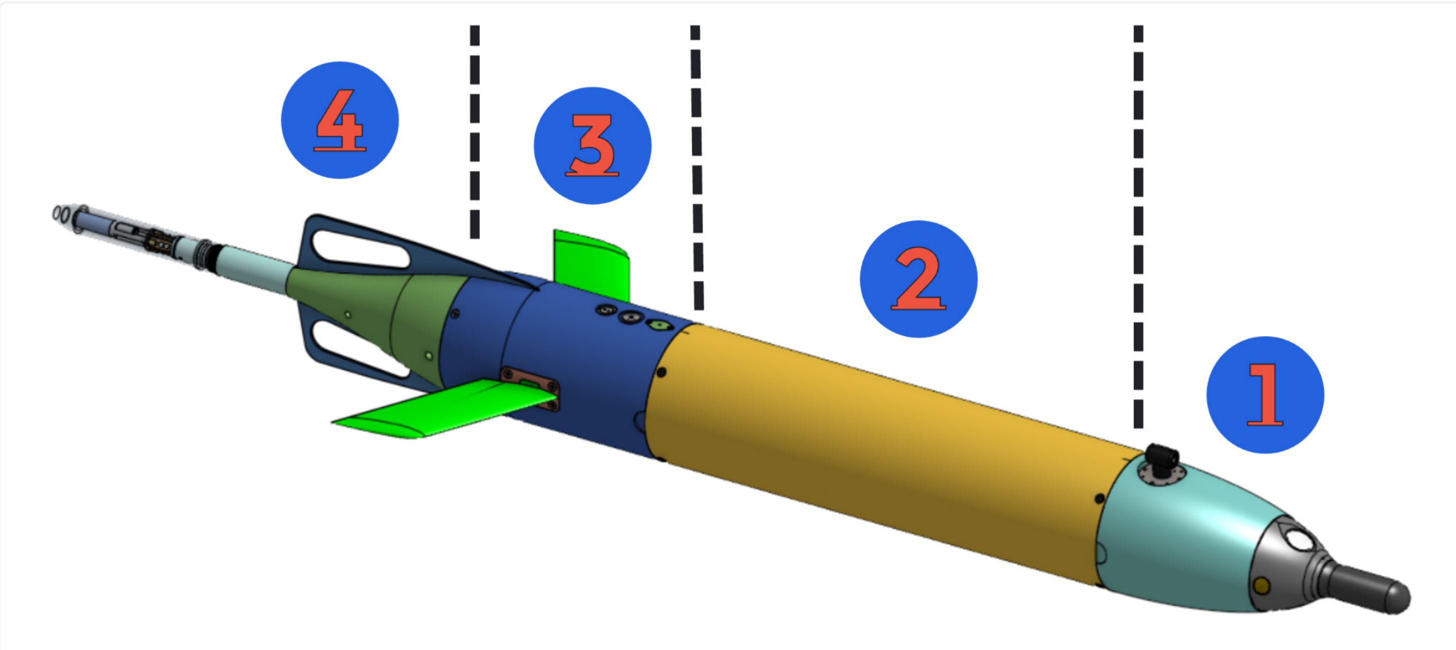
Hardware

Glider Sections



1. **Nose**
   - The nose contains the brain of the glider and the sensor payload, including the hydrophone, altimeter, pressure sensor, and CT sensor.
2. **Long Section Hull**
   - The long section hull is the center of the vehicle. The batteries are contained in this partition within the "Pitch and Roll Mechanism."
3. **Short Section Hull**
   - The short section hull hosts (in order from left to right) the vent port for the vehicle, the vacuum port, and the vehicle status LED along the top of the partition. The cambered wings for flight are also located on this section.
4. **Tail**
   - The tail of the glider houses the Wi-Fi and Iridium/GPS antennas, as well as a strobe light. Two tail fin handles which can be used to lift the glider are located on this section, as well as half of the Variable Buoyancy Engine (VBE) which can be seen as the narrow piston which extends and retracts.

Key Terms

Yo: Gliders travel through the ocean by adjusting weight and buoyancy and as such run in a very specific pattern underwater known as a 'yo.' One 'yo' is one down and up of the vehicle.

Dive: A series of yos between surfacings.

VBE: Variable Buoyancy Engine, the motor and piston that changes vehicle buoyancy.

PAM: Passive Acoustic Monitor, the hydrophone and associated system for recording sound.

CT / **CTD**: Conductivity Temperature Depth sensor or data

Glider Power Switch

The glider is supplied with a magnet allowing for easy control of powering the vehicle. Hold the magnet in place on the left side of the vehicle over the half moon notch where the long section and short section hulls join. When the glider turns on a loud constant tone is produced, and the vehicle's LED will turn on. The magnet's receiver installed in the glider consumes a small amount of power even when the glider is shut off, so it's important to always remove the batteries when the glider won't be used for an extended period of time. To power off the glider simply repeat the same process for turning it on, until the LED turns off and the glider emits a staccato tone.

Tools

The following tools are required to deploy the glider:

- Magnet tool, for magnetic glider power switch
- Metric allen wrenches sizes 4, 3.5, 2.5, 2, 1.5
- Flathead screwdriver (3.5mm, 5.5mm, 6.5mm)
- Phillips head screwdriver (#1,#2, #3)
- Plastic Hull Opener tool (qty. 2)
- O-ring pick
- 120VAC vacuum pump with Hefring adapter / valve / gauge assy. installed

Glider Assembly, Preparation, and Disassembly

Nose Removal

1. The glider can be safely lifted from the carry handle, or supported anywhere along the body. **DO NOT** support, carry, or lift the glider from the wings, movable antenna section, CTD

guard, or hydrophone element (severe damage to the glider may result).

2. Place the glider longitudinally on supports, preferably on a flat surface. One support should be under the long-section hull immediately after the junction to the nose, and the other under the wings. (This will prevent the glider from tipping when the nose and/or batteries are removed).
3. Make sure the glider is rotated so that the vacuum port, pressure relief port, and RGB LED are pointing upwards.
4. If the glider has recently been submerged, wipe away all water. Remove all water using a lint-free cloth paying special attention to the region around the glider's vacuum port. Water droplets remaining on the vacuum port could be sucked into the glider when it is opened to release vacuum.
5. Using a 3.5mm allen wrench or the T-handle built into the vacuum pump assembly, gently open the vacuum port cap (CCW). If the glider was previously under vacuum, an audible hissing sound will immediately be noticeable. Patiently wait until hissing stops - this is typically under 1 min.
6. Remove the four Nose Cone Screws and Cup Washers using an allen wrench. (A pick may be necessary to pull out Cup Washers).
7. Push the two T-handle Hull Openers into the D-shaped slots at the intersection of the Nose Cone and Long Section Hull. Rotate them 90 degrees, being careful to push radially inward so they don't slide out of position.
8. Set the Hull Openers aside, and gently pull the nose the remainder of the way out of the Long Section Hull (CAUTION: a cable is attached at the back of the Nose, **DO NOT** apply tension to the cable as it may result in damage.)
9. Have a support stand ready under the nose (or have an assistant hold the nose while it's being removed) - the nose must **not** be allowed to drop forcefully once unseated.
10. With the nose now removed from the long-section hull, gently rotate it away from the glider to provide access to the battery compartment.

    Reference Mechanical, Nose, Image 1.

Mechanical, Nose,
Image 1

Ballasting

Overview:

The OceanScout glider is designed to operate in a range of potential water densities. **The Oceanscout does not need complex ballast tuning procedures like other vehicles. A simple Ballast Weight Disk change between fresh and salt water is all that is required.** This a result of the Oceanscout's large buoyancy engine to hull displacement ratio, and an automated action to find neutral buoyancy on each mission.

Ballast Weight Disks:

On the Nose Cone Plate there are slots for holding Ballast Weight Disks. You can add or subtract Ballast Weight Disks in these slots to increase or decrease the glider weight.

Reference Mechanical, Nose, Image 4.

Weighting for neutral buoyancy:

- Freshwater (1,000kg/m^3): 0 Ballast Weight Disks
- Saltwater (~1,025kg/m^3): 8 Ballast Weight Disks (2 per slot)

These two weight configurations should cover all common deployment scenarios.

To install or remove Ballast Weight Disks:

1. Remove the vehicle nose.
2. Each stack of Ballast Weight Disks is retained by a single screw.
3. **CAUTION** : WHEN ADDING/SUBTRACTING WEIGHTS DO NOT OVERTIGHTEN THE SCREWS. A small amount of LOCTITE 425 (low strength, plastic-safe thread locker) may be applied to ensure screw retention.
4. After adding or subtracting weights, the distribution should be roughly equal amongst the 4 slots. I.e. do not fill one slot and leave the rest empty. In the standard 8-weight saltwater configuration, each slot gets 2 Ballast Weight Disks. For freshwater, remove all 8 disks and 4 screws.

Ballast Tuning and custom adjustment:

Please contact Hefring Engineering for ballasting assistance if:

- You suspect your glider is suffering from a ballasting issue.
- You intend to adjust ballasting to a configuration other than 0 or 8 Ballast Weight Disks.

- You plan to operate under unusual conditions such as extreme density gradients, brackish estuaries, salt lakes, or with additional equipment installed on your Oceanscout glider.

Our engineering team will be happy to assist with ballast tuning and adjustment procedures.

For technical reference:

- Each disk weighs approximately 37 grams.
- 1 gram of added weight is approximately 1mL of VBE movement.
- Ideally, the glider is neutrally buoyant when the VBE is positioned somewhere in the 200-400mL range.

CAUTION: Do not deploy your OceanScout glider in fresh water if it is ballasted with Weight Disks for salt water! Doing so could result in immediate sinking. When deploying in fresh water, Hefring strongly advises all users to double check for the removal of Ballast Weight Disks, and to launch gliders carefully to ensure they are buoyant before release.

Battery Installation

The OceanScout glider is powered from a custom designed Lithium-primary pack ($LiMnO_2$) - with an estimated capacity of 1.5 kW*hr, and a nominal voltage of 36VDC. Each glider has 7 slots for individual battery "sticks", which must be installed by the user. (The glider can operate with fewer sticks if necessary, but runtime will be proportionally reduced; this mode of operation is not recommended). Battery sticks are somewhat water-resistant but not waterproof - therefore direct exposure of sticks to water should be avoided.

1. Visually inspect all battery sticks before installing. Bulges, cracks, corrosion on connectors, or any other noticeable deformity in the stick casing should immediately result in the battery being taken out of service. Battery sticks should be clean, and free of foreign debris.
2. All sticks should be checked for abnormal temperature when handling; any stick noticeably warm or hot should also be taken out of service, and immediately be isolated in a safe environment. (If this happens please notify Hefring immediately).
3. Ensure that your OceanScout is turned off (no illuminated status light).
4. Remove the vehicle nose to access the Battery Cover Plate. The nose cable may be disconnected for easier access, though doing so is not required.

   Reference Mechanical, Batteries, Image 1.
5. Remove the triangular nose cable guard piece.

6. Loosen the three brass allen screws on the Battery Cover. These screws are retained in the cover. Carefully pull the cover from the central shaft. Carefully guide the notch in the cover around the cable assembly (connected to the nose). The Battery Restrainer slots should now be fully visible.
7. Gently insert each battery stick into the slots in the Battery Restrainer. Each stick is “keyed”, so incorrect insertion position should not be possible. Align rib on one side of the battery pack with the slot in Battery Restrainer. The connector side faces the Short Section Hull. Try to balance placement of sticks when installing; this will prevent rotation of the Battery Restrainer.
8. Do not force battery sticks into slots - some mild resistance is normal and might require some minimal additional effort to seat fully, but significant force should never be required when installing the batteries. If usage of significant force becomes needed when installing sticks, remove the stick from the slot, inspect the slot / battery stick for deformities or interfering objects (e.g. tape), and try again.
9. As the battery stick approaches full insertion depth (and the electrical contacts on the battery stick make contact with the glider’s internal connector), be aware of any unexpected or unusual noises - this might indicate a serious electrical fault.
10. Stick is fully seated when pushed completely into the slot. (Note: there is no internal retaining mechanism to keep the stick in the fully inserted position - this is accomplished by the Battery Cover). Some slight variation of fully-inserted stick position is to be expected before the Battery Cover is reinstalled.
11. Slide Battery Cover in place - guide Nose Cone cable through the central hole. Be careful to align properly.

    Reference Mechanical, Batteries, Image 2.
12. Secure Battery Cover with 3X screws. Carefully align the Battery Cover with the screw holes and alignment features on the Battery Restrainer. Push on the screws while tightening. Ensure all screws are fully seated.
13. Add the triangular Cable Retainer Bracket, being sure to align properly. A retention ball should click into place once aligned.

Mechanical, Batteries, Image 1

Mechanical, Batteries, Image 2

Nose Installation and Pulling Vacuum

It is possible for one person to install the nose, but is considerably easier with two persons.

1. Thoroughly inspect the nose o-rings, and corresponding mating surface in the long-section hull for debris, contamination, or damage. Clean all surfaces with a lint-fr ee material. Kimtech wipes are ideal.
2. Lubricate o-rings (with approved grease only, Molykote 55 recommended).
3. Make sure the glider vacuum port is fully open (approx. 3mm protruding from the surface of the glider).

   Reference [Mechanical, Vacuum, Image 1](#).
4. Bring the Nose close to the vehicle body and secure the Nose Cone Cable to the Nose Cone Connector, being careful not to tug on the cable. Connector is directional, and attempting to plug it in backwards may damage pins.

   Reference [Mechanical, Nose, Image 1, 5, 6](#).
5. Insert the small cotter pin to lock the nose cable connector in place.
6. Tuck the nose cable into the hooks on the inside of the nose and/or ensure its coil sits inside the nose, not over the edge.
7. Align the key on the nose with the slot on the long-section hull.
8. Very firmly push the nose onto the long-section hull. (It is unlikely the nose will be fully seated after this step - the vacuum pump can be used to seat the nose fully). The o-rings on the nose must make partial contact with the long-section hull.

   Reference [Mechanical, Vacuum, Image 2](#). Ensure the Nose is held in place before releasing.
9. Pick up the Vacuum Adapter, making sure that the adapter's ball valve is in the closed position. Turn the pump on.
10. Push the T-handle of the vacuum-pump adapter approx. 2 cm so it protrudes from the bottom of the Vacuum Housing. With the vacuum-pump adapter held approx. 1cm (not critical) over the vacuum port, guide the T-Handle allen key into the allen socket on the glider's Vacuum Screw.

    Reference [Mechanical, Vacuum, Image 3](#).
11. Slide the Vacuum Housing down the T-Handle and firmly press the vacuum adapter's outer housing onto the contact surface on the glider. (One hand should now be holding the vacuum adapter to the glider, and the other holding the T-handle).

    Reference [Mechanical, Vacuum, Image 4](#).

Note : If the O-ring is falling out of position on the Vacuum Housing, try pulling it out, adding some O-ring grease, and reinserting.

12. While maintaining light downward force on the vacuum adapter, turn the ball valve to the open position. Air will start to be removed from the glider. (If there is a noticeable hissing sound during this step, the vacuum adapter's O-ring is likely making poor contact, allowing air to escape; adjust the position of the adapter and/or amount of downward force).
13. Nose should automatically be seated onto the long-section hull after a few seconds - visually confirm even seating of the nose before proceeding.
14. After 10 seconds have elapsed, close the ball valve and note the reading on the vacuum gauge. This is the internal vacuum of the glider. The gauge will not read accurately while the valve is open and the pump is running. Open the valve and continue pulling vacuum, periodically closing the valve to check until the target reading is reached. The target vacuum for the vehicle is **35kPa (10inHg)**. Don't vacuum less than 20kPa (6inHg), and don't exceed 50kPa (15inHg).

    Reference *Mechanical, Vacuum, Image 5 & 6*.
15. Once the measured vacuum is adequate, proceed to tighten the Vacuum Screw. While continuing to maintain downward force on the adapter, begin rotating the T-handle CW. Only tighten the Vacuum Screw until it is fully seated and not any more (finger tight), you will feel this because the torque will increase. **Additional tightening will not improve the seal.** It is normal for the gauge to drop when the screw is close to seated.

    Reference *Mechanical, Vacuum, Image 7*.

    CAUTION : DO NOT OVERTIGHTEN THE VACUUM SCREW, doing so may strip the threads.
16. Remove the vacuum adapter, and shut the pump off.
17. In the 4 external screw holes between the nose and aluminum hull, install Nose Cup Washers first, then add Nose screws.

    Reference *Mechanical, Nose, Image 2 & 3*.

    CAUTION : DO NOT OVERTIGHTEN THE SCREWS. FINGER TIGHT TO SEAT THE SCREWS IS SUFFICIENT

Mechanical, Vacuum,
Image 1

Mechanical, Nose,
Image 1, 5, 6

Mechanical, Vacuum,
Image 2

Mechanical, Vacuum,
Image 3

Mechanical, Vacuum,
Image 4

Mechanical, Vacuum,
Image 5 & 6

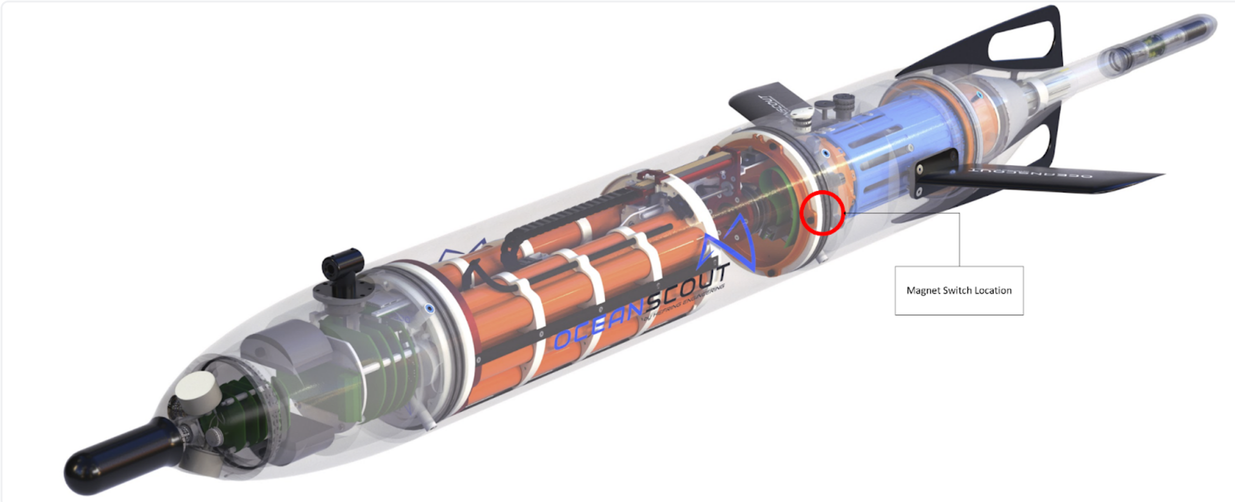
Mechanical, Vacuum,
Image 7

Mechanical, Nose,
Image 2 & 3

Powering Up the Vehicle

Before powering up the vehicle, conduct a final visual check of the glider. Make sure there are no obvious defects in the hull, wings, fins, or tail areas. Check no screws or fasteners are missing, and that the strobe / antenna cover in the tail is fully secured (can be verified by attempting to turn this CW).

1. To power up the vehicle, hold the magnet in place on the left side of the vehicle over the half moon notch where the long section and short section hulls join. When the glider turns on a loud constant tone is produced, and the vehicle's LED will turn on. A brief steady tone should

be audible from the glider (this is confirmation that power has been switched on to the glider). 

2. The RGB LED should start to blink red, then should transition to blinking blue / green. If the LED does not illuminate, or If the LED remains blinking red after several minutes, please contact Hefring immediately.
3. Some brief motor noises (and small movement of the tail) are normal during the glider boot sequence. If a motor noise persists for several seconds or more, this is likely a fault; immediately disable the glider using the magnet tool and contact Hefring.
    a. A loud motor noise on startup may be the result of the nose cable being pinched between the back edge of the nose cone and battery plate when the pitch mechanism moves on startup. If this occurs, remove the glider nose and reposition the nose cable. Contact Hefring for more assistance.
4. If the boot sequence completes successfully, the glider will create a wifi access-point with the SSID "[name]Glider".
5. Connect to the SSID using password "[name]glider". If this step is unsuccessful after several attempts, power-cycle the glider with the magnet tool and try again.

Powering Down the Vehicle

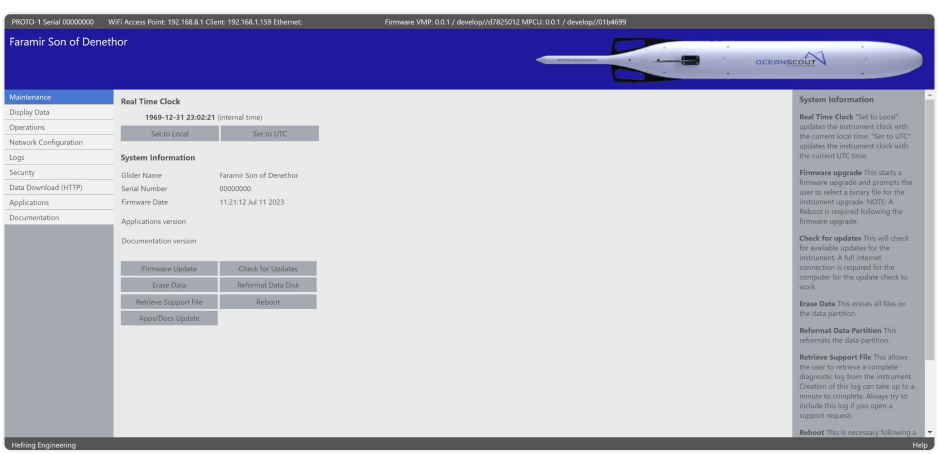
The glider can be powered down any time using the magnet tool - the notable exception being when the glider is in the middle of an update - **do not interrupt power until this process is complete**. (If an update is interrupted there is a chance the glider's software could become corrupted).

1. When ready to power the glider down, simply repeat the same process for turning it on, holding the magnet tool over the left rear D notch until the LED turns off and the glider emits a staccato tone.
2. If the glider will not be used for an extended period of time in the powered-down state (>a few hours), the batteries should be removed.

Removing the Batteries

1. Remove the nose from the vehicle (see "**Nose Removal**" section of manual).
2. Conduct a quick inspection of the battery compartment - be aware of **any** signs of problems (discolored plastic or metal, elevated temperatures, film deposits, smoke, chemical odors). If these are noticed, move the glider to a safe location and notify Hefring immediately.
3. Ensure that the glider is powered off.
4. Inspect cabling along its entire length, as well as connector on the nose - look for frayed, damaged, or broken wires.
5. Visually check for any significant accumulation of water inside the glider.
6. Remove the triangular Cable Retainer Bracket.
7. Remove the 3 screws securing the Battery Cover. Carefully remove the cover from the center shaft (align the notch over the cables as it's removed).
8. Pull each battery stick approx. 3cm out of its respective slot. (The intent of this step is to quickly disconnect power from the glider).
9. Carefully remove each battery stick from the glider.
    a. Note the temperature of each stick as it's handled - sticks should not be warm / hot.
    b. If a stick resists removal, you may gently pull the stick using a string through the tab hole or pliers. Do not use excessive force, if a battery is stuck or swollen contact Hefring for assistance.
10. Place electrical tape over the connector on each battery stick once outside of the glider *Reference Electrical, Batteries, Image 1*.
11. Place the batteries in a safe storage location.

Electrical, Batteries, Image 1



Glider Operation

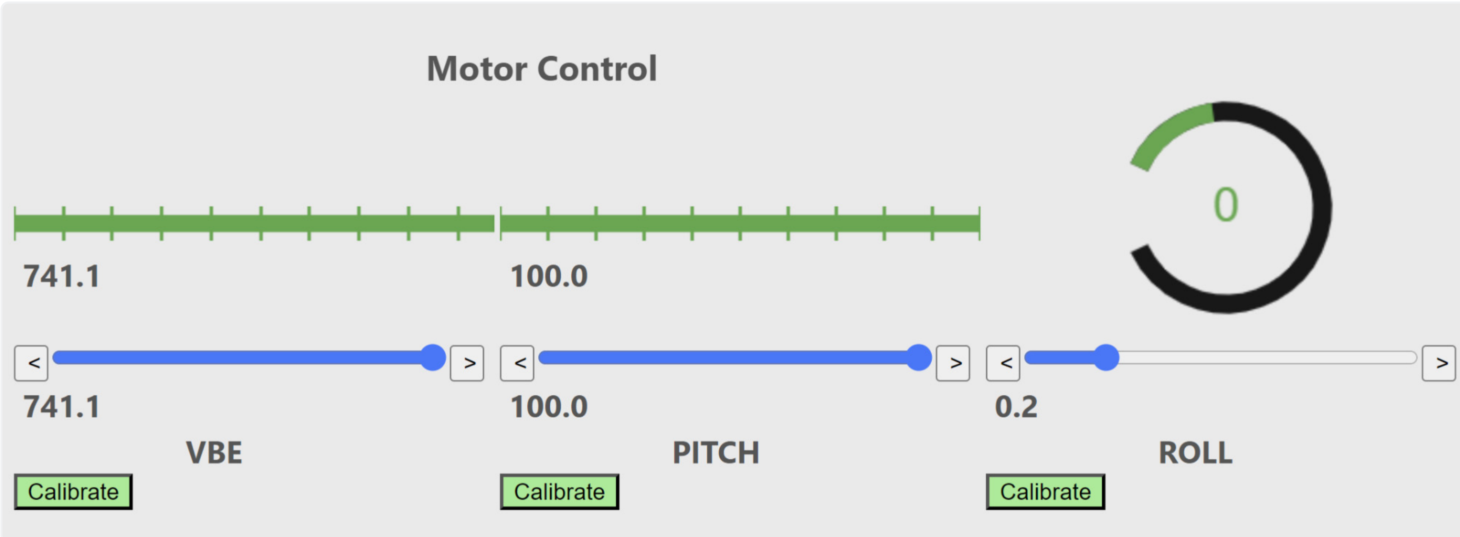
Connecting to the Glider

Once you are logged onto [name]Glider WiFi (see “Powering up the Vehicle”) you can access the glider’s internal webpage using Chrome or Firefox as your web browser. Navigate to the webpage by typing the glider’s IP into the address bar (**192.168.8.1**).

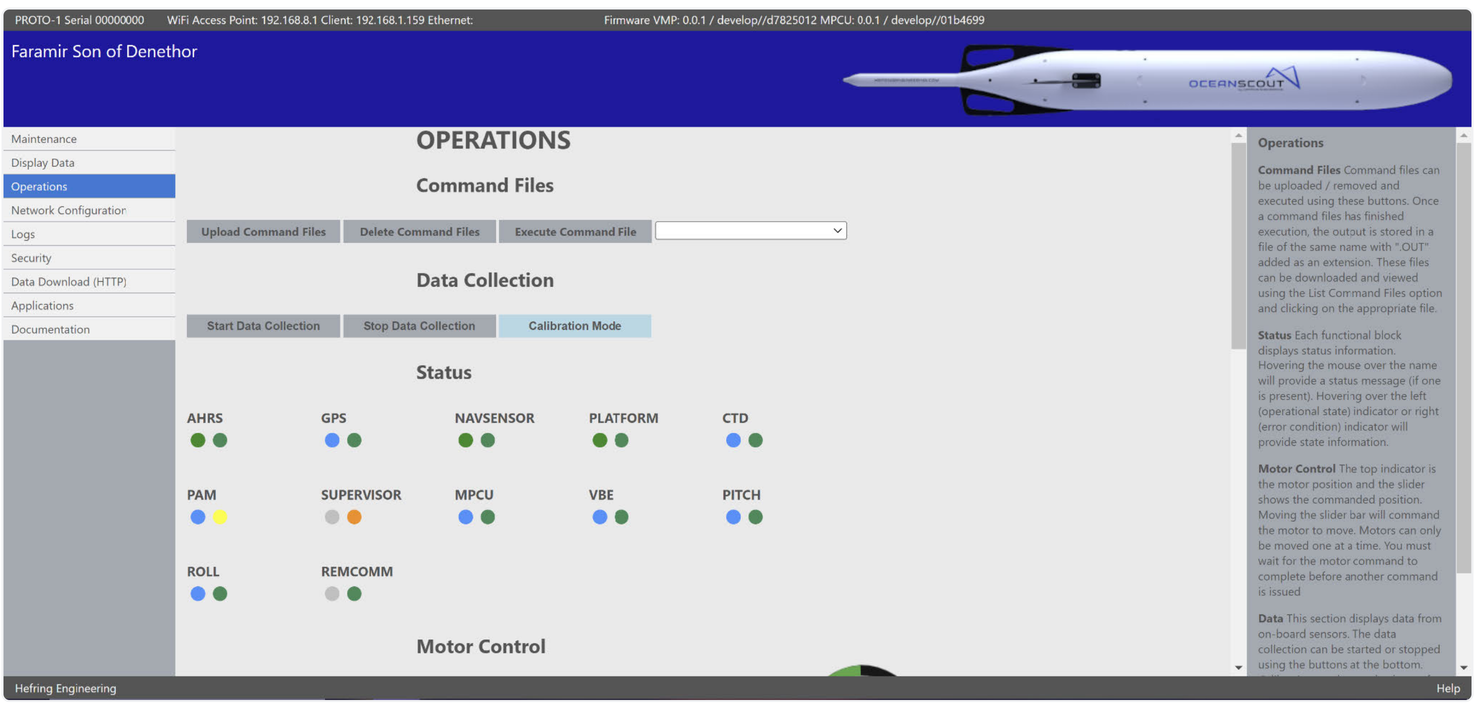
You should start on the maintenance page. This allows you to check the date of the firmware, and update the glider when necessary (see “Updating Glider Firmware” for more information).

Calibrating Motors

Once connected to the glider webpage click on the “Operations” tab along the left hand side of the page. Here you can see the status of the different sensors and motors in the glider and interact with it outside of running a mission.



In the motor control section you will see buttons available to calibrate each motor. Be sure to calibrate all three motors or a mission will not begin.



Recovery of PAM Data

1. Shutdown the glider, and remove the nose from the vehicle. Battery removal is optional. (See sections “Powering down the vehicle” and “Removing the Batteries”).

2. Remove the nose cable connector. PAM data is stored on SD cards accessible from a slot in the nose bulkhead wall behind the nose cable connector.
3. Push on the SD card to eject. Card may now be removed from the glider.
4. Ensure the vehicle is powered off before reconnecting the nose cable connector.

Glider behaviors

Start dive

- Communicates current position (starts in comms position)
- Move motors into position required to enter descent mode

Parameters

- Completion Depth
- Timeout to achieve depth

Control implications

- First dive of mission, the VBE sinking point is determined by slowly moving the VBE until the glider stays to sink. This motor position is then used by subsequent dives directly instead of searching for it.
- The sink search is done every 12 hours to make sure that the density hasn't changed significantly.

Glide (descend)
Parameters

- Timeout to completion
- Target depth

- Target altitude
- Target heading
- Target heading rate (for spiral descent)
- Target pitch
- Target depth rate
- Speed control (on/off)
    - Use pump volume if off
- Pump volume
    - Only applies if no speed control
    - Pitch control (on/off)
        - Use feed forward setting only if off
- Guidance interval
    - “Deep sleep time” (no monitoring)

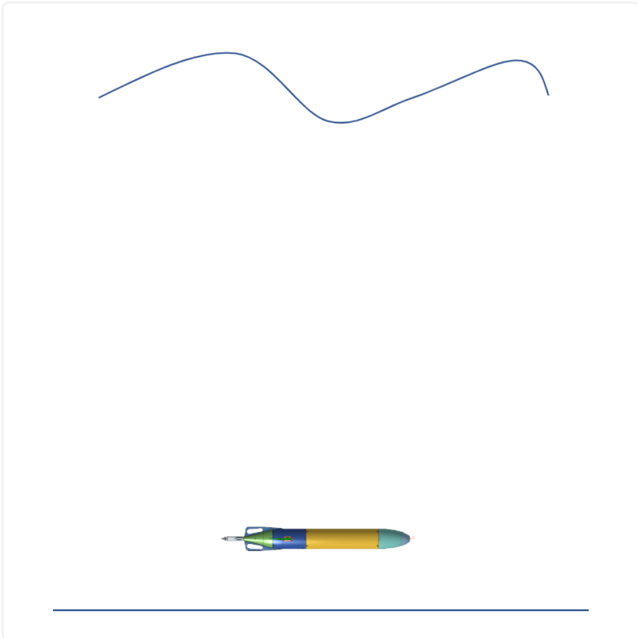
Control Implications

- ...???

Quiet

Parameters

- Number of yos between quiet periods
- Timeout for PID convergence
- Duration (non-essential systems off)



Control Implications

- Depth control to minimize vertical motion
- Pitch control to make glider horizontal

    - Maximize drag

Future

- Rest on bottom and collect data

Bottom inflection
Inflect, rotate, move VBE. Monitor orientation until pitch / roll are within expected range.

Parameters

- Timeout to complete behaviour

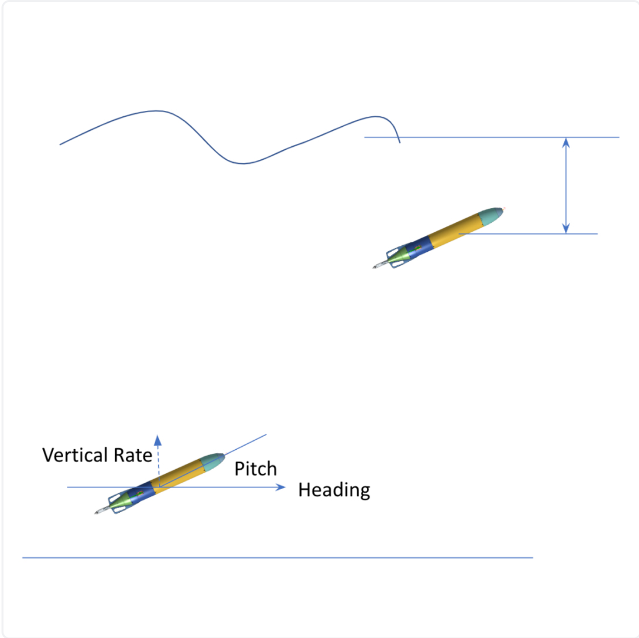
Control implications

- Is this a straight forward maneuver (simply set motors to new positions) or will it require some sort of monitoring) with additional motor motion)
- Different behaviour if no quiet behaviour (straight from descend to ascend) ?

Glide (ascend)

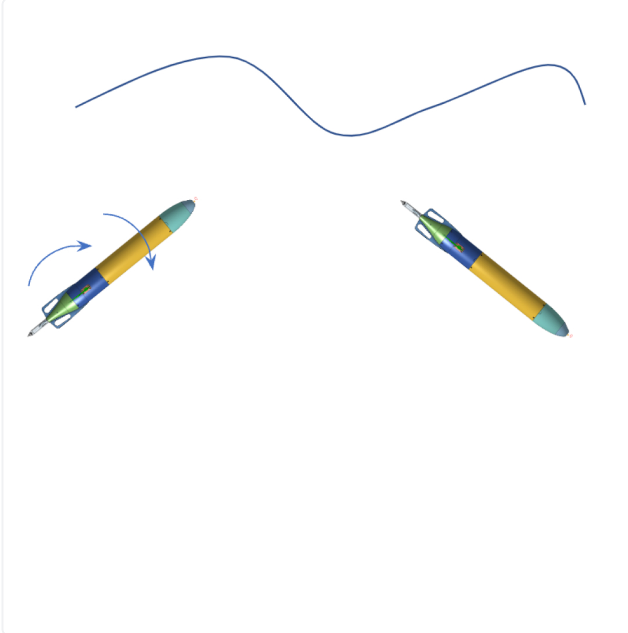
Parameters

- Timeout for completion
- Target Depth
- Target heading
- Target heading rate (for spiral ascent)
- Target pitch
- Target depth rate
- Speed control (on/off)
  - Use pump volume if off
- Pump volume
  - Only applies if no speed control
- Pitch control (on/off)
  - Use feed forward setting only if off
- Guidance interval
  - “Deep sleep time” (no monitoring)



Top inflection

Inflect, rotate, move VBE. Monitor orientation until pitch / roll are within expected range.



Parameters

- Timeout to complete behaviour

Control implications

- Use previous VBE position during descent to guesstimate initial VBE position for ascent.

Surface

GPS fix + dive summary/ check for shore + data transmission.

Surfacing

- Timeout to complete
- Surface when waypoint reached (on/off)
- Number of yos to surface
- Timeout to reach surface

Control Implications

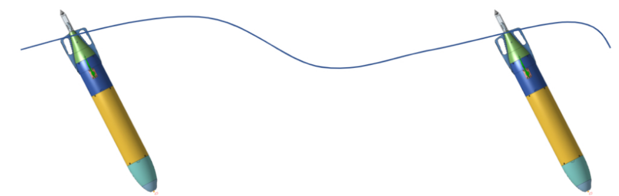
- VBE set to maximum buoyancy and pitch to maximum nose down

Drift
Remain on surface and regularly transmit telemetry / check for shore messages

- Occurs at waypoints

Parameters

- Telemetry interval
- Duration
- Waypoint travel information for station keeping



Hover
Part of station keeping

- Occurs at waypoints

Parameters

- Min depth
- Max depth
- Quiet time
- Hover time
- Timeout (for reaching depth)

Control Implications

- Depth control to achieve minimum vertical rate
- Pitch control to horizontal
  - Maximize drag

Recovery

Turns on strobe / WiFi and sends periodic position reports

- Entered via shore command

Parameters

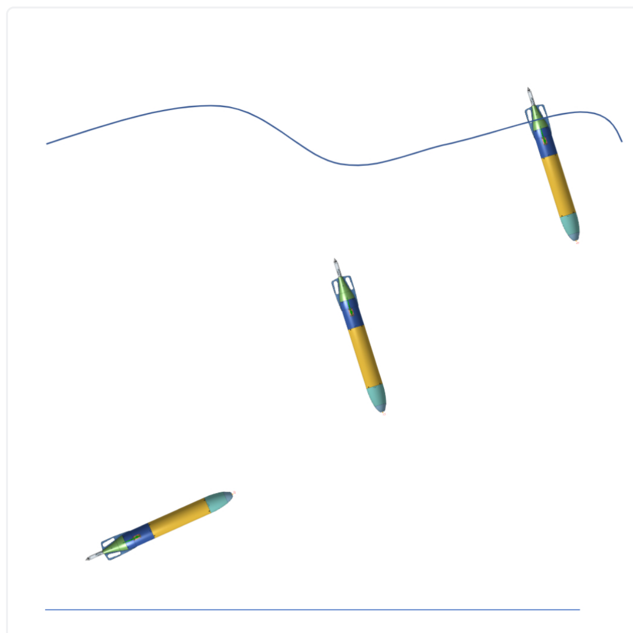
- Strobe on / off / cycle times
- Wifi on / off times
    - When a client connects, WiFi must stay on.
- Telemetry interval

Control Implications

- None (?)

Abort

- VBE to maximum buoyancy, pitch to nose down
- Strobe lights turned on
- Send telemetry information



Abort Conditions

- No communications timeout
- Mission timeout
- Max Depth Exceeded
- Minimum Battery percent
- Minimum Battery voltage
- Minimum disk space percent
- Minimum disk space MB
- Internal Pressure
- Leak detect count

Parameters

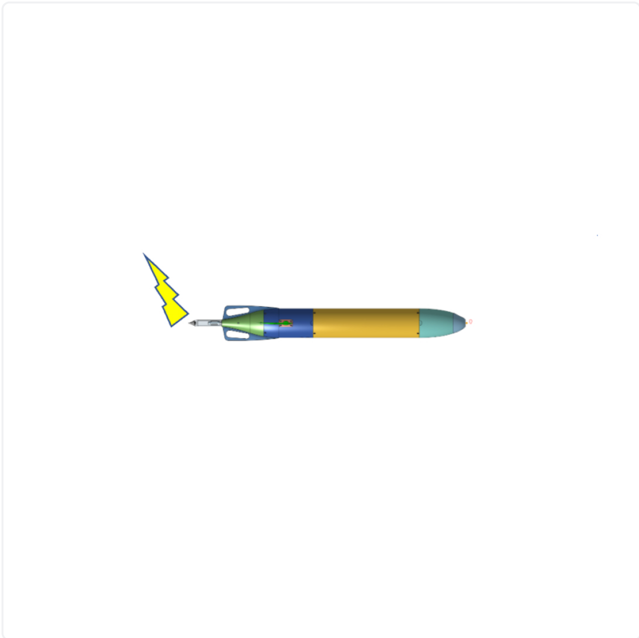
- Telemetry reporting interval

Control Implications

- Abort ascent needs to be monitored and “bad” situations (e.g. obstructed by kelp) need to be dealt with if possible

Idle (power on)

- Runs any time the glider is powered on
- Sends telemetry, checks for incoming messages
- Checks for depth and issues abort if depth greater than defined (“Oops” recovery)



Science sensor control

- CT / PAM
- Sensors can be turned on and off according to glider behaviour, segment and yo
    - `segment_description_id` : The segment description ID to apply this configuration (0 = test dive segment, -1 = all segments). (Not implemented yet) Range: `-1 - 255`
    - `sample_always` : Sensor is always sampling.
    - `sample_surface` : Sample when surfaced / surfacing.
    - `sample_ascend` : Sample when ascending.
    - `sample_descend` : Sample when descending.
    - `sample_quiet` : Sample when drifting.

    - `sample_hover` : Sample when in hover mode.
    - `power_always` : Sensor is always on.
    - `power_surface` : Turn sensor on when surfaced / surfacing.
    - `power_ascend` : Turn sensor on when ascending.
    - `power_descend` : Turn sensor on when descending.
    - `power_quiet` : Turn sensor on when drifting.
    - `power_hover` : Turn sensor on when in hover mode.
    - `yo` : The yo that the sampling should start.
    - `yo_interval` : Allows sampling on multiple yos. For constant sampling, use 1. For a single yo, use 0.
- Sampling based on depth
    - Multiple ranges can be set up with each range having a defined depth interval.
        - `depth_interval` : Depth interval between samples (0 = not depth based) Units: meters. Range [`0 20`]
        - `start_depth` : Start depth Units: meters. Range: [`0 200`]
        - `end_depth` : End depth (end depth = 0 means sample over the entire depth). Units: meters. Range: [`0 200`]

Sequencing

- Behaviours are loaded into a sequencer which executes the behaviours sequentially.
- Each behaviour is labelled which provides the ability to jump to a behaviour label out-of-sequence.
- Decision points occur between certain behaviours which result in different behaviour sequences being executed depending upon certain conditions
    - Surfacing
        - Runs after op inflection
        - Whether or not to surface
    - Waypoints
        - Runs after surface behaviour
        - Determines if waypoint has been reached and selects next waypoint

        - Sets up for next waypoint
        - Hover / Drift / Characterization “sub-routines”

- Allows development of novel behaviours, sequences and decision points
- Typical sequence
    a. Start Dive
    b. Descend
    c. Quiet
    d. Bottom Inflection
    e. Ascend
    f. Top Inflection
    g. Check Surfacing
    h. Surface
    i. Check Waypoint
- Out of sequence behaviours
    - Abort
    - Recovery