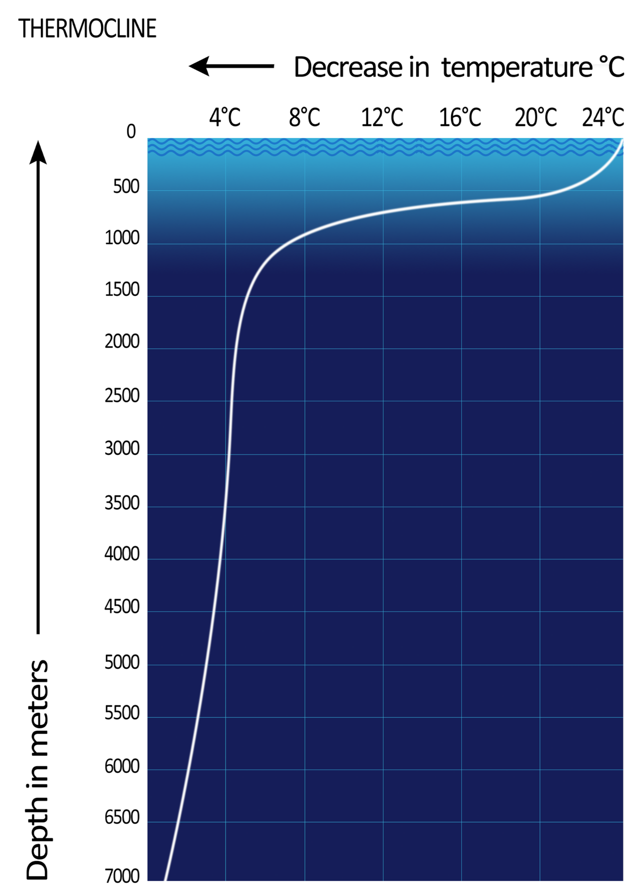
DALHOUSIE UNIVERSITY

Buoyancy Engine

ULTRA | Maritime



Depth v.s. Temperature, *Thermocline (Wikimedia Commons)* [1].

Why are we building this buoyancy engine?

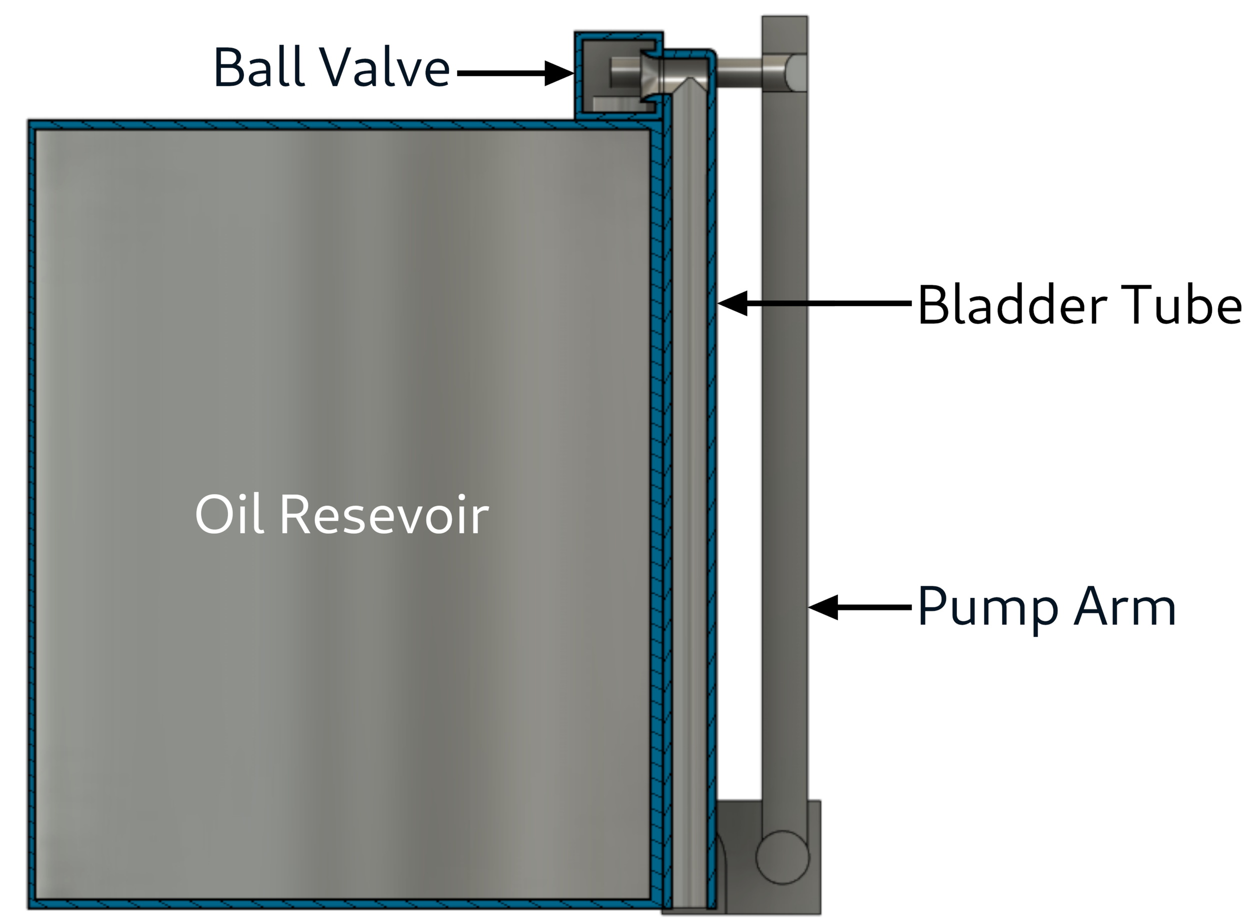
Ultra Electronics has asked us to develop a buoyancy engine to power their next generation bathythermal sonobuoy, or "bathy". This bathy will take temperature measurements within a column of water to build temperature profiles in support of acoustic analysis. This analysis is fed by sonar readings which can vary from changing water temperature.

How does the buoyancy engine work?

At the highest level, the buoyancy engine has three functional groups, the mechanical system, the electrical system, and the software system.

The Mechanical System

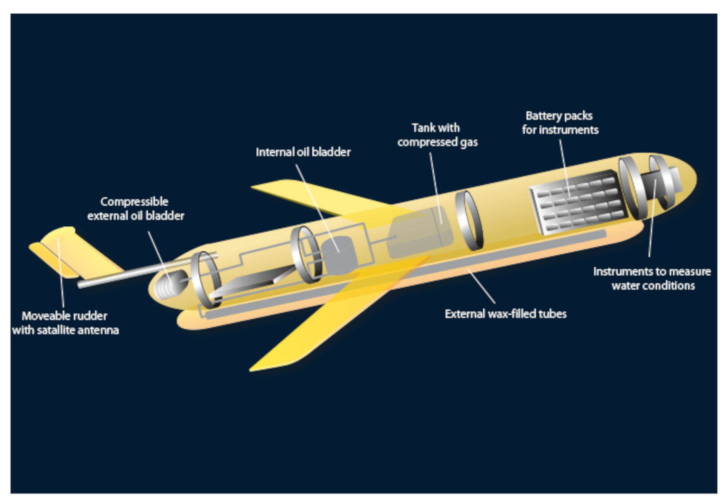
In a similar fashion to how a bottle jack uses one-way fluid pressure to lift a car, our buoyancy engine will use a series of valves and passageways to inflate a bladder. When the oil resevoir expands, oil rushes in from the resevoir and when the chamber compresses, the oil is forced by the valves to fill the bladder. The bladder will provide the displacement necessary for movement underwater.



The mechanical system modelled after a bottle jack, Logan Crooks.

What is a buoyancy engine?

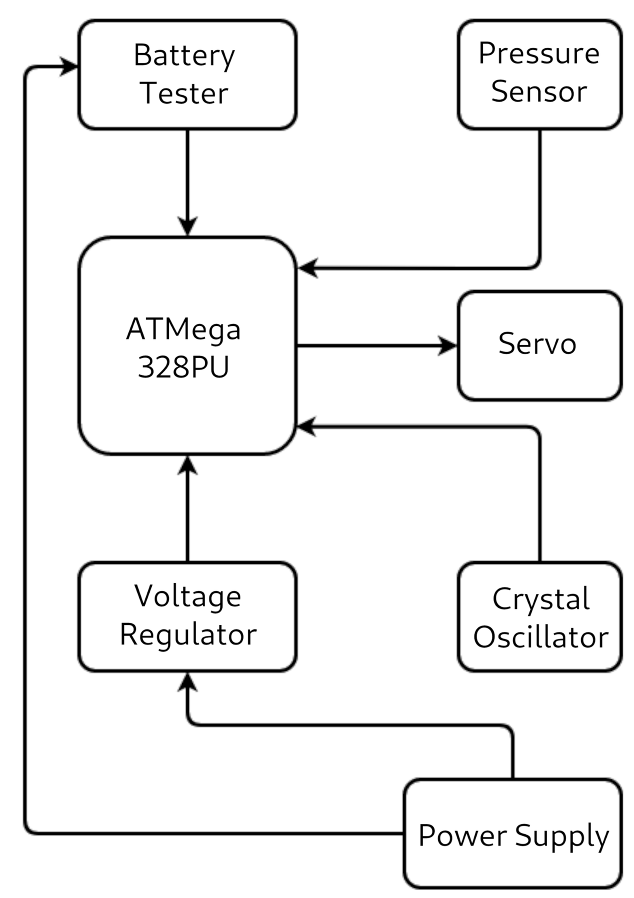
A buoyancy engine provides the mechanical action necessary for a submersible to dive and surface. Typically, this is done by displacing water through the inflation of a bladder.



Cross section of a glider with a bladder based buoyancy engine, Jack Cook, Woods Hole Oceanographic Insitition [2].

The Electrical System

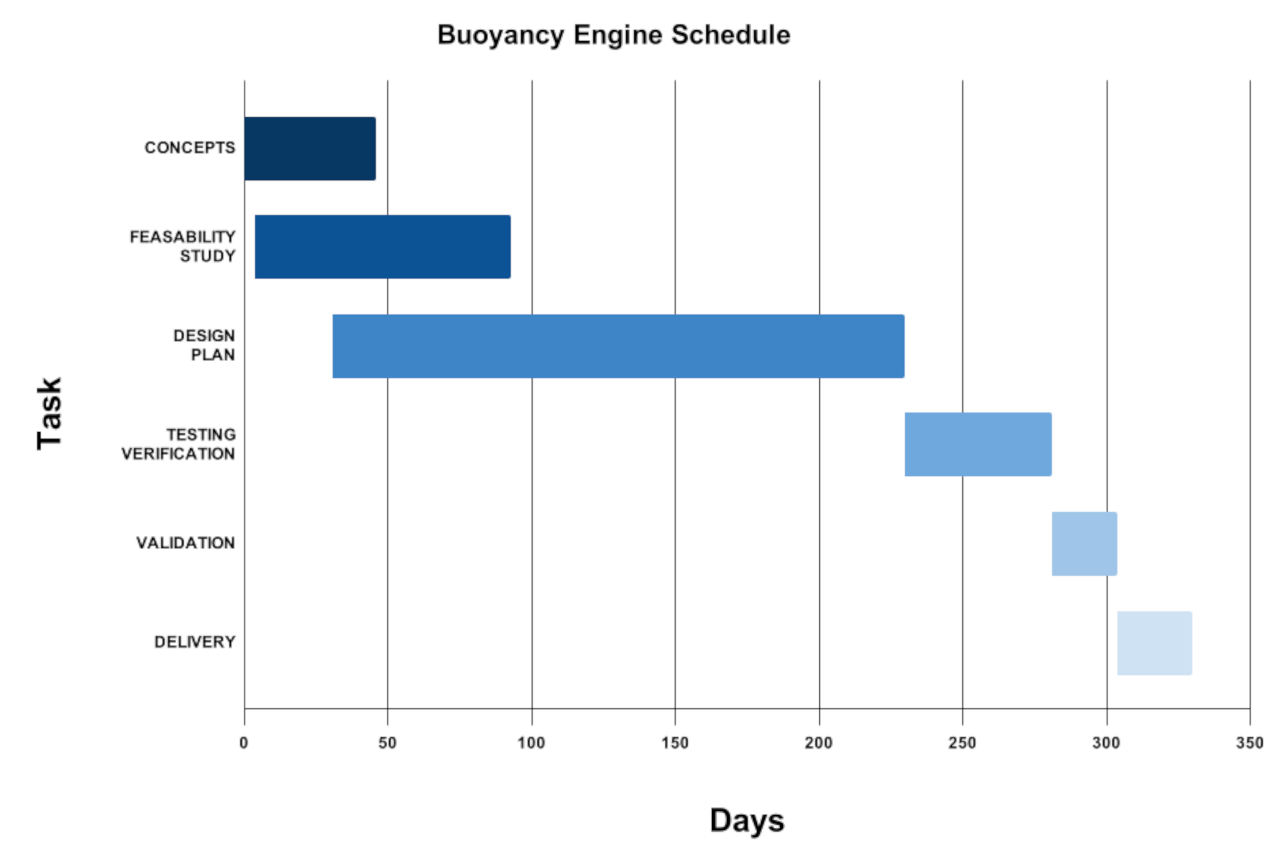
The brain of our engine lies with the ATMega328PU, the Atmel microcontroller. The microcontroller is in charge of reading data from the pressure sensor, generating a clock to maintain the dive schedule, polling the battery for available power, and activating/deactivting the motor.



Hardware system block diagram, Devon Allie.

Where do we go from here?

Substantial work must be done to realize this project but we have a well defined system design and plan from which to work from. The three components of the buoyancy engine must be built; The mechanical system must be prototyped, the electrical system will have to be finalized, the software system must be programmed and installed, and the resulting device will need extensive testing both on land and at sea.



Project development schedule, Benjamin Anderson.

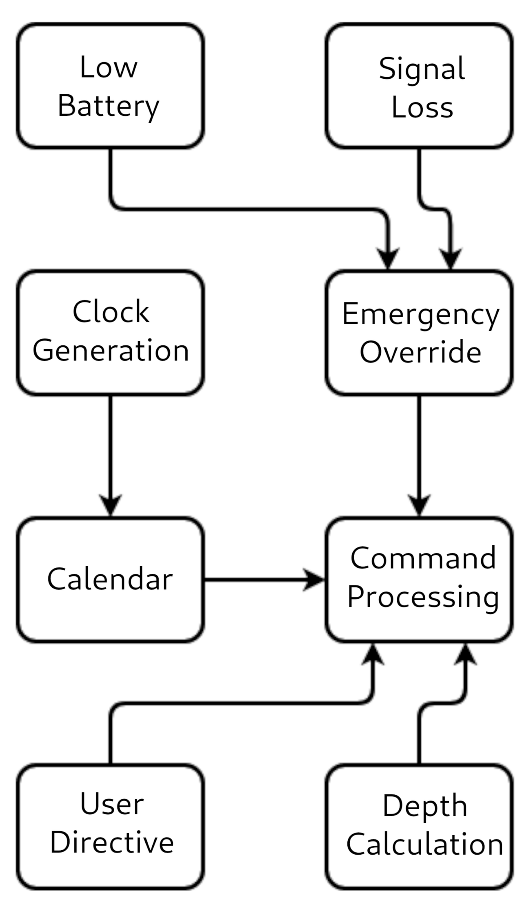
Performance Requirements

- Reach a depth of 800 meters, precision of ± 1 meter
- Dive and surface 100 times on a single charge*
- Completely waterproof

Design Constraints

- Dimensions of 4.566" ID x 5.5" length
- Buoyant force of 3 lbs (81 in³ of displacement)
- Operating temperature range of -20° C to 55° C

* Batteries are included.



Software system block diagram, Devon Allie.

The Software System

The buoyancy engine needs a set of rules from which to guide its actions. The software system provides the logic and calculations to be implemented by the microcontroller. This includes converting data from the pressure sensor into depth, pulling the proper depth target from the calendar, maintaining depth upon arrival, and engaging in emergency resurface routines if errors arise.

References & Credits

[1] Thermocline, Praveenron. Retrieved from https://commons.wikimedia.org/wiki/-File:THERMOCLINE.png on March 30th 2021. CC BY-SA 3.0
[2] Glider cross section, Jack Cook. Retrieved from https://www.whoi.edu/oceanrobots/-robots/glider-phone.html on March 31st 2021.

Credit to Andrew Mercer, Logan Crooks, Benjamin Anderson, and Devon Allie for the development of this project. Many thanks to Abigail LeFrank , the client, and Yuan Ma, the faculty advisor, for their feedback and insight during this development cycle.