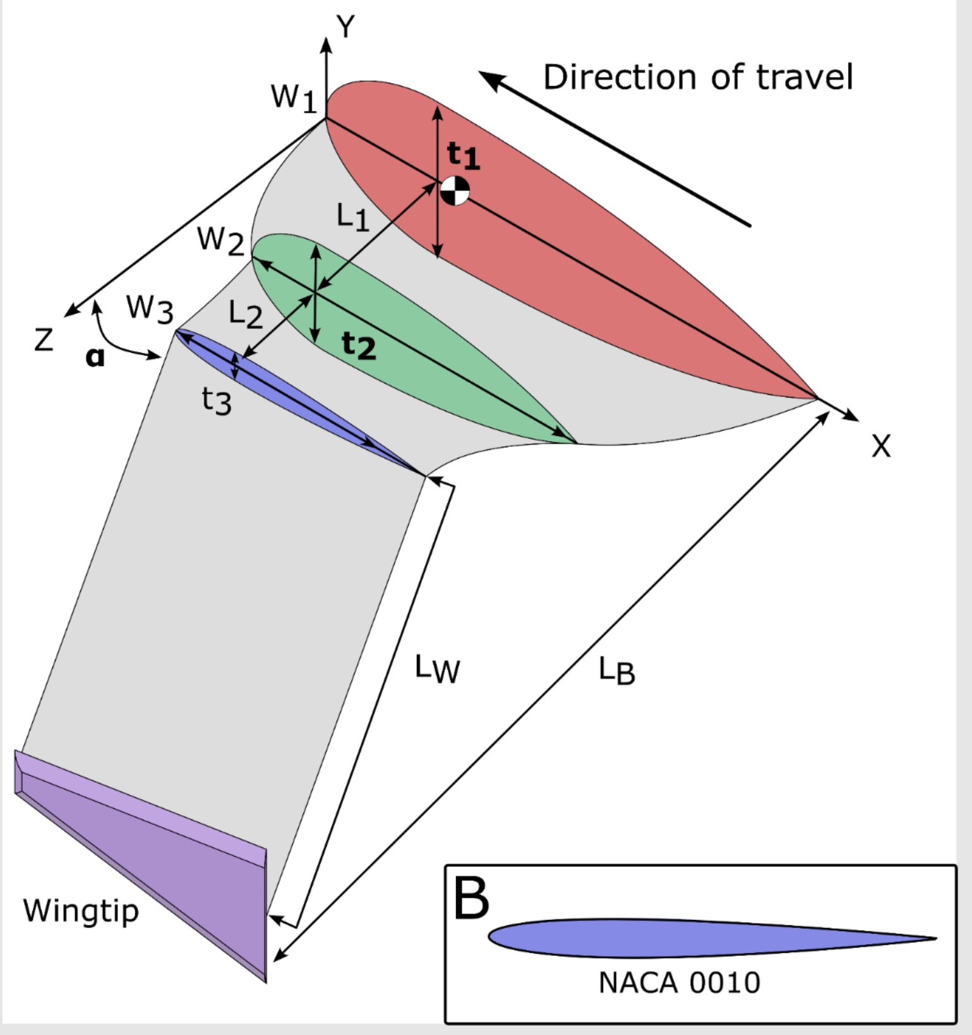


1) Glider dives at approximately 6°.
2) Four-meter depth is reached. Novel soft fluidic hydrostatic sensor is triggered, and swim bladder inflates.
3) Glider ascends with a much steeper angle until the ice sheet is hit. Pressure is recorded and converted to thickness of the icesheet.
4) Glider reaches less than half a meter depth and hydrostatic sensor flips again, and swim bladders deflates.

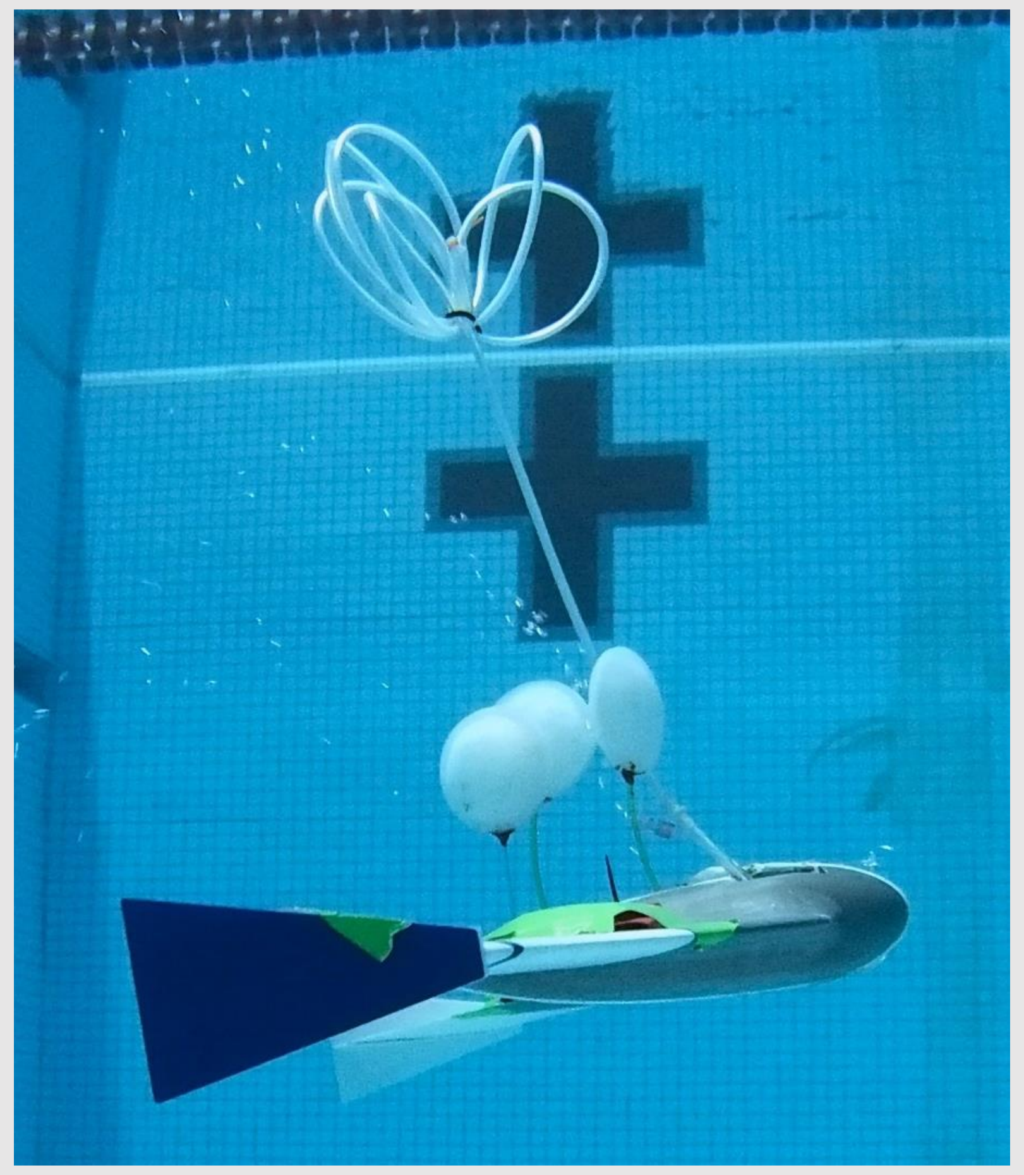
Process repeats until glider is out of CO_2.

Glider

Our glider body is based on the Blended Wing Body Underwater Glider (BWBUG) type. The smooth transition from the wings to the body allows for greater hydrodynamic performance with no additional power input. We choose this design type to maximize the gliding range and power efficiency of our system.



Above figure (Bonofiglio et al, IEEE International Conference on Soft Robotics,2023) key variables prioritizes in the design were the sweep back angle (α), the length of the glider (L_B), midplane thickness (t_1) and locations of the spanwise coordinates (W_1, W_2 and W_3). The ideal ranges for these parameters were determined from a simulation-based optimization of BWBUG gliders (C. Sun et al, IJNAOE, 2017).



Final Design

- 16g CO_2 cartridge
- 4m depth of flip
- Airtight internal cavity
- Electronics included in waterproof compartment.
- 3D printed PLA, 100% infill.
- Silicone conformal coating for additional waterproofing.
- Shallower decent angle than ascent angle.

System specifications	Final
Total Glider Mass (kg)	3.064
Glider Volume (cm^3)	2814
Swim Bladder Volume (cm^3)	300 *
Lift/Drag ratio	6.89
Glide range (m)	344.87 *
Deployment time (hr)	0.25 *
Power Efficiency (mW/m)	12.31 *

* Maximum theoretical values

Scan for video!