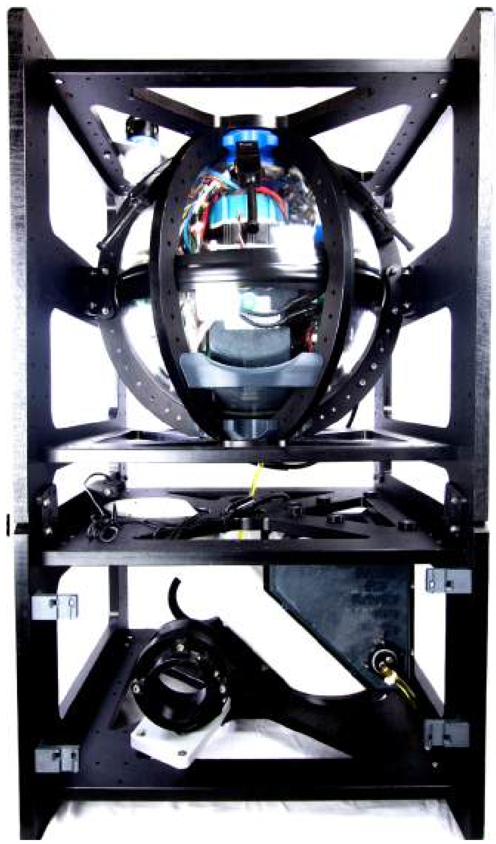
Drifter: General Purpose Sensor Platform

User's Manual

Revision 4



SECOND STAR ROBOTICS

Contact: info@secondstarrobotics.com
2333 Distribution Cir
Silver Spring, MD 20910

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Document Revision History

Revision No.	Description of Change	Date
1	First draft of document. Hardware rev0	9/27/2020
2	Second Draft referencing assembly video	10/7/2020
3	Incorporated new FW functionality Driftcam to Drifter updates. Hardware rev1.	7/7/2023
4	Revision incorporating Drifter hardware revision 2 changes	6/20/2024

Contents

1. INTRODUCTION

The Drifter General Purpose Sensing Platform (GPSP) is a freely drifting buoyancy controlled platform for studying and positioning sensors in epipelagic, mesopelagic, bathypelagic, and benthic zones. Designed to be deployed in groups of up to 14, the platform can carry out a preprogrammed survey or remotely controlled via acoustic commands. The platform is capable of carrying 100 L (100 kg) sensor payloads down to 2000 m and powering these payloads as needed.

1.1. Purpose

This document will guide the user in preparation, deployment, operations, recovery, data download, and maintenance of the Drifter GPSP platform.

1.2. Reference Documents

For more information please reference the following documents:

Blueprint Subsea "SeaTrac PinPoint Tracking System: User Manual", https://www.blueprintsubsea.com/sys/download.php?Id=seatrac_pinpoint_manual, 2020.

X100 Series Micro-USBL Tracking, Data Modem & AHRS Acoustic Beacons: User Manual", https://www.blueprintsubsea.com/sys/download.php?Id=seatrac_beacon_manual, 2020.

ACME Systems "Fox Board D27 technical documentation", https://www.acmesystems.it/doc_foxd27, 2024

Second Star Robotics "Drifter GPSP Support Repository" https://github.com/Second-Star-Robotics/Drifter-GPSP-Support-Repository.git, 2024

2. SYSTEM OVERVIEW

The Drifter GPSP is shown in Figure 2.1. Major subsystems are mounted within two housings. A glass spherical housing protects the buoyancy engine, control computer, battery system, and camera system. A second cylindrical housing holds an externally mounted USBL/modem system. The USBL system contains the main sensors used to allow the Drifter to communicate, be tracked, and determine its depth and location. A magnet switch on the side of the Platform Control Sphere allows the user to turn on the vehicle. Self contained Iridium and VHF beacons aid in surface tracking and recovery. At the bottom a sensor payload section allows the platform to carry sensor payloads.

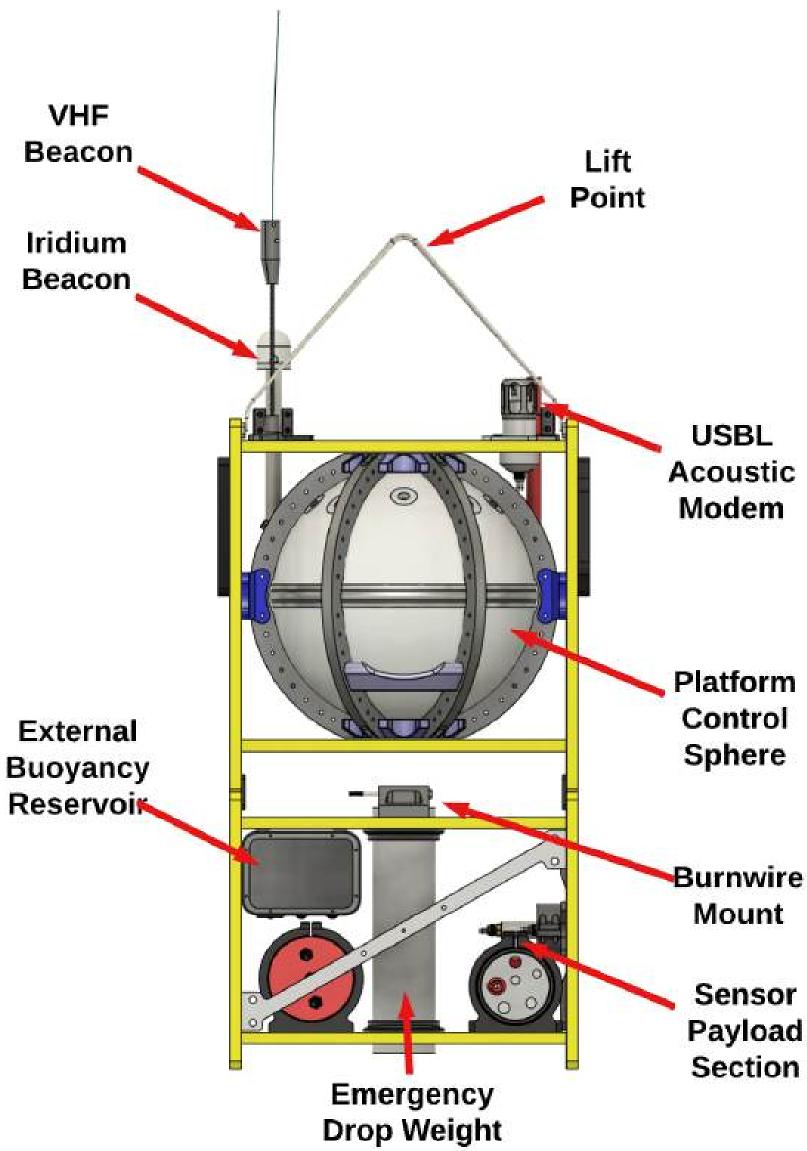


Figure 2.1: A drawing of the Drifter vehicle showing the major system components.

2.1 Platform Specifications

Table 2.1 presents the detailed specifications of the Drifter GPSP. These specifications cover various aspects of the platform, including its physical dimensions, power system, sensing capabilities, and connectivity options. The table provides an overview of the platform's capabilities and compatibility with sensors and payloads.

Table 2.1: Platform Specifications

General Information	
Product Name	Drifter GPSP
Use Cases	Active acoustics, passive acoustics, camera sampling, CTD profiling, eDNA, bottom surveys
Physical Specifications	
Length	60 cm
Width	56 cm
Height	102 cm
Weight (Empty)	68 kg
Frame Composition	HDPE
Housing Componsition	Borosillicate Glass
Adjustable Volume	3.5 L
ΔV/V	5%
Working Fluid	Inert Mineral Oil
Operational Depth	
Minimum Controllable	0 m
Maximum Controllable	2000 m
Maximum Recoverable	6000 m
Maximum Velocity	0.25 m/s
Power System	
Battery Type	Lithium Ion Rechargeable
Battery Capacity	1206 W-hr
Nominal Battery Voltage	36 V
Charge Time	5 hrs
Hibernation Consumption	100 mW
Nominal Buoyancy Correction	30 W
Sensing and Payload	
Integrated Sensors	Temperature, Pressure, IMU
Integrated Sensor Sample Rate	1 Hz
Payload Mass	100 kg
Payload Volume	100 L
Payload Voltages *	5 V, 12 V, 15 V, 24V
Number of Voltage Supplies	2
Payload Power	200 W

General Purpose Computer (DAQ)	
CPU	ARM Cortex A5 (SAMA5D27)
OS	Linux
Memory	256 MB
Storage	64 GB
Bulkhead Connectivity	Ethernet, USB, RS232, GPIO
Nominal Power	500 mW
Hibernation Power	0 mW
Analog Channels	12
ADC Sample Rate	1000 ksps
ADC Resolution	12 bit
Development Kit	Python SDK Logging Example
Subsea Tracking and Communication	
Type	USBL/ Acoustic Modem
Range	2 km
Available Commands	Status, Abort, Set Depth, Set Velocity
Surface Tracking and Localization	
Type	VHF, Iridium
Accessories and Options	
Auxiliary Battery	2653 W-hr
Solar Compatible	40 W
Auxiliary Imaging Computer	nVidia Jetson (GPU)
Auxiliary Storage	4 TB
Custom Sensor Integration	

2.2 Electrical Bulkhead Connectors

There are 10 feedthroughs, eight of which are electrical bulkheads located at the top of the control sphere that connect to external subsystems and allow for charging, programming, and data download (Figure 2.2). The Charge bulkhead connects to a charge cable while the vehicle is in preparation. This cable also serves to set the platform to Configuration Mode when the platform is powered. A power umbilical can be used to share battery power between housings. A USBL bulkhead connects to the Seatrac USBL, depth/temperature/AHRS sensor, and modem. An ethernet bulkhead allows connection to the on-board GPC to allow data download and system configuration. Two 9-pin auxiliary bulkheads are not wired but provide ports for future expansion. The vacuum port enables vacuum to be drawn or released when opening the sphere housing. A list of bulkheads is provided in Table 2.2.

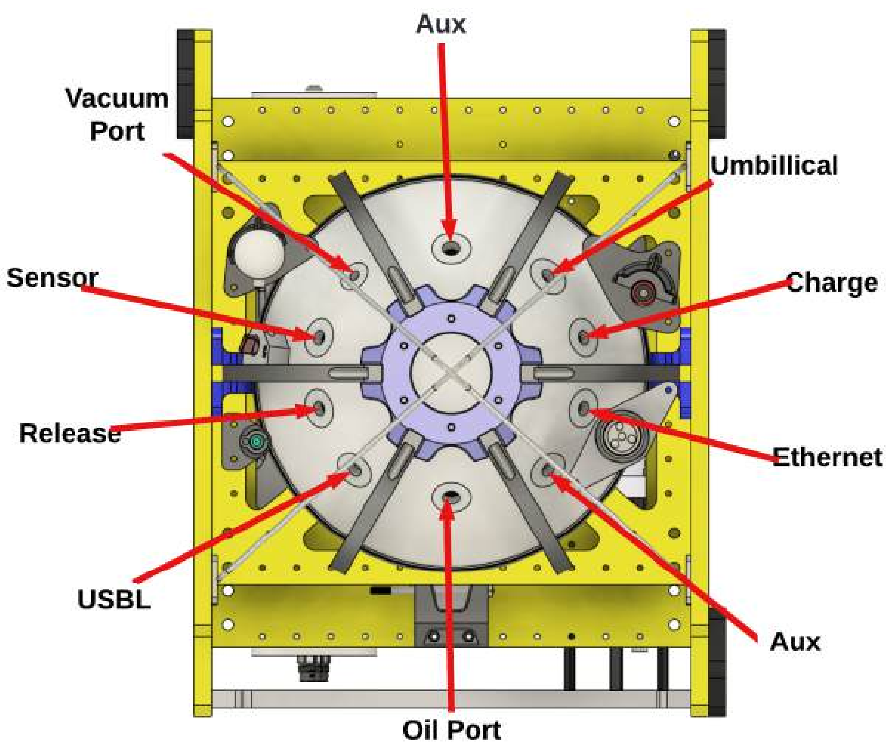


Figure 2.2: A top-down diagram of the Drifter vehicle showing the location of electrical bulkheads in reference to other components (USBL, vacuum port, power magnets).

Table 2.2: Drifter Bulkheads

Bulkhead	**Description**
Umbilical	Cable for sharing power between battery housings using a power path controller.
Charge	Cable for charging the batteries and a serial connection for the buoyancy engine controller for debugging.
Ethernet	Data connection for platform control and configuration.
Aux (x2)	Auxiliary are unwired 9 pin connectors allowing additional connectivity for future use.
Oil Port	A fluid connection from the inside of the glass housing to the external reservoir allowing platform displacement to be adjusted.
USBL	Data/power connection for the Seatrac USBL Modem. Must be plugged in.
Release	This bulkhead connects to the burn wire enabling release of the emergency drop weight. The port is also used to flash the firmware of the buoyancy engine control processor.
Sensor	External sensor connectivity. Two programmatically controlled voltages for external power and two serial ports for data connectivity.
Vacuum Port	The vacuum purge port allows vacuum to be pulled on the housing and the air to be purged with dry air after closing the sphere.

2.3 Depth Control System

The Drifter General Purpose Sensing Platform (GPSP) it contains a precision buoyancy engine made up of a fully software controlled electromechanical pump and robust model-based feedback depth control system, which allows the platform to hover and profile efficiently in the presence of large and time varying dynamic system parameter uncertainty at up to 2000 m. The engine is controlled by a dedicated low power microcontroller which handles control tasks. The platform has a large, high-precision adjustable volume (3.5 L with μL resolution) and a high payload capacity (100 kg/100 L). Experimentation has shown the depth control system of the Drifter GPSP suitable for near surface operation in the highly unstable mixing layer and in the presence variable density strata and thermoclines typically found in the littoral zone. Significant effort has been applied to achieve minimum self-generated noise on the platform making it ideal for passive acoustic monitoring. The control system utilizes pressure-based feedback control to estimate depth and vertical motion.

Platform behavior is divided into 5 operating modes or control states. Dive, Control, Hibernate, Surface, and Surface Interval. This basic state machine governs the platform's behavior and continues until a preprogrammed “Abort Time” has expired or the user depowers the platform.

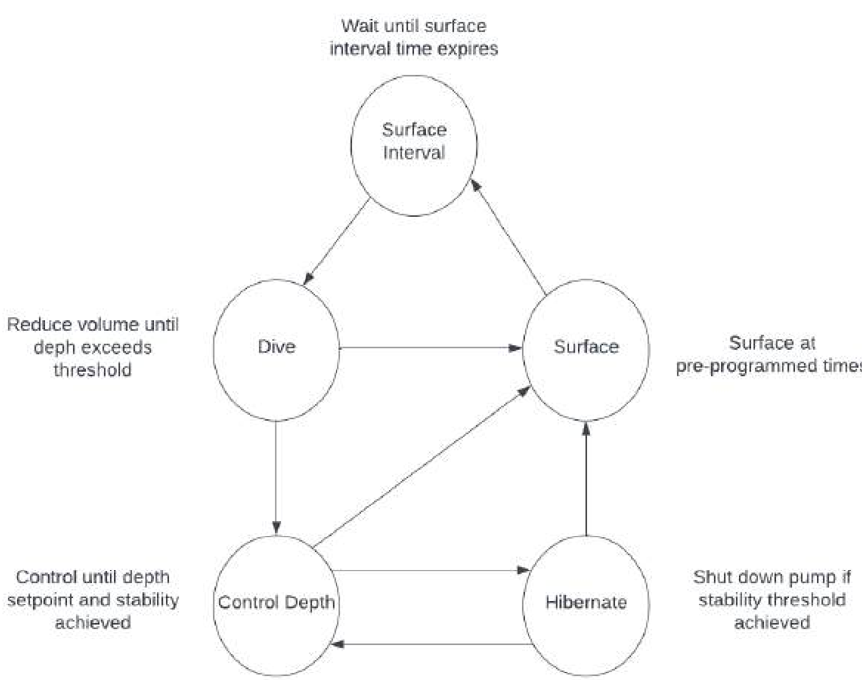


Figure 2.3: The circular state machine which governs Drifter behavior. States include Dive, Control Depth, Hibernate (at depth), Surface, and Surface Interval.

Surface

Surface Mode is the initial state the platform starts in. Preprogrammed surface intervals can be set throughout the dive to allow the platform to surface periodically to obtain a satellite fix or at the end of mission to allow recovery of the platform (without dropping the emergency drop weight). During this state the platform expands its adjustable volume at the maximum rate until it has pumped all the oil from the internal reservoir to the external reservoir AND the platform's depth is below a certain minimum depth threshold (usually 2m). Once these conditions have been met the platform will transition to the Interval Mode.

Surface Interval

During the Surface Interval Mode the platform will turn off the engine and wait until a preprogrammed surface interval. If the platform unexpectedly dives during the surface interval the platform will enter a fault state if the depth exceeds a threshold (typically 20 m). If a fault state occurs the platform will automatically abort and release its drop weight and attempt to expand its volume until it is recovered. After the surface interval time has expired the platform transitions to Dive mode. If an initial surface interval has not been set at start of dive the platform will transition immediately to a Dive Mode.

Dive

During the Dive Mode, the platform rapidly reduces its adjustable volume to cause the depth to increase until a certain threshold is reached. Once the threshold is reached the platform will transition to Control mode. If a pre-scheduled Surface Interval occurs during Dive Mode the platform will transition to the Surface Mode.

Control

Control Mode uses pressure based depth feedback to control the velocity and depth of the platform. A series of depth setpoints and velocity setpoints can be pre-scheduled to occur throughout the dive to allow the platform to achieve specific depths or profile at pre-programmed vertical velocities. During the Control Mode the engine will turn on and off and make volume corrections as needed to achieve the desired depth and vertical velocity. While hovering in Control Mode the platform is said to be isobaric or constant pressure. Once the platform has stabilized at a depth and the depth error is below a pre-programmed threshold (typically 1m) and the vertical velocity is below a velocity threshold (typically 1 mm/s) the platform transitions to Hibernate Mode.

Hibernate Mode

While in Hibernate Mode the platform turns off the buoyancy engine to save power and reduce platform radiated acoustic noise. The platform will remain in Hibernate Mode until the platform exceeds a certain absolute depth error between the current depth and the depth setpoint. While hovering in hibernate mode the platform is said to be isopycnal or in constant density. If a pre scheduled surface interval occurs during Hibernate Mode the platform will transition to Surface mode but will retain its current depth setpoint when the platform re-enters Hibernate Mode. Changes in the local density or thermal expansion or compression of the platform will tend to cause it to drift slowly away from the threshold.

These five modes allow a host of profiling behaviors including park-and-profile, land-and-listen, hover, bounce profiles and can be set by configuring the platform through a series of programming "Registers" (see Section *4. PROGRAMMING*).

2.4 Power System

The platform's power system supplies DC power to various subsystems at pre scheduled times or automatically when needed. By turning on components only when they are required, increases platform endurance and allows the user to pre-program a dive based on the available battery power. The battery system is described in detail in section *3.1 Battery Charging* and section *11 Battery System and Safety*. The platform contains two individually schedulable external DC power supplies which can be used to schedule powering external sensors and instruments at 5V, 12V, 15V, or 24V. These supplies can deliver around 100 W continuously but utilize switch-mode power supplies for efficient power power conversion from the raw battery voltage. Due to the switched nature of these supplies, linear regulation can be added for low-noise applications.

2.4 Acoustic Communications and Tracking

The platform is integrated with a USBL/Acoustic Modem (Blueprint Seatrack X110). This device is used by the platform to measure depth, attitude, and seawater temperature. When used in conjunction with a topside USBL/Modem (Blueprint Seatrack X150) the user can communicate and track the Drifter platform during a dive up to 1.5 km away from the platform. This is useful for testing new payloads or performing opportunistic changes in depth or surfacing. If multiple platforms are used the USBL/Modem system can be used to log interplatform range, azimuth, and depth as well as share a small amount of data between platforms. Information about controlling and tracking the platform can be found in section *6 Operations*.

2.5 General Purpose Data Acquisition Computer

The Drifter platform contains a general purpose computer (GPC) for sensing applications as well as user interface functionality. The GPC is an ARM Cortex A5 with 256 MB of ram and 64 GB of storage running the Linux operating system. It serves as the core general-purpose onboard computer for the Drifter autonomous robotic float. The GPC captures and processes serial data, ensuring accurate and reliable measurements. Its dual-mode functionality, capable of switching between mission-critical data collection and terminal configuration, allows a host of user generated configurations using simple bash or python scripting. When the Drifter is in Configuration Mode the GPC acts as network attached storage allowing the user to easily download collected data. During dives the GPC can be pre scheduled to turn on for intervals to perform sensing or control tasks.

User's familiar with Linux embedded systems (eg. Raspberry Pi) will be right at home using integrated GPC. A github repository has been provided by Second Star Robotics which contains example source code and scripts that can be run on the GPC as well as instructions for configuration of the FOX D27 to function in the Drifter as the GPC.

https://github.com/Second-Star-Robotics/Drifter-GPSP-Example-Repository.git

3. PREPARATION FOR DEPLOYMENT

This section outlines the physical preparation of a Drifter for deployment. Including battery charging and rigging.

3.1 Battery Charging

The Drifter battery system is rechargeable allowing the platform to be redeployed without requiring replacement of the battery. The battery system facilitates functions such as power sharing between modules and energy harvesting. The Drifter battery system is made up of two 5-cell battery banks in series for a total of 1.2 kW-hrs. Cells are individually monitored by a protection circuit for overcharge, overdrain, short circuit, and overtemperature. Each 5-cell battery should be charged to 20.75V (or 4.15 V per cell) nominally at 2A. The Charge-Programming cable facilitates charging by allowing the operator to connect two 5-cell Lithium Ion Chargers to each battery using the +Vbatt and Battery-Split connection and the Battery-Split and GND connection (Figure 3.1).

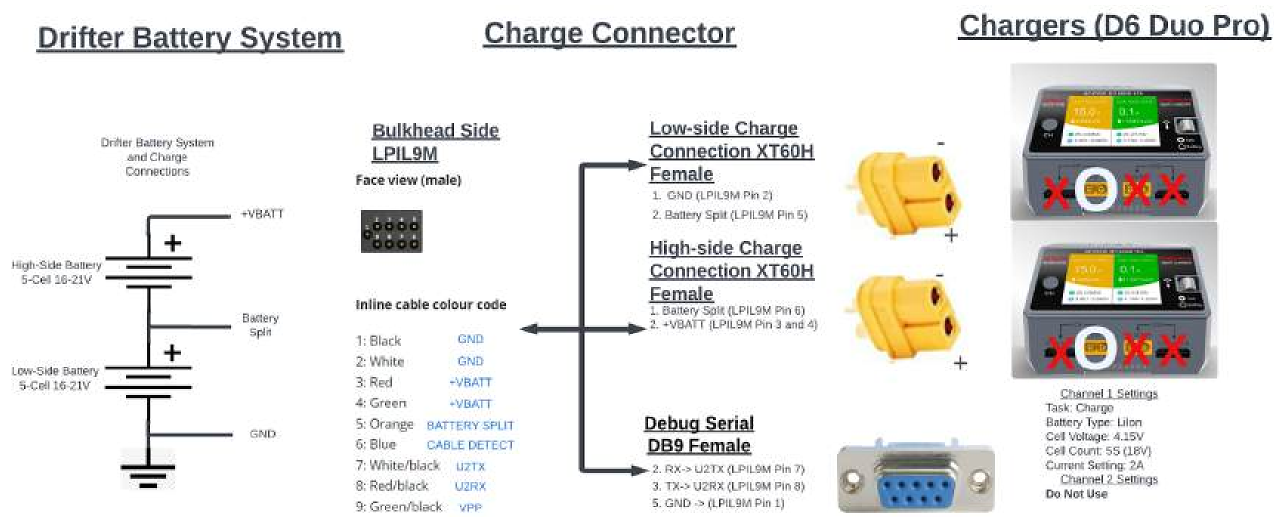


Figure 3.1: A diagram of the Drifter battery system, charge cable, and battery chargers. The battery system is made up of two 5-cell banks (high-side and low-side), which are separately charged by two isolated chargers. Shown are recommended charge settings.

To charge the battery system you will need the Drifter GPSP platform, the charge cable, two lithium ion smart chargers. Charging should be done as follows:

1. Remove the Dummy Plug or from the Charge bulkhead.
2. Apply a small amount of Molykote (Dow Corning, Molykote 55) to the bulkhead to lubricate the pins and protect them from seawater
3. Connect the Charge cable to the Charge bulkhead. Note: avoid plugging the

charge port into the identical to the Umbilical bulkhead as it will not charge.

4. Use a multimeter to verify that a 15 - 20.75V is between the +Vbatt and Battery-Split connection and 15 - 20.75V is measurable between the Battery-Split and GND connection. If a bank battery level has dropped below 15V it may require a protection circuit reset.
5. Plug the Low-side and High-side connectors into separate chargers in a single channel. Note: do not plug both connectors into the same charger as a short circuit condition will occur between the high side and low-side batteries.
6. On each battery charger press the CH button to select Channel 1
7. Press the selection wheel to configure channel 1 on both chargers.
    a. Task: Charge
    b. Battery Type: LiIon (for Lithium Ion)
    c. Cell Voltage: 4.15V
    d. Cell Count: 5S (18V)
    e. Current Setting: <5A (recommended value 2A)
8. Press “Start Task” on each charger.
9. The charger will prompt “Perform Task Without Balancer”. Press “Yes” as the battery system is self balancing.
    a. If the battery has been fully discharged the battery system may be in a disconnected safety state. This is to protect the battery from damage by keeping the cells at a minimum safe state of charge. If the smart charger issues an error when starting charging of a fully discharged battery it is recommended to follow the procedure for resetting the battery protection system. Please follow the procedure in *11.5 Low Battery Charging and Battery Protection Reset.*
10. During normal charging behavior the battery voltage will increase to the maximum cell voltage (20.75V) and then current will decrease. Charging is complete when each connection is at 20.75V and no current is flowing from the charger. A fully discharged battery system may take 12-18 hrs to charge at 2A.
11. Replace the dummy plug or Release Cable using Molykote.

3.4 Rigging

The Drifter must be rigged to allow it to be deployed from a ship or boat. Prior to deployment and recovery all staff involved in the operation should be briefed on lift points as well as sensitive locations on the platform (glass sphere, sensors, cables etc). When deploying the Drifter platform PPE should be used by all involved (steel toed boots, hard hat, personal floatation device).

A stainless steel cage at the top of the Drifter is designed to allow easy attachment to a Pelican Hook or other quick-release shackle. If using a crane multiple taglines should be looped through the low part of the frame to prevent swinging. Example lift points and tagline handles are shown in Figure 3.2. Ensure a gaffe pole is utilized to fend the platform off during deployment to avoid collisions with the vessel.

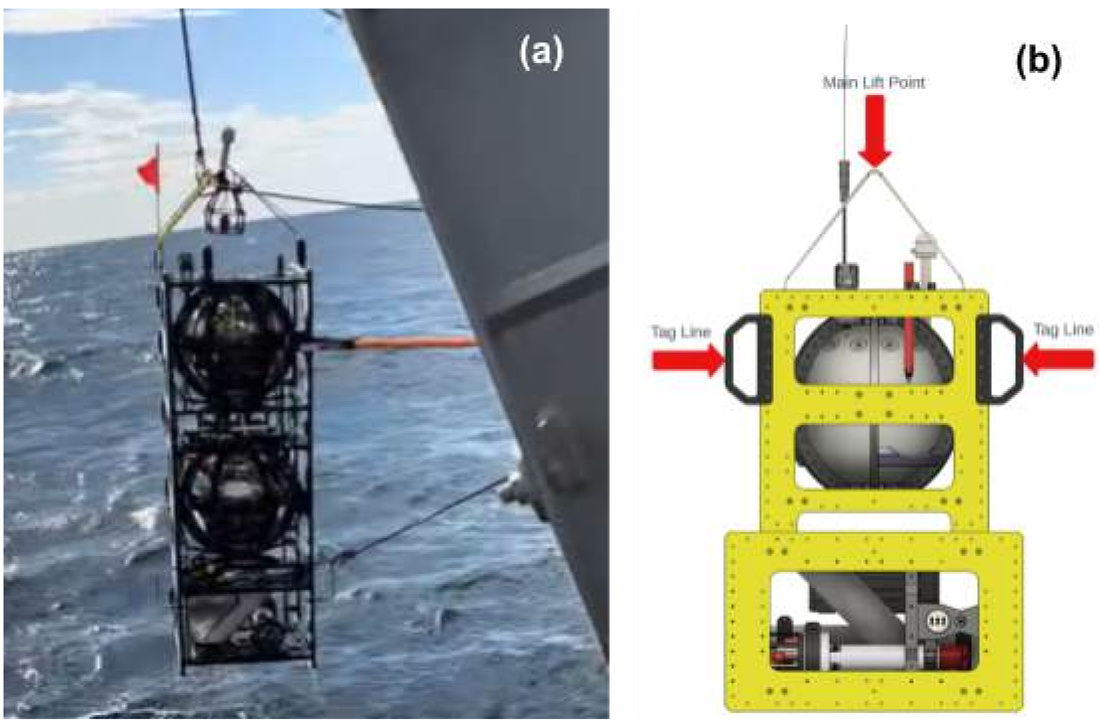


Figure 3.2: (a) A lift point found on the top of the platform is utilized to recover the platform on the top as well as multiple tag lines to safely bring the platform onboard. (b) Tag lines can be attached to handles on the front and back of the platform.

The emergency drop weight is held in a Guide Tube by a series connection of an electrically actuated Burn Wire, and a Galvanic Timed Release. If either of these components release the emergency drop weight will fall from the platform and the platform will return to the surface. The guide tube is angled so that instrumentation can be mounted or hung below the platform and the emergency drop weight will not strike it. If there is a chance the platform may come in contact with the seafloor, it is recommended that the emergency drop weight be hung by a length of rope to ensure that if the platform becomes entangled on the seafloor, only the drop weight will become entangled.

Use the following procedure to rig the platform for deployment:

1. Hang the emergency drop weight by placing it in the bottom guide tube (Figure 3.3).

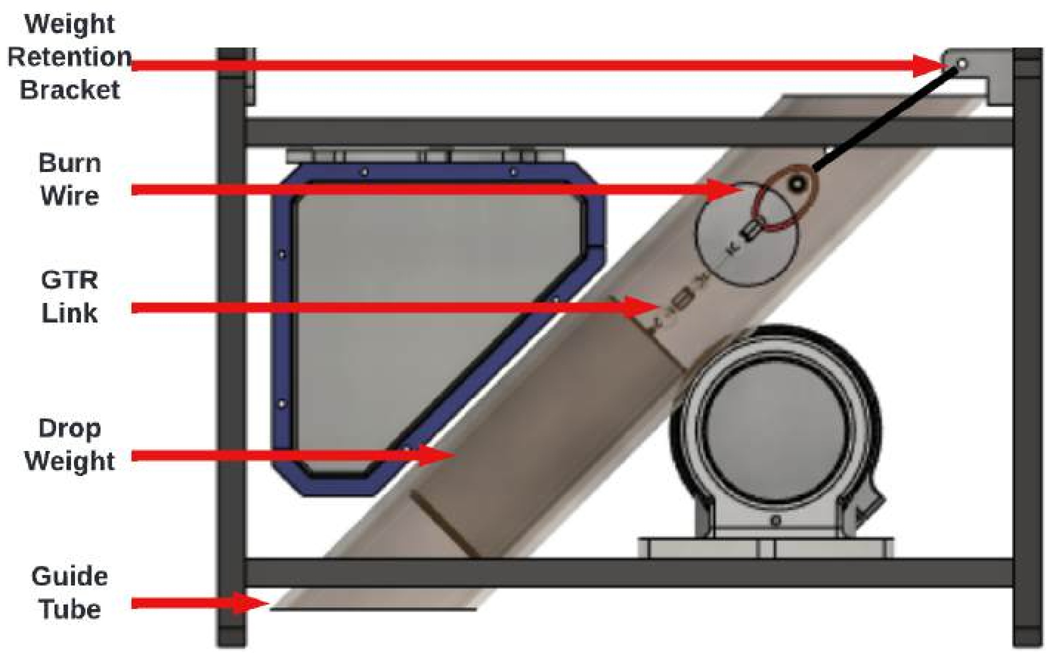


Figure 3.3: A drawing of the bottom of the Drifter platform which houses the drop weight. The drop weight is installed in a guide tube and connected to a weight retention bracket by a galvanic timed release and an electrical burn wire.

2. Connect a burn-wire release to the Drifter by looping it through the bolt above the drop weight on the weight retention bracket (Figure 3.4).

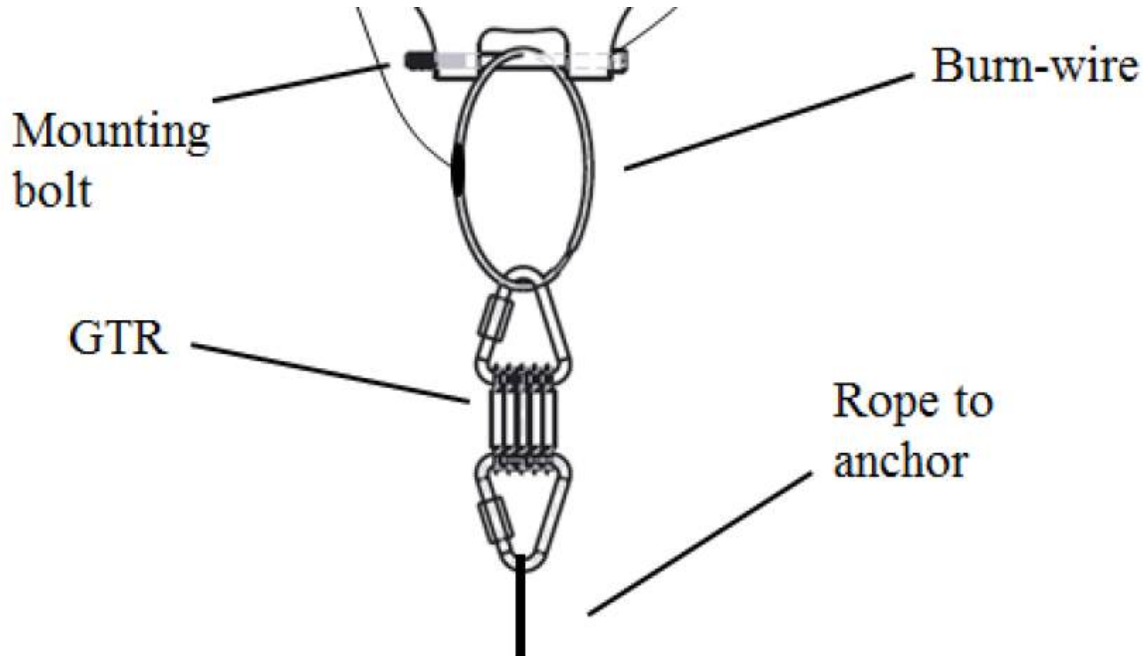


Figure 3.4: The burnwire is rigged by connecting it to the grounded mounting bolt. A GTR serves as a backup release and is connected directly to the drop weight anchor.

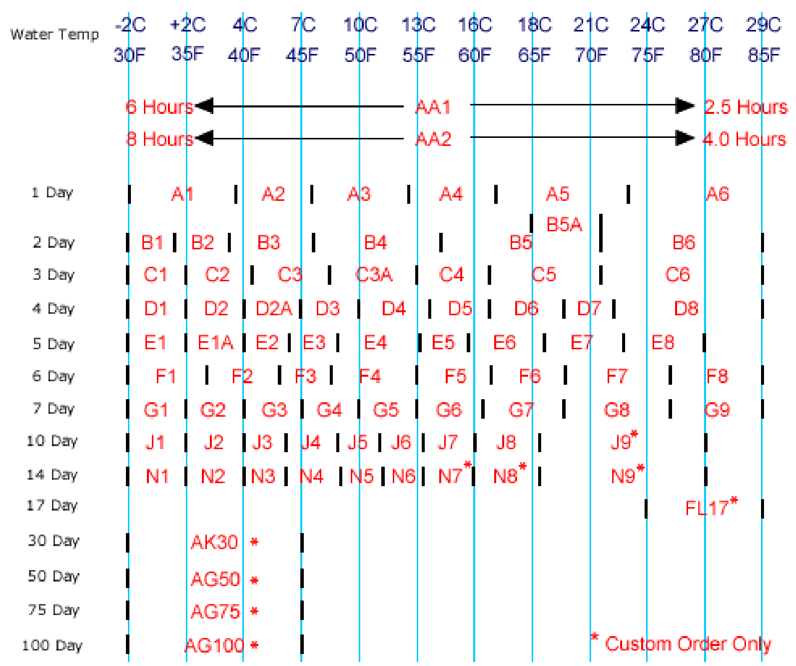


Figure 3.5: A chart indicating release time associated with International Fishing Devices GTRs which can be used as a backup release for the platform. A GTR should be selected which will not drop the weight until after the planned dive has ended.

3. Use a GTR link to connect the burnwire release to the Dropweight. During the deployment a GTR link will act as a failsafe backup to release the weight by slowly dissolving in seawater. As such the GTR link should be replaced after every deployment to avoid premature release of the dropweight (see Figure 3.5).
4. Cable-tie the burn-wire to the bolt to ensure that it does not directly come in contact with the bolt.
5. A VHF receiver should be installed on the top cage of the Drifter to enable nearby surface localization.
6. In preparation for deployment, rig the topside USBL transponder (Figure 3.6). The USBL should be hung at least 3 m (9 ft) in the water to minimize interference due to surface reflections. The transponder should be mounting so that it doesn't rotate rapidly. Consult the Seatrac USBL users manual for more details.

Figure 3.6: Rig the topside USBL transponder by connecting its data and power cable.

7. Connect the USBL data power cable to a laptop via a serial-to-USB converter.
8. Connect the USBL data cable to a 12V supply or included battery.
9. Start the Seatrac tools application and connect to the USBL beacon by setting

the correct COM port and selecting 115200 baud communications. Click ‘Open’ to verify that the USBL beacon is working (Figure 3.7).

10. Connect the Starfish GPS receiver to the laptop and ensure it has a clear view of the sky. Run the application ‘GPSinfo’ included with the SeaTrac Tools and allow it to calculate a fix based on the GPS constellation. This should take no more than 5 minutes. If a fix cannot be made, the GPS receiver may be in a poor location for signal reception.
11. Disconnect the data cable from the battery to save power if needed.

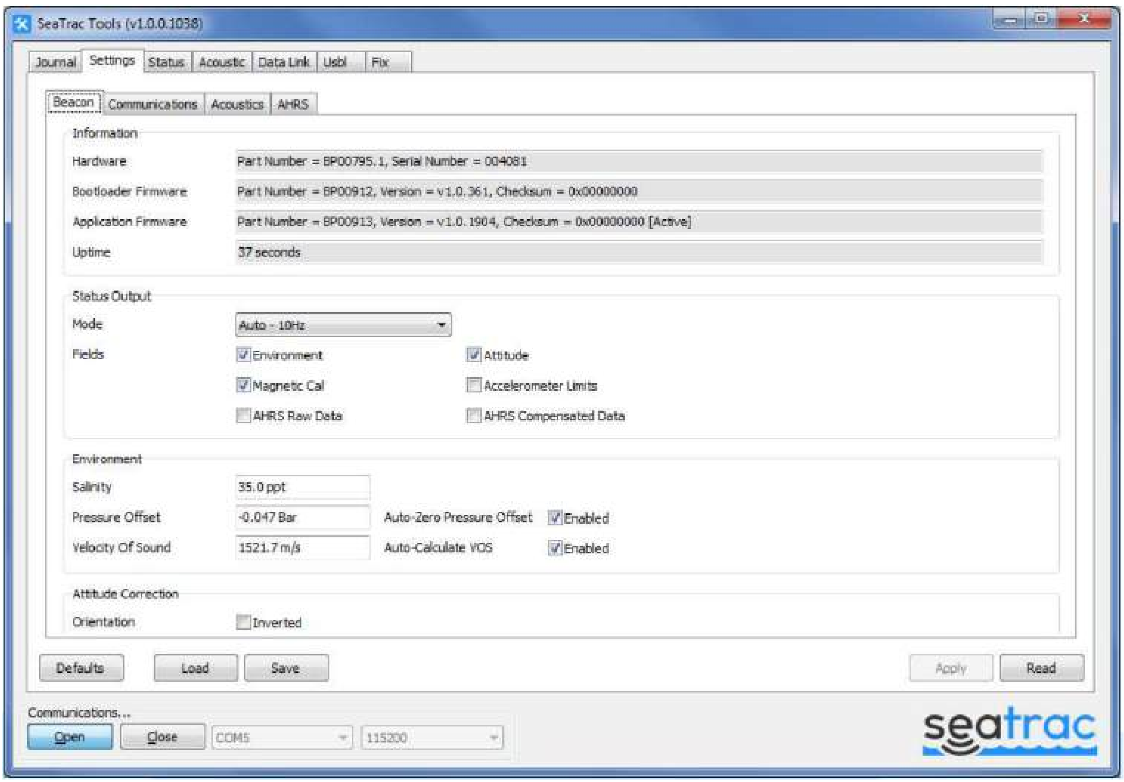


Figure 3.7: A screenshot of the SeaTrac Tools application used to verify that the USBL is working properly.

3.3 Ballast Adjustment

The Drifter platform contains a buoyancy engine which allows the vehicle to traverse the water column vertically. Depending on the volume of payload the Drifter buoyancy engine should have sufficient adjustable volume to achieve depths down to 2000 m and allow sufficient freeboard at the surface to lift radio antennas to be above water line. The engine adjusts the volume of the system by pumping oil to an external reservoir. Pumping fluid into the external reservoir effectively increases the platform volume causing the vehicle to travel toward the surface and pumping fluid out of the reservoir causes it to dive. Effectively this volume adjustment causes the platform to change its density. When the platform density matches the local density the platform will hover in the water column. The engine control system will automatically adjust the engine volume by monitoring the motion and depth of the platform. Because the system has a finite amount of adjustable volume, it is recommended that at the beginning of any Drifter project the user should adjust the ballast of the system by adding or removing weights from the system. Sea-water density increases with depth (Figure 3.8), this will have the effect of making the Drifter more buoyant as it gets deeper. For that reason, it is preferred that the platform be ballasted slightly negative.

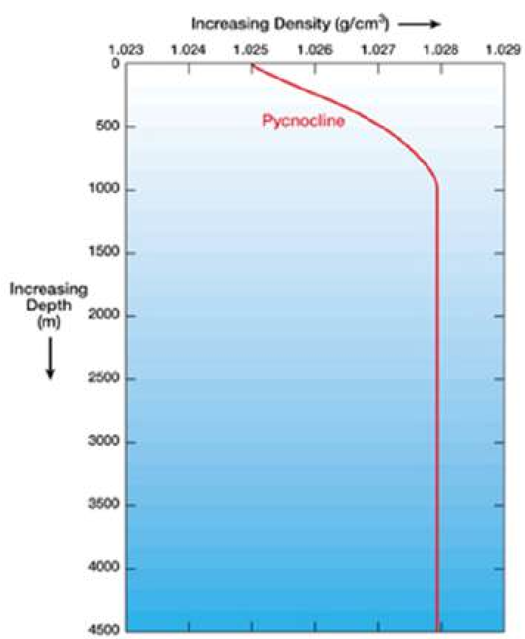


Figure 3.8: Ocean density increases with depth. The Drifter must be ballasted so that it can reach desired depths.

Ballasting the platform involves first setting the adjustable volume to approximately half of its full range and starting with the platform on the surface adding weight until the platform starts to sink in seawater (or water with a known density). Additionally ballast weight should be added so that the platform remains trimmed for floating vertically on the surface. Please use the following procedure to set the ballast on the platform:

1. Set the platform vertically on level ground. The platform utilizes an internal oil sensor which weighs the oil to measure the oil displaced.
2. Connect the Charge cable to the Drifter's Charge port and remove the magnet switch to start the platform in Configuration mode
3. Connect an ethernet cable to the platform.
4. Start the Drifter platform by removing the magnet from the magnet switch holder and wait 1 minute for the platform to start up.
5. Start a PuTTY session and connect to the platform via the Ethernet cable using the Drifter's IP address 192.168.9.1
6. Log into the platform with the following credentials.
    a. User: ssr
    b. Password: Jameswebb18-
7. Start the Drifter terminal to allow direct command control of the buoyancy engine by typing 'drifterterm' and press enter to start the terminal program and press 'p' to enter the engine terminal interface.
8. Press 'p' to toggle the buoyancy engine pump to ON.
9. Pump all of the oil into the external reservoir of the engine by using the command 'w255 200000'. The pump will start transferring oil from the internal reservoir to the external reservoir to increase the platform volume.
10. Monitor the "Internal Volume XXXX mL" by repeatedly pressing the 'd' <enter> command to display the updated system status. The internal volume will slowly decrease at around 0.5 mL/s until all the oil has been pumped out of the internal reservoir. This process may take 90 minutes.
11. When the internal volume is no longer decreasing, tare the internal oil weight sensor by pressing 'c' <enter>.
12. Set the estimated external volume to 2800 mL by using the command 'w383 2800' <enter>.
13. Pump around 1400 mL to the internal reservoir by entering the command 'w382 1400'. This will start a routine which pumps until the external estimated volume reaches 1400 mL.
14. When the routine is complete verify that the internal volume is within 100 mL of 1400 mL by pressing the 'd' command.
15. If the internal volume is more than 100 mL from the 1400 mL target:
    a. type 'w255 200000' to reduce the internal volume.
    b. type 'w255 -200000' to increase the internal volume
    c. monitor the adjustment by repeatedly pressing 'd' <enter> and checking the last line "Internal Volume XXXX mL".
    d. When 1400 mL has been achieved type 'w255 0' to stop the pump.
16. The Drifter buoyancy engine is now set for approximately half its adjustable volume, exit the terminal program by pressing <CTRL + A> and then 'X'. Press <Enter> to shut down the Drifter GPC.
17. Replace the magnet switch in the Drifter to turn it off.
18. Remove the electrical cables and replace dummy connectors in preparation for

immersing the platform in the water.

19. Carefully lower the Drifter into seawater in a calm place near a dock or a pool (freshwater or known density).
20. Record the local density. Electrochemical based density measurements can fail in brackish water and it is recommended to use a hydrometer.

Figure 3.11: A hydrometer provides a true density measurement over a large range of water densities with adequate accuracy and resolution.

21. Lightly tie the platform off so that it can float more or less freely.
22. Add lead or steel weights (or weights with known mass and density) to the top of the Drifter until it starts to submerge (Figure 3.12).

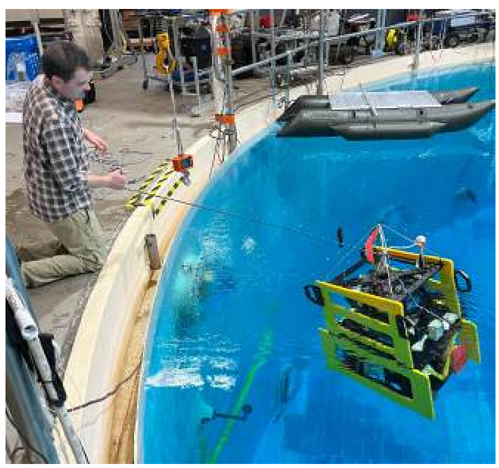


Figure 3.12: With the Drifter in the water add ballast until the platform begins to sink.

23. Remove the weights from the Drifter, set them aside, and pull the Drifter out of the water.
24. Attach the weights previously set aside to the bottom of the Drifter frame securely to maintain a low center of gravity.
25. If possible weigh the platform correctly ballasted which will allow an accurate

volume and mass for the platform for later ballast adjustments.

Figure 3.13: A crane scale can be used to get an accurate mass and volume for the Drifter platform after it has been ballasted to neutral in a known water density.

26. Connect the Drifter to a computer and put it in terminal mode again as was done previously with the ‘drifterterm’ command.
27. Pump all the oil out of the Drifter by using the command ‘w382 2800’
28. Wait until the process is complete.
29. Prepare the Drifter to be put back in the water by covering all connectors.
30. Place the Drifter in the water and ensure that it floats.
31. Ensure that the platform is floating upright and trim as needed by adjusting the ballast position near the bottom of the platform.
32. Remove the emergency drop weight and check that the platform floats upright with the attached payload and ballast alone.
33. Additional weight and floatation may be required if the platform is unstable on the surface to maintain a center of buoyancy center of gravity separation with and without the emergency drop weight.

After the platform has been ballasted and trimmed no additional adjustments should be required unless the payload has been adjusted. The platform has a large adjustable volume which should adequately correct for large swings in water density. If desired the platform ballast can be corrected based on changes in local density and logged engine data. MATLAB tools have been provided for calculating ballast adjustments based on the data logged from dives or measurements of local seawater density. These tools can be found in the Drifter github repository.

https://github.com/Second-Star-Robotics/Drifter-GPSP-Support-Repository.git

4. PROGRAMMING

The Drifter utilizes a dedicated low-power microprocessor which reads and logs all sensors, commands subsystems, and controls power distribution within the vehicle. Called the buoyancy engine controller, it is configured prior to a dive with a series of registers which allow the operator to set up its device ID, mission duration, depth profile, and GPC behavior during the mission. Most registers come factory pre-programmed but it will be necessary for the operator to set some settings depending on the requirements of the specific dive. The basic behavior of the system is governed by a state machine shown in Figure 4.2. Initialization occurs when the Drifter is powered by removing the magnet switch, Pre-Mission allows the vehicle to wait for a certain amount of time before beginning operations (ie. time to physically deploy it in the water after startup), during the Mission state machine the platform controls depth and collects data. The Post-Mission state occurs when abort time or certain safety thresholds have been exceeded and will cause the platform to release the emergency drop weight and return to the surface for recovery. The Interface state is enabled by plugging in a Charge cable which is detected on power up and to be configured and data to be downloaded from the platform.

Figure 4.1: The buoyancy engine controller utilizes a low-power microprocessor to control platform functions including task schedule, depth control, and communications.

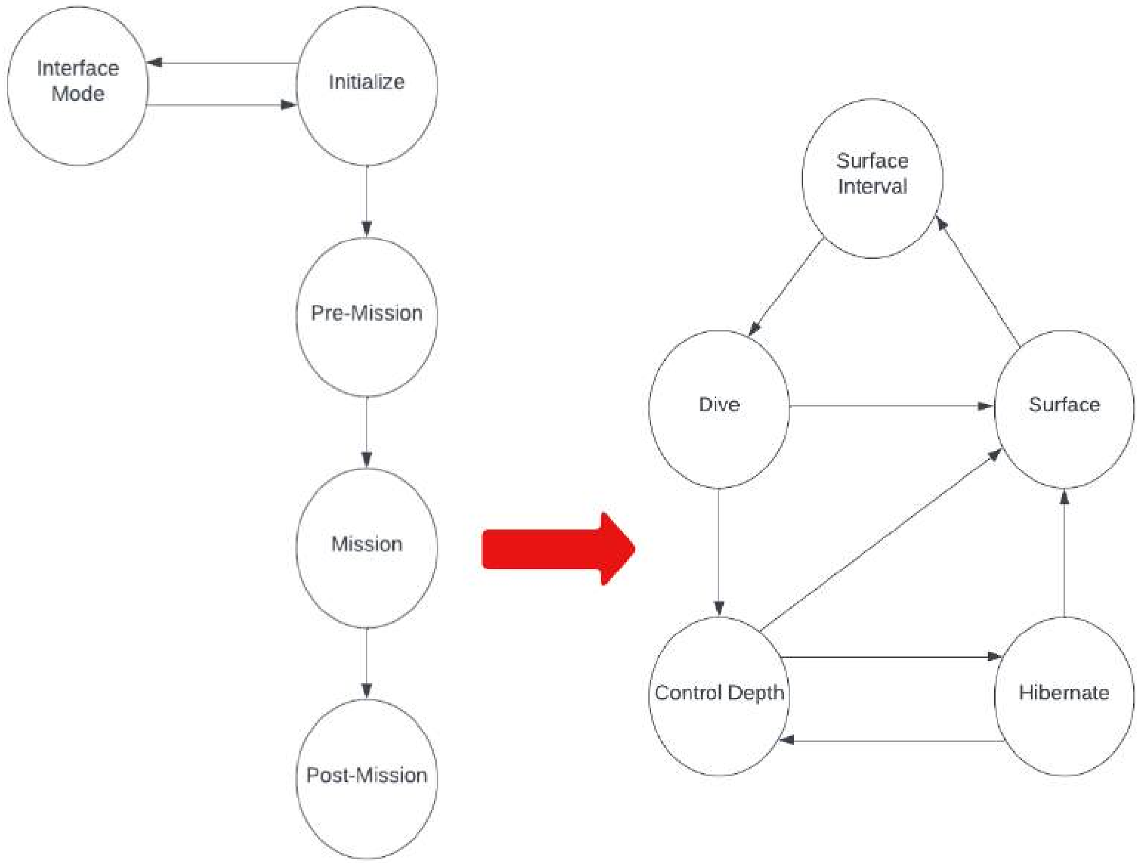


Figure 4.2: The overall behavior for the Drifter is governed by a state machine. It is divided into seven high level parent states: initialize hardware, interface, pre-mission, mission, post mission, and shutdown. Within the 'Mission' the dive behavior is controlled.

During the Mission State the Drifter is governed by a circular state machine (Figure 4.2 right) which allows the platform to dive, control depth, hibernate at depth, surface, hibernate on the surface (surface interval), and then repeat. Surface intervals and depth setpoints and translation velocities are preprogrammed in the Interface Mode as registers. A detailed description of this state machine is provided in the section *2.3 Depth Control System*

Most registers involve setting timing for when these events occur off a reference time called mission start time when the vehicle begins its mission after the pre-mission timer has expired. Programming is done with the Charge and Ethernet cables and a laptop computer running a graphical user interface as well as the PuTTY session.

4.1 Platform Configuration Registers

Platform behavior is configured by a series of registers which allow the system to carry out pre scheduled tasks as well as handle fault situations during the course of a dive. These registers are listed in Table 4.1 and are primarily grouped in the following categories, mission timing, sampling configuration, scheduled depth setpoints, scheduled velocity setpoints, scheduled surface intervals, maximum depth settings, low battery settings, and depth control settings. These settings can be configured via a graphical user interface or a terminal program. See Appendix A for a comprehensive list of platform registers.

Table 4.1: Platform Configuration Register Categories

Register Category	Register or Range	Description
Device ID	1	Device ID number for addressing the platform.
Pre Mission Timer	3	Setting for the number of seconds to delay start of Mission after the magnet is removed.
Mission Abort Time	5	Setting for the number of seconds until the emergency drop weight is released
GPC Sampling Timing	9-15	Configures timing for turning on sensors and the GPC during the dive.
Depth Setpoint Timing	20-34	Specifies the start times for associated depth, and velocity setpoints.
Depth Setpoints	256-270	Sets the depth setpoints in floating point values for depth setpoints in m.
Velocity Setpoints	271-285	Sets the maximum absolute velocity that the platform will achieve to the next setpoint in m/s.
Surface Interval Timing	35-44	Defines the start times for surface intervals during the mission.
Surface Interval Duration	45-54	Sets the duration of surface intervals associated with Surface Interval Timing.
Depth Triggers	59-61	Settings for configuring Abort if depth exceeded.
Battery Triggers	95-97	Settings for configuring Abort on low battery.
Mission Termination and Release	126-128	Settings for controlling the emergency drop weight release functionality.
Real-Time Clock Settings	129-132	Manages real-time clock settings like DST, time zone, and mission start/end times.
Sensor 1 and GPC Event Windows	153-165	Configurations to allow the GPC or Sensors to turn on based on a time of day window.
Sensor 1 and GPC Event Window Timings	180-205	Specifies on/off timings for Sensor 1 and GPC events based on the Mission clock.
GPC Sensor Synch	204-205	Settings to allow Sensor 1 to turn on after the GPC with a specified delay.
Depth Control Parameters	299-349	Configures depth controller parameters.
Dive State Control	360-367	Manages thresholds and state control parameters for dive, surface, and hibernate states.

4.2 Graphical User Interface

A graphical user interface called the Drifter Configuration Editor has been created to allow the user to save, load, apply, fetch Drifter and edit configurations used to govern platform behavior. Settings are saved in .cfg files (Figure 4.3). The GUI allows the user to load and edit configuration files on a personal computer, save them for future use or documentation purposes, apply them to the platform, and fetch and view them from the platform. These are organized as json files and can be modified with a text editor if needed.

Registers can be viewed by loading a configuration file from the Documents folder on the computer or fetching settings from the Drifter platform. The scroll wheel can be used to scroll up and down through the list of settings. By double clicking on a register's value, a new value can be typed in, and entered using the Enter key. Register settings can also be manually changed by running the Drifter Terminal program (see section *4.3 Drifter Terminal*).

It is recommended that a configuration file for each dive performed be named and saved locally on the computer for documentation purposes.

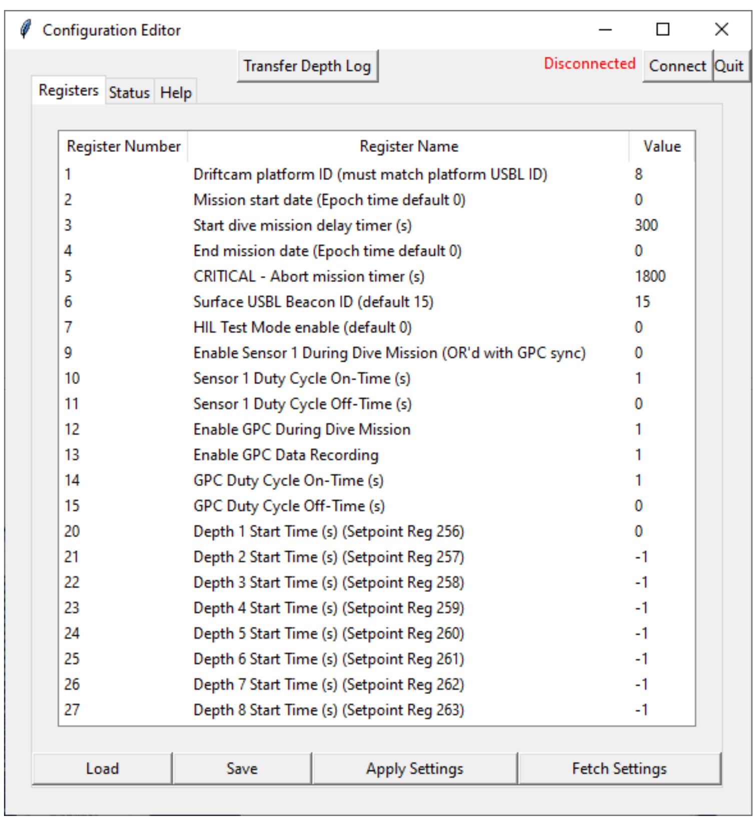


Figure 4.3: A graphical user interface has been created to allow the user to edit settings, save them for later, apply them to the platform, or fetch them from the platform.

The Configuration Editor also allows the user to view current platform sensor status as well as control the buoyancy engine pump in (Figure 4.4). Commands include “Pump In” to decrease adjustable volume, “Pump Out” to increase adjustable volume, “Stop Pump” to stop the pump, and “Tare Volume” to zero the internal oil sensor at the current level.

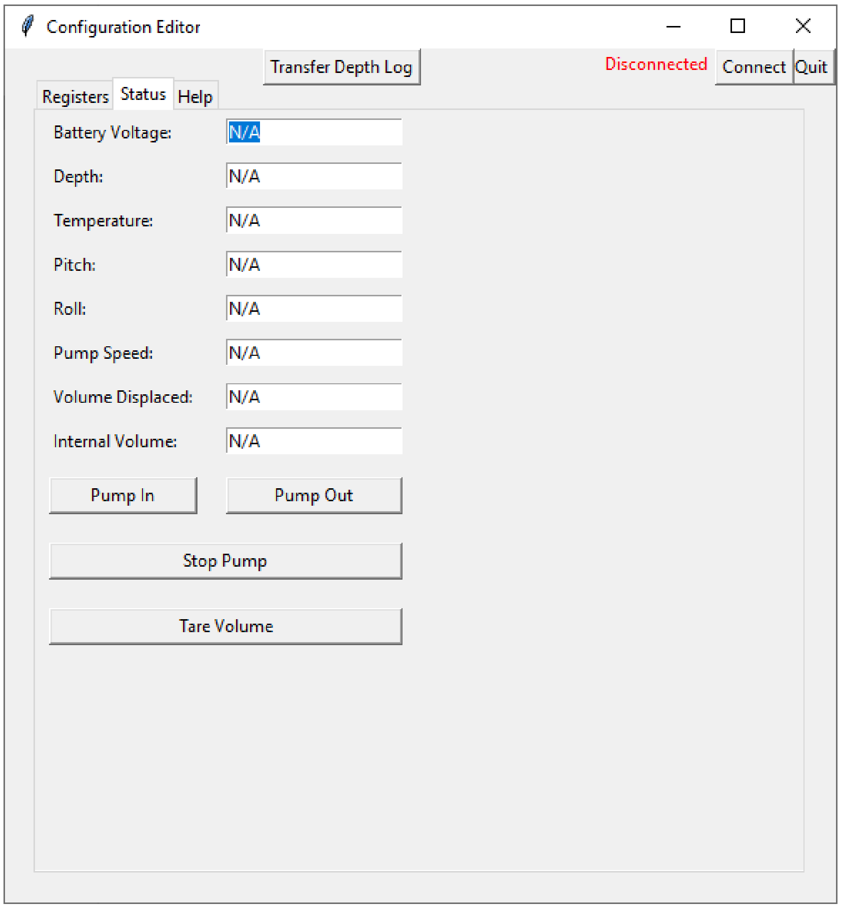
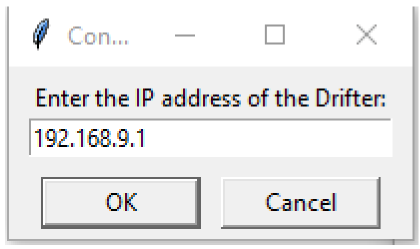


Figure 4.4: The Status Tab allows the user to view Drifter configurations and control the buoyancy engine pump.

When in Configuration Mode the Drifter platform acts as network attached storage which can be mapped as a normal networked disk drive. This drive can be accessed by mapping the network drive \\192.168.9.1\sambashare to a drive in Windows (username: ssr, password: Jameswebb18-). The Configuration Editor also allows the user to generate a depth log saved by the buoyancy engine controller into a .csv file which can be copied from the platform. After clicking Transfer Depth Log the depth log will appear as a .csv file on the network attached drive (note this process could take several hours depending on the datalog length).

To connect the Configuration Editor to the Drifter please follow the procedure:

1. Starting with the Drifter's magnet switch installed and the platform depowered. Connect the Charge cable to the Drifter's charge bulkhead.
2. Connect the Ethernet cable to the ethernet bulkhead and a laptop computer running the Configuration Editor.
3. Turn on the Drifter by removing the magnet switch and wait 1 minute for the platform to boot up in Configuration mode.
4. Start the Configuration Editor by executing the application Drifter-Configurator.exe.
5. Click Connect in the top right corner of the application and enter the platform's IP address 192.168.9.1 and click <Okay>.



6. The connection status in the top right corner of the application should change from "Disconnected" to "Connected". You are now ready to use the Configuration Editor.
    a. If the platform does not connect to the Configuration Editor check cables and restart the platform with the magnet switch leaving adequate time for the platform to start up.

To shut down the Drifter after Connecting with the Configuration Editor follow the following steps:

1. Starting with the Drifter on and the Configuration Editor connected click <Quit> on the top right corner of the Configuration Editor application window.
2. Replace the magnet switch on the Drifter platform and observe the status lights turning off.
3. The Configuration Editor is now disconnected and the Drifter is off.

4.4. Drifter Command Terminal

An alternative method to configure the Drifter is through the Drifter Command Terminal. This allows configuration of all registers that can be set through the GUI as well as a number of commands for manually adjusting the platform's adjustable volume, testing sensors, setting the onboard clock/calendar, and power or depowering platform systems. The Drifter Terminal is a command line interface that allows direct communication with the microprocessor that controls the engine. A screen capture of the command interface is shown in Figure 4.5.

```
Drifter Controller Interface

Second Star Robotics
Version    : 3.19
Build Date : May 17, 2024
Hardware   : Rev2
Data Status: Not Downloaded
System Time: Mon Jun  3 10:15:42 2024

Commands:
    'r' = Return a register value ("r <ADDRESS>")
    'w' = Write a value to a register ("w <ADDRESS> <VALUE>")
    'd' = Display system status ("d")
    'a' = Toggle Payload Voltage 1 ("a")
    'b' = Toggle Payload Voltage 2 ("b")
    'p' = Toggle Pump Power ("p")
    'v' = Toggle Data Record ("v")
    'c' = Tare Engine Volume ("c")
    't' = Firmware Test ("t")
    's' = Start Mission ("s")
    'q' = Restart Terminal Interface ("q")
>>
```

Figure 4.5: A screenshot of the Drifter Command Interface. This interface allows direct control of a number of Drifter functions currently not available in the Drifter Configuration Editor GUI.

Table 4.2 shows the available commands and how they are used. Commands can be entered after the '>>' prompt. Once <Enter> is pressed the command is executed. Back space can be used to delete and revise command text.

Table 4.2: Drifter Interface Commands

Command	Description	Key Sequence
Read a Register	Return a register value by address from the Drifter registers.	‘r <address number> ‘
Write a Register	Set a register value by entering that register's address and updated value.	‘w <address number> <value>
Display System Status	Return the current status of the Drifter platform by echoing the following: ● System Date/Time ● Epoch Time in Seconds ● Depth in Meters ● Temperature in Degrees C ● Valve Index State ● GPC Power State ● GPC Idle State ● Battery Value in AD Counts ● Battery Voltage in Volts ● New Depth Acoustic Command Flag ● New Depth Setpoint ● New Abort Time Acoustic Command Flag ● New Abort Time ● Platform Pitch in Degrees ● Platform Roll in Degrees ● Platform Yaw in Degrees ● Engine Flow Rate in mL/s ● Previous Pump Encoder Position in Counts ● Pump Encoder Position in Counts ● Pump Displaced Volume in Counts ● Estimated Volume Displaced in mL ● Measured Internal Volume in mL	‘d’
Toggle Sensor 1 Power	Toggle the power state of Sensor 1	‘a’
Toggle Sensor 2 Power	Toggle the power state of Sensor 2	‘b’
Toggle Pump Power	Toggle the power state of the engine pump.	‘p’
Toggle GPC Data Recorder	Toggle a command flag to tell the GPC to record serial data.	‘v’
Tare Engine Volume	Tare the internal oil sensor. Note: Drifter must be vertical and level (ie. roll and pitch < 5 degrees)	‘c’
Firmware Test	Reserved command for firmware development and diagnosing.	‘t’
Start Mission	Start the current Drifter mission. Primarily for bench testing and not recommended for field deployment.	‘s’
Restart Terminal	Restart terminal interface and display command list	‘q’

To start the Drifter Command Interface terminal the user should use PuTTY or some other appropriate application for terminal emulation. PuTTY can be downloaded from putty.org. The following procedure can be used to connect to the Drifter Command Interface:

1. Connect the Charge cable to the Drifter’s Charge port and remove the magnet switch to start the platform in Configuration mode
2. Connect the Ethernet cable to the platform.
3. Start the Drifter platform by removing the magnet from the magnet switch holder and wait 1 minute for the platform to start up.
4. Start a PuTTY session and connect to the platform via the Ethernet cable using the Drifter’s IP address 192.168.9.1 and click <Open>.

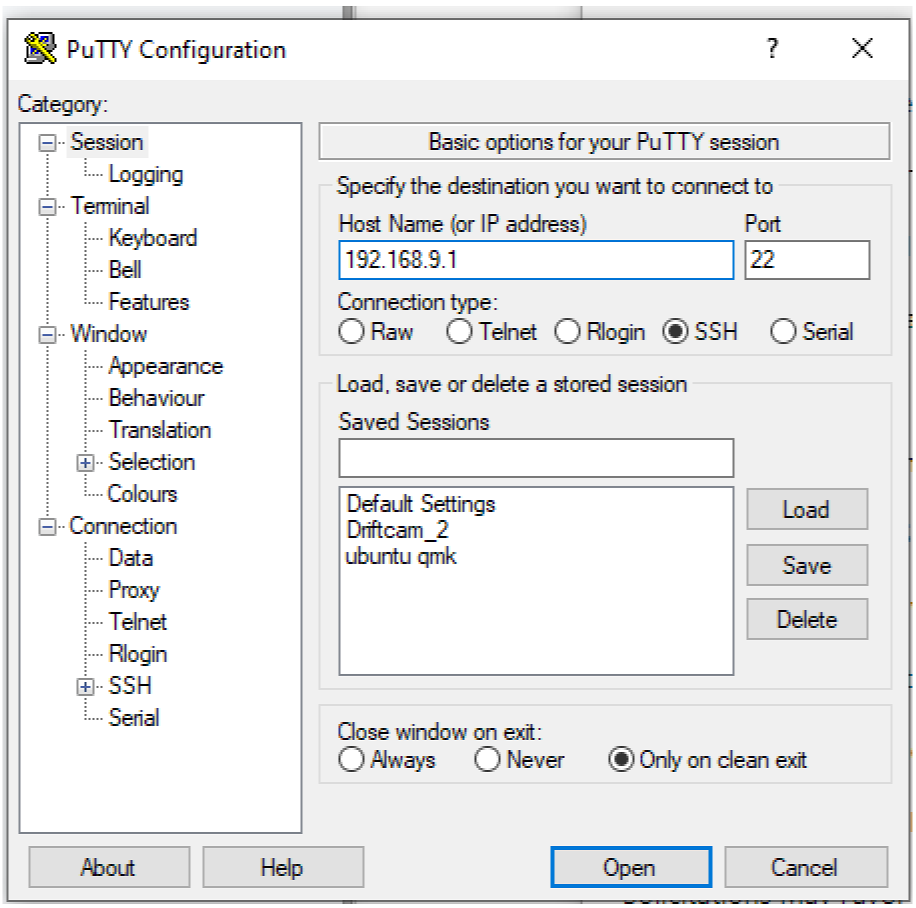


Figure 4.6: The PuTTY terminal is used to connect to the platform via the SSH protocol.

5. Log into the platform with the following credentials.
   a. User: ssr
   b. Password: Jameswebb18-
6. Start the Drifter terminal to allow direct command control of the buoyancy engine by typing ‘drifterterm’ and press enter to start the terminal program and press ‘p’ to enter the engine terminal interface.
7. Enter terminal commands as needed.
8. To exit drifterterm press <Ctrl> + <A> and then <X> followed by <Enter>
9. Press <Enter> after exiting to shut down the platform and replace the magnet switch to depower it.

4.5 Designing a Profile

A number of configuration registers are dedicated to pre-scheduling dive behavior including surface intervals, controlled velocity profiling, hovering, and landing. The platform will retain the program over the course of multiple deployments, and can be restarted by simply shutting the platform down with the magnet and removing it to restart the preprogrammed mission.

An example depth log of a 74 hr deployment is shown in Figure 4.7 top curve. The platform dives to an initial setpoint of 100 m and hovers for 48 hrs performing a four hour surface interval and diving to a new setpoint of 250 m hovering for another 10 hrs before the galvanic timed release dissolves and causes the platform to surface where it is recovered at 74 hrs. The log of the platform state is shown in Figure 4.7 middle indicates dive state behavior over the course of the dive and the bottom curve indicates when the buoyancy engine was powered and actuating.

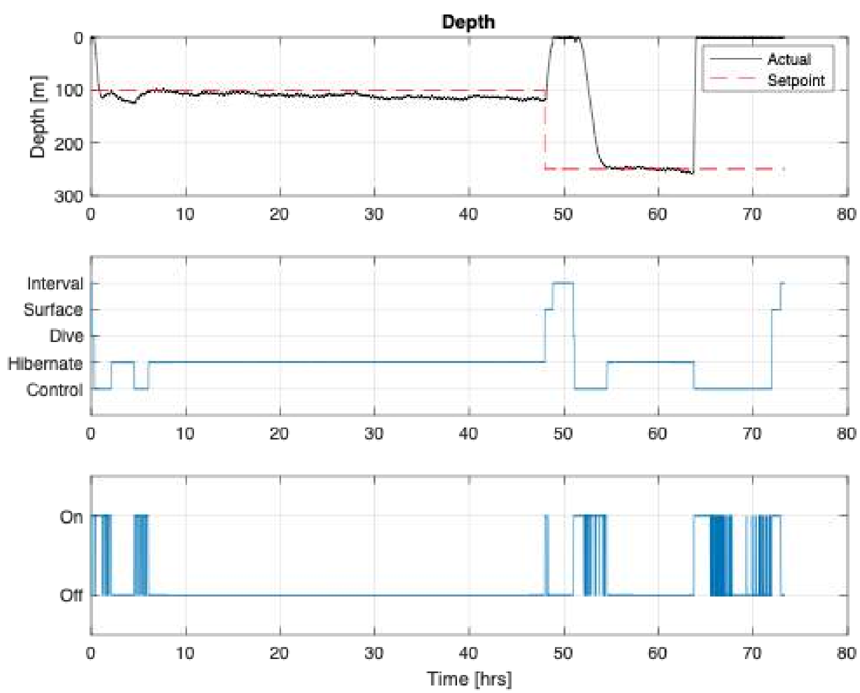
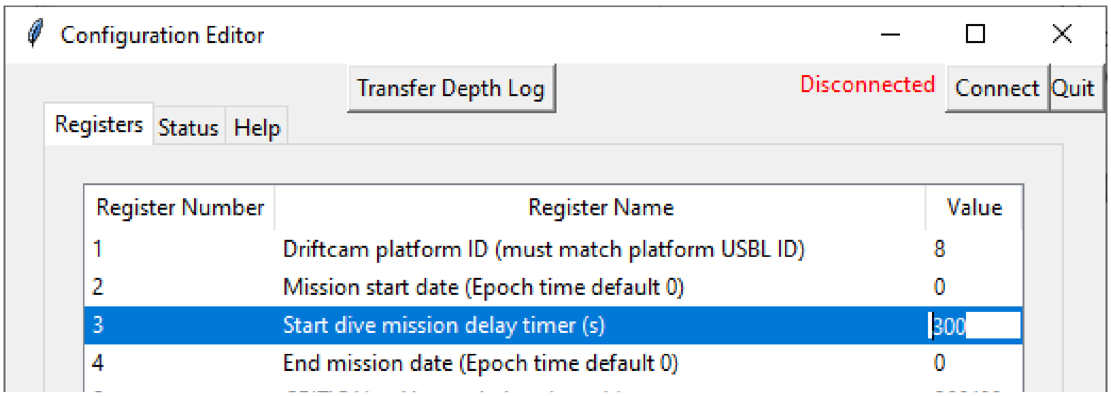


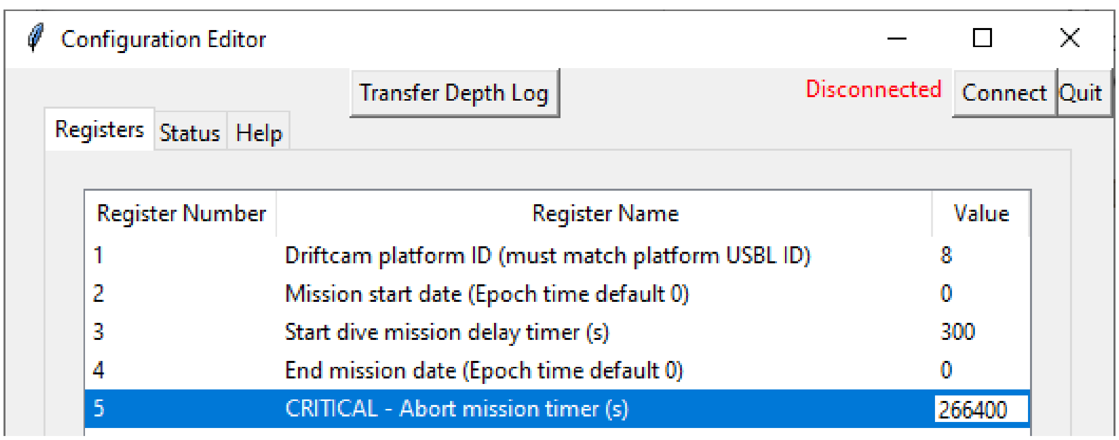
Figure 4.7: An example depth log showing the platform diving to 100 m and hovering for 48 hrs followed by a surface interval and then a second dive to 250 m ending with a rapid ascent (after the GTR released the drop weight).

This profile can be recreated by setting registers which control timing, depth setpoints, and surface intervals. To recreate the dive shown in Figure 4.7 use the following procedure:

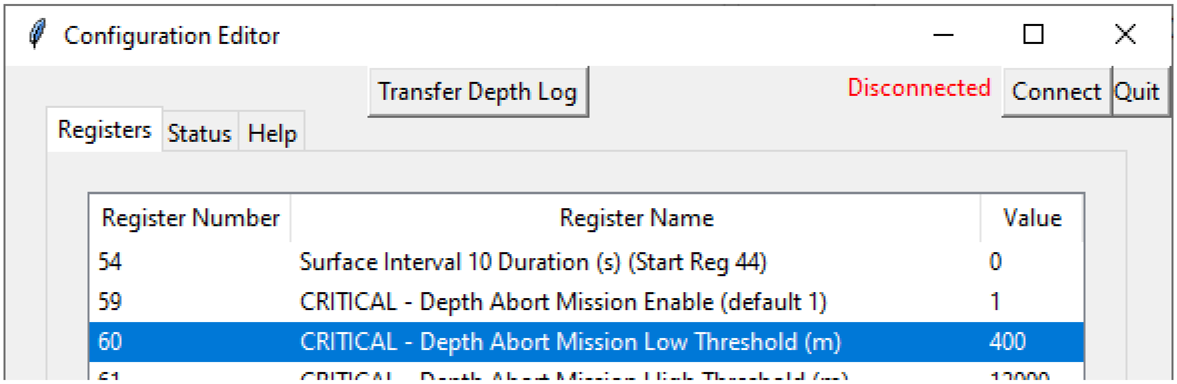
1. Set a pre-mission delay timer of 5 minutes to allow time for the platform to be deployed and released before beginning a dive. It is recommended that this timer be set long enough so that the platform initially spends some time in pre-mission before beginning to attempt to dive.



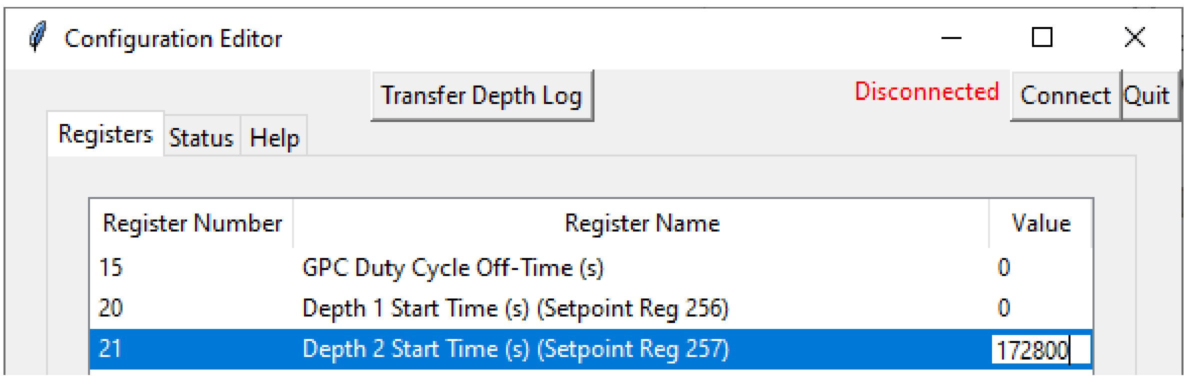
2. Set the end of mission Abort Time duration to 74 hrs or 266400 s by setting register 5.



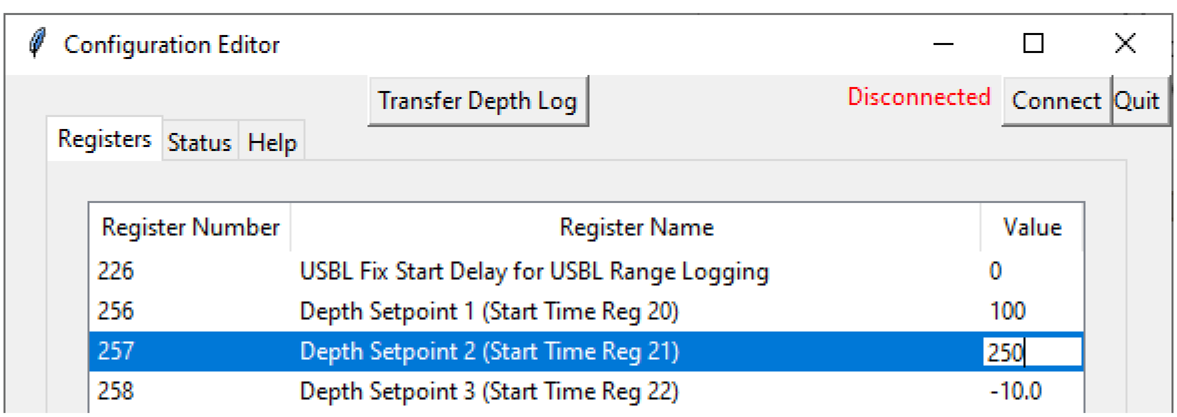
3. Set the maximum abort depth to 400 m to allow the platform to drop the emergency drop weight in the case the platform exceeds 400 m. This should be selected based on local bathymetry as well as pressure tolerances for onboard sensors. It is recommended that the abort depth be set no shallower than 100 m deeper than the maximum planned depth in consideration of any overshoot when attempted to achieve the depth setpoint. Ensure that register 59 is set to 1 to enable abort depth functionality.



4. Schedule the initial depth setpoint/velocity to 0 s (reg20) and the second depth/velocity setpoint for 48 hrs or 172800 s. All other scheduled start times should be set to -1 to disable them.

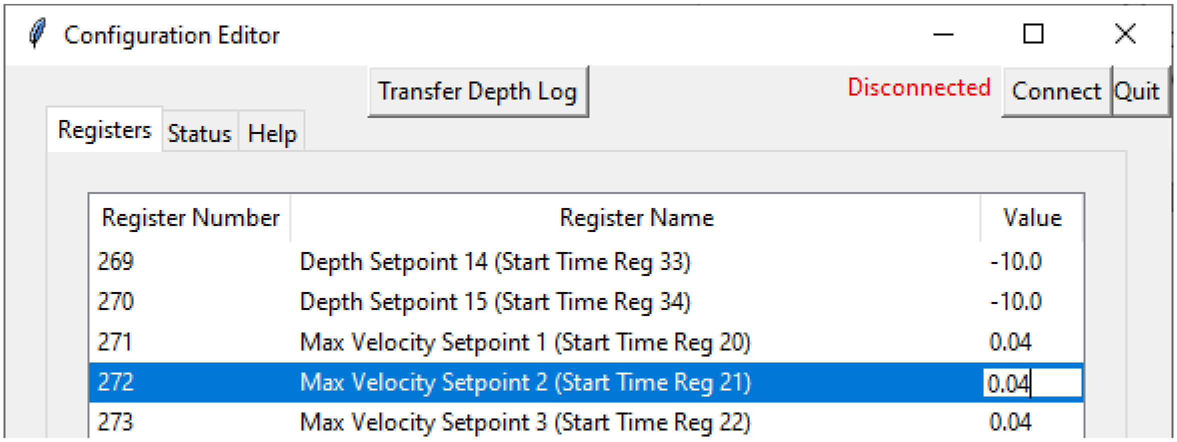


5. Set the associated depth setpoint values for depth Setpoint 1 and 2 by setting register 256 to 100 and register 257 to 250. All other depth setpoints should be set to -10 m.

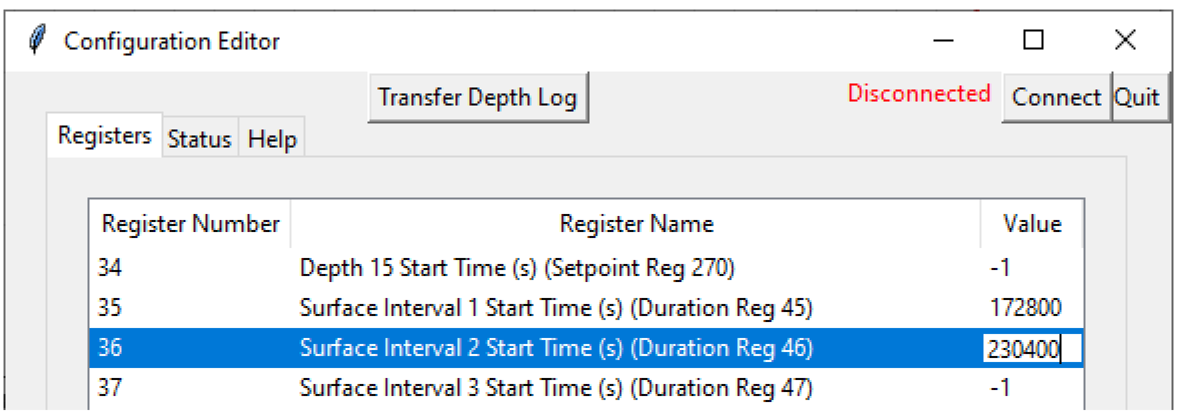


6. Set the max velocities for the scheduled depth setpoints. 0.05 m/s is recommended Depending on platform drag velocities up to 0.2 m/s can be achieved with some experimentation. Consult with SSR if velocities higher than

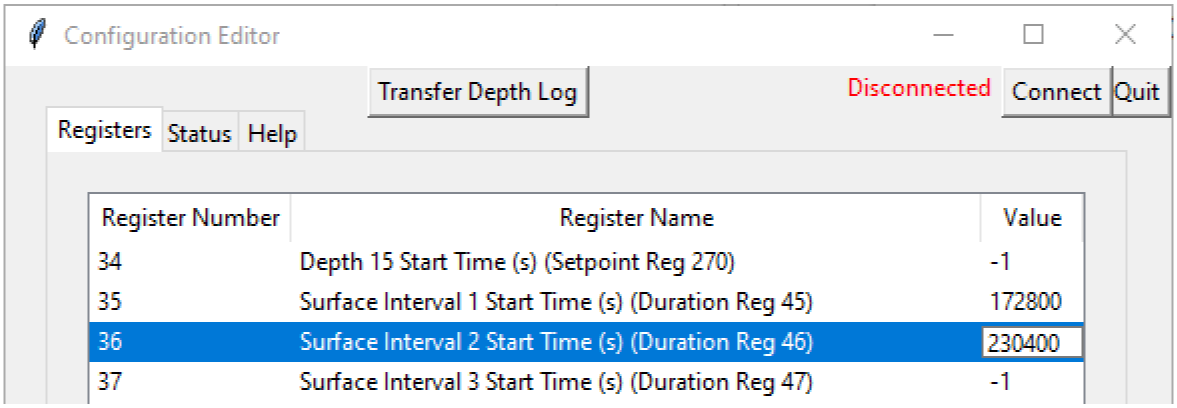
0.05 m/s are desired. In this case we will select 0.04 m/s or 4 cm/s as our maximum vertical velocity by setting registers 271 and 272 to 0.04.



7. Schedule two surface intervals one at 48 hrs to obtain a mid-dive location fix and one at 64 hrs to allow for a planned recovery window before the weight is dropped. Set the surface interval start time (register 35) to 172800 s and set the surface interval 2 start time (register 36) to 230400. All other surface interval start time registers should be set to -1.



8. Set the Surface Interval 1 Duration (register 45) to 4 hrs or 14400 s and set the surface interval 2 duration (register 46) to 10 hrs or 36000 to allow sufficient time for platform recovery before the emergency drop weight is dropped. All other surface interval durations should be set to 0.



9. Save the settings locally to your hard drive using the Save button. Select a name (eg. 24May21-Deployment1.cfg) and press <Enter>.
10. To evaluate what the profile will look like a function called plot_dive_profile has been created for the MATLAB computation environment to load and view profiles created by the configuration editor. This tool is included with the Drifter support repository.

https://github.com/Second-Star-Robotics/Drifter-GPSP-Support-Repository.git

```
>> help plot_dive_profile
  Plot a notional dive profile using settings from a JSON file
  INPUTS:
    json_filename: path to the JSON file with drifter settings
    deploy_time: (optional) deployment time to set the x-axis in terms of time
                 otherwise, it will be in hours
  OUTPUTS:
    None:plot
```

   a. To plot the previously created dive profile copy the .cfg file to the to directory containing the function plot_dive_profile.
   b. Set the planned deployment time as a datetime structure.
      eg. magnet_time = datetime(2024, 5, 21, 10, 0, 0) for May 21, 2024 at 10am.
   c. Run the function by passing the cfg filename and the datetime to plot_dive_profile. eg. plot_dive_profile('24May21-Deployment1.cfg' , magnet_time).

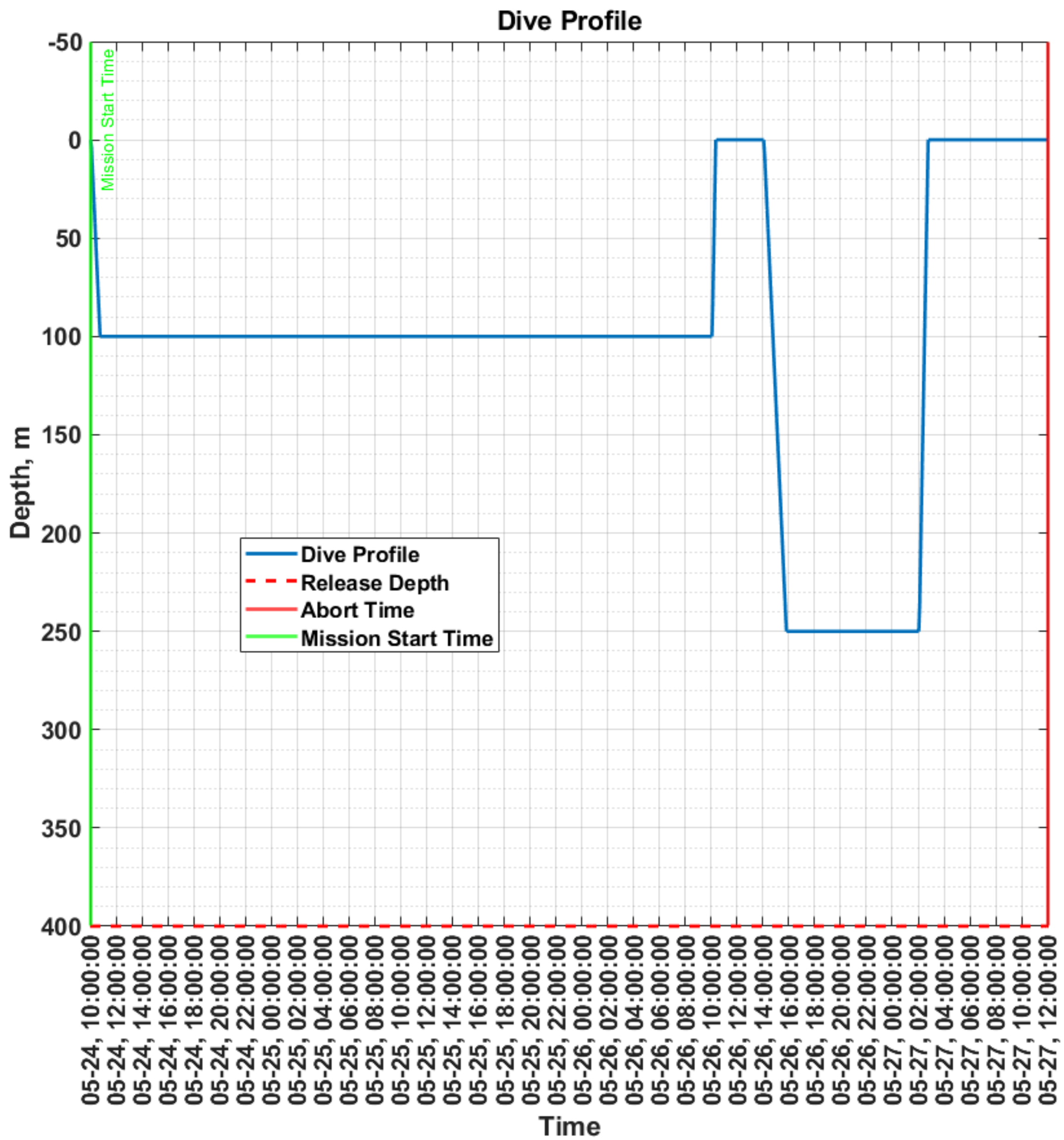


Figure 4.8: The resulting plot generated by plot_dive_profile.m indicates the expected behavior of the platform during the dive, roughly matching the behavior seen in Figure 4.7

By setting platform registers nearly any profile type can be created for example Figure 4.9 shows a bounce profile created by setting a depth setpoint of 700 m (reg. 256) and scheduling a series of 0 s five duration surface intervals every 8 hrs and a final 6th surface interval to allow a 3 hour recovery window before the emergency drop weight is released.

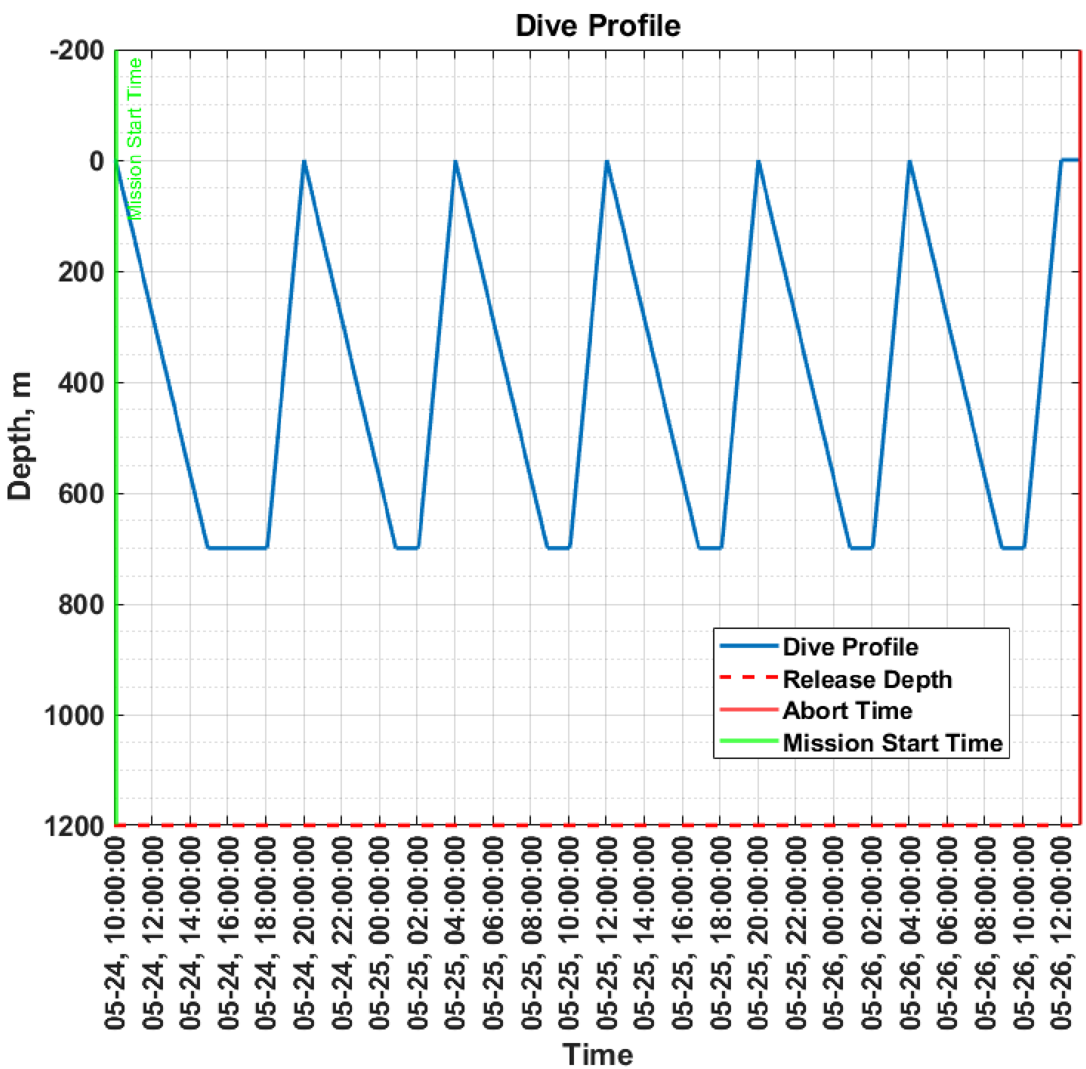


Figure 4.9: A series of six bounce profiles generated by selecting a 700 m depth setpoint and scheduling 5 surface intervals with zero duration and a 6th one with a 3 hour recovery window.

4.6 Failsafe Settings and Considerations

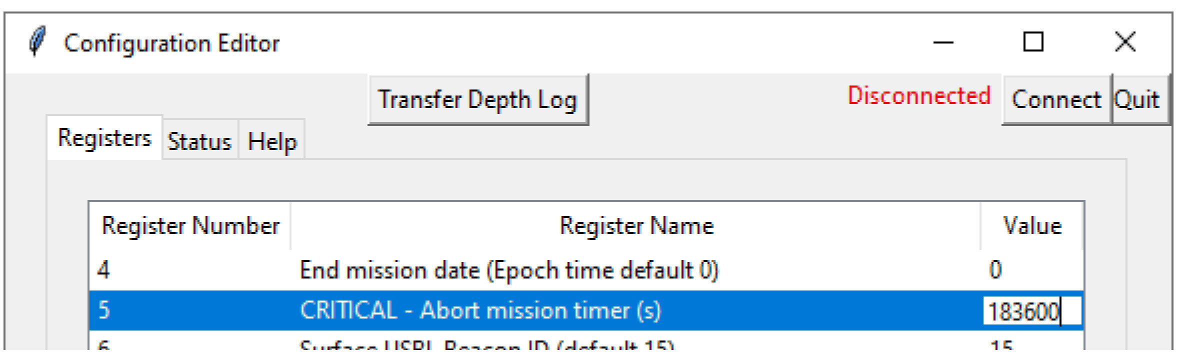
The Drifter GPSP has a series of physical and software failsafes which allow the platform to be recovered in most situations. The platform is physically capable of surviving a dive to 6000 m depth though the engine will only be able to adjust buoyancy to 2000 m. As long as the drop weight is properly rigged and the platform was initially ballasted correctly it should be recoverable even with a full system failure and dive to abyssal depths.

Several CRITICAL failsafe registers will also ensure the platform is easily recoverable in the event of a fault, unforeseen event, or improperly programmed dive profile. These failsafe settings will automatically trigger the weight to drop if the platform exceeds an abort time, depth, or low battery threshold. They should always be used and properly configured during every dive.

If the platform enters Abort Mode it will shut down all sensors and the GPC, release the drop weight, and start pumping all of the oil from the internal reservoir to the external reservoir. It will continue to pump until the battery is dead or the platform is turned off. While in abort mode the platform will no longer respond to acoustic commands but can still be tracked acoustically.

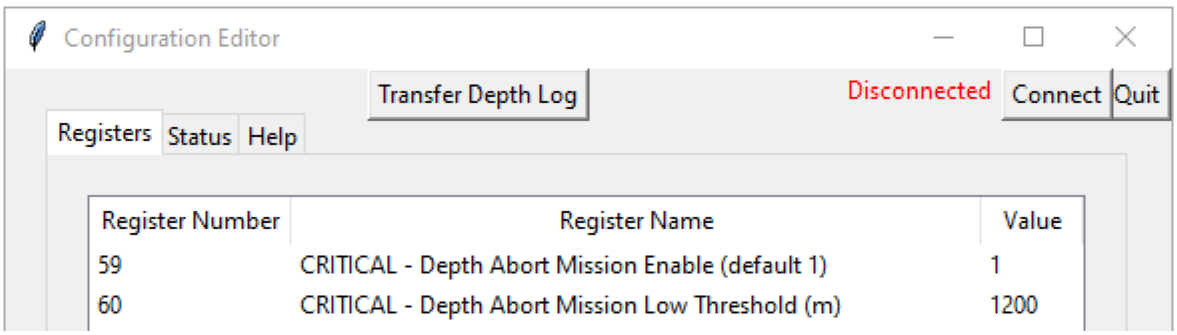
Abort Time

The abort time is the time in seconds from the start of the mission until Abort Mode is triggered. The abort time is always enabled and is set with register 5. The abort time is typically set several hours after a final surface interval is scheduled to enable enough time to recover the platform with the drop weight still attached. When the abort time is exceeded the platform automatically attempts to rapidly surface.



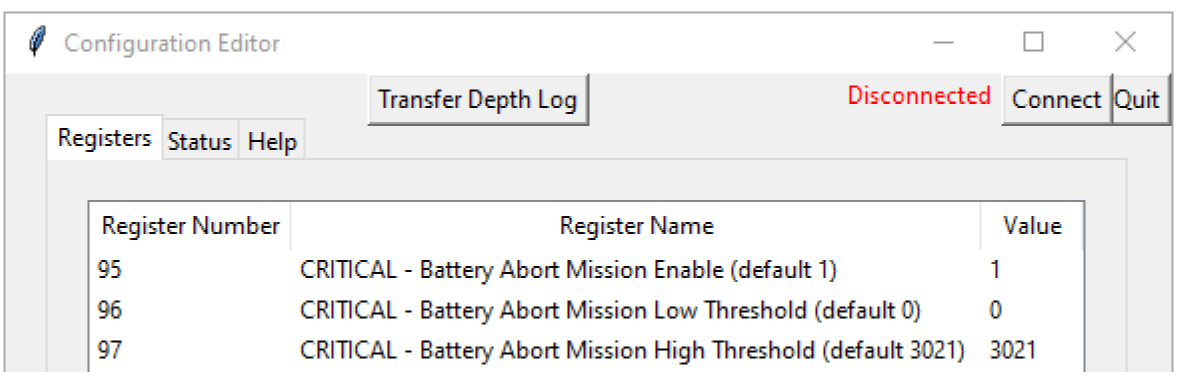
Maximum Depth Abort Threshold

The maximum depth abort threshold is a depth at which the platform will automatically enter Abort Mode in the event the platform dives too deep. This function is enabled by setting register 59 to 1 and setting register 60 to the max depth threshold in meters. The maximum depth threshold should be set with bathymetry and payload depth tolerances in mind. Ensure that the value is set deeper than the deepest setpoint. It is recommended that this value be at least 100 m deeper than the deepest setpoint to avoid triggering an Abort due to an overshoot condition in the depth controller.



Low Battery Abort Threshold

The low battery abort threshold ensures that in the Drifter GPSP will release the drop weight and attempt to surface before the available battery energy is consumed. This has been factory set to an AD count threshold (3021) which corresponds roughly to 33 V and ensures that there is sufficient power to run the burn wire and adjust the platform volume to maximum to ensure recovery. It is set with register 95 and 97 and should always be enabled.



Burn Wire Release Time

Once triggered the burn wire will typically take 4 minutes to release the drop weight. During the operation ionic current flow in seawater will corrode the burn wire and any exposed electrically connected conductive materials. To limit corrosion after an Abort Condition a timer is set to allow the release to burn long enough to release the drop weight but also avoid excessive corrosion caused by a continuously energized circuit. Ensure that the release time is set to 1800 s by setting register 128 to 1800.

Register Number	Register Name	Value
127	Release Depth Threshold (m)	65535
128	CRITICAL - Release Time (s) (default 2800)	2800

4.7 Payload Schedule Settings

During the deployment the GPC and external payload power for sensors can be scheduled to be always on or duty cycled. Additional settings allow the sensor payload to be synchronized to the GPC with a delay to account for boot up time on the GPC.

Sensor Scheduling

The Sensor 1 payload power voltage is provided out of the Sensor bulkhead and can be scheduled using register 9 (set to 1 to enable or 0 to disable), register 10 Sensor 1 Duty Cycle On-Time in seconds, and register 11 Sensor 1 Duty Cycle Off-Time in seconds.

Register Number	Register Name	Value
9	Enable Sensor 1 During Dive Mission (OR'd with GPC sync)	1
10	Sensor 1 Duty Cycle On-Time (s)	1
11	Sensor 1 Duty Cycle Off-Time (s)	0

By setting register 9 to 1 and 10 to 1 or more and register 11 to 0 the Sensor 1 payload voltage will always be on. If duty cycling is desired use the off time and on time.

Sensor 1 can also be synchronized with the GPC with some delay. This feature is useful if you would like to use the GPC for data acquisition and would like to save power while the GPC boots up (usually 1 min process). To use the synchronization feature, disable the sensor duty cycle function by setting register 9 to 0 and enable GPC synchronization with register 207 and set the delay to 60 seconds (if needed).

Register Number	Register Name	Value
206	Sensor 1 Sync to GPC Enable (Or'd with Sensor 1 Duty Cycle)	1
207	Sensor 1 Sync ON Delay Time after GPC ON (s)	60

This will cause Sensor 1 to be powered 60 seconds after the GPC is powered.

GPC Scheduling

The GPC can be scheduled to be on continuously or with a duty cycle. A record flag is set by the platform to command it to record; however this behavior may be modified by the user to enable custom behaviors via scripting. The GPC is enabled during a dive by setting register 12 to 1 (0 to disable), to set the record line to command the GPC to capture sensor data set register 13 to 1 (0 to disable), the GPC duty cycle On-Time is set using register 14 and the Off-time is set using register 15. In general the On-Time should be set to at least 60 seconds since it takes the GPC approximately 1 minute to boot up, and the off time should be set to at least 30 seconds to allow the GPC to shut down properly. For continuous operation the On-Time should be set to 1 and the Off-time should be set to 0.

Register Number	Register Name	Value
12	Enable GPC During Dive Mission	1
13	Enable GPC Data Recording	1
14	GPC Duty Cycle On-Time (s)	1
15	GPC Duty Cycle Off-Time (s)	0

4.8 Other Register Settings

In general it is not recommended that the user reset or change registers which set depth control parameters, oil sensor calibration thresholds, hardware-in-the-loop modes etc. Please consult with SSR regarding any questions regarding register values. Several registers can be used to set up advanced scheduling for sensors and the GPC.

Arbitrary GPC and Sensor Scheduling

A number of registers can be set to enable general purpose operational windows for GPC and Sensor 1 during the dive. These may be utilized but it is recommended that benchtop "test dives" be performed to ensure that the platform is behaving as expected.

Table 4.3: Window Settings for Scheduling Arbitrary On/Off Times for Sensors

Register Number	Register Name	Value
180	GPC On Window Time 1	0
181	GPC On Window Time 2	0
182	GPC On Window Time 3	0
183	GPC On Window Time 4	0
184	GPC On Window Time 5	0
185	GPC On Window Time 6	0
186	GPC Off Window Time 1	0
187	GPC Off Window Time 2	0
188	GPC Off Window Time 3	0
189	GPC Off Window Time 4	0
190	GPC Off Window Time 5	0
191	GPC Off Window Time 6	0
192	Sensor 1 On Window Time 1	0
193	Sensor 1 On Window Time 2	0
194	Sensor 1 On Window Time 3	0
195	Sensor 1 On Window Time 4	0
196	Sensor 1 O Window Time 5	0
197	Sensor 1 On Window Time 6	0
198	Sensor 1 Off Window Time 1	0
199	Sensor 1 Off Window Time 2	0
200	Sensor 1 Off Window Time 3	0
201	Sensor 1 Off Window Time 4	0
202	Sensor 1 Off Window Time 5	0
203	Sensor 1 Off Window Time 6	0
204	Enable GPC Event Windows (Reg 180-191)	0
205	Enable Sensor Event Windows (Reg 192-203)	0

Interplatform Range, Azimuth, and Depth Logging

Additionally there are a set of registers for logging interplatform range if multiple platforms are deployed, via USBL tracking. This functionality is useful to log distance, azimuth, and depth of mobile or fixed USBLs for determining platform formation or position over the course of a dive (eg. the range to an anchored vessel can be logged by enabling this functionality).

Table 4.4: Register addresses for setting up interplatform range logging.

Register Number	Register Name	Value
210	Platform 1 Address for USBL Range Logging	0
211	Platform 2 Address for USBL Range Logging	0
212	Platform 3 Address for USBL Range Logging	0
213	Platform 4 Address for USBL Range Logging	0
214	Platform 5 Address for USBL Range Logging	0
215	Platform 6 Address for USBL Range Logging	0
216	Platform 7 Address for USBL Range Logging	0
217	Platform 8 Address for USBL Range Logging	0
218	Platform 9 Address for USBL Range Logging	0
219	Platform 10 Address for USBL Range Logging	0
220	Platform 11 Address for USBL Range Logging	0
221	Platform 12 Address for USBL Range Logging	0
222	Platform 13 Address for USBL Range Logging	0
223	Platform 14 Address for USBL Range Logging	0
224	Platform 15 Address for USBL Range Logging	0
225	Fix Period for USBL Range Logging	0
226	USBL Fix Start Delay for USBL Range Logging	0

4.9 Applying to or Fetching settings from the Drifter GPSP

In addition to loading, editing, and saving a local copy of the Drifter GPSP configuration to a .cfg file, the Configuration Editor can be used to Apply Settings to an ethernet connected platform or to Fetch Settings from the platform.

Fetch Settings

The Fetch Settings command is used to download the current configuration settings from the Drifter GPSP engine controller. It is useful for troubleshooting or modifying an existing configuration. To download the current settings, connect to the Drifter platform as previously described (Section 4.2) and click Fetch Settings. The process of downloading the settings may take several minutes during which time the Fetch Settings button will remain depressed in the application window.

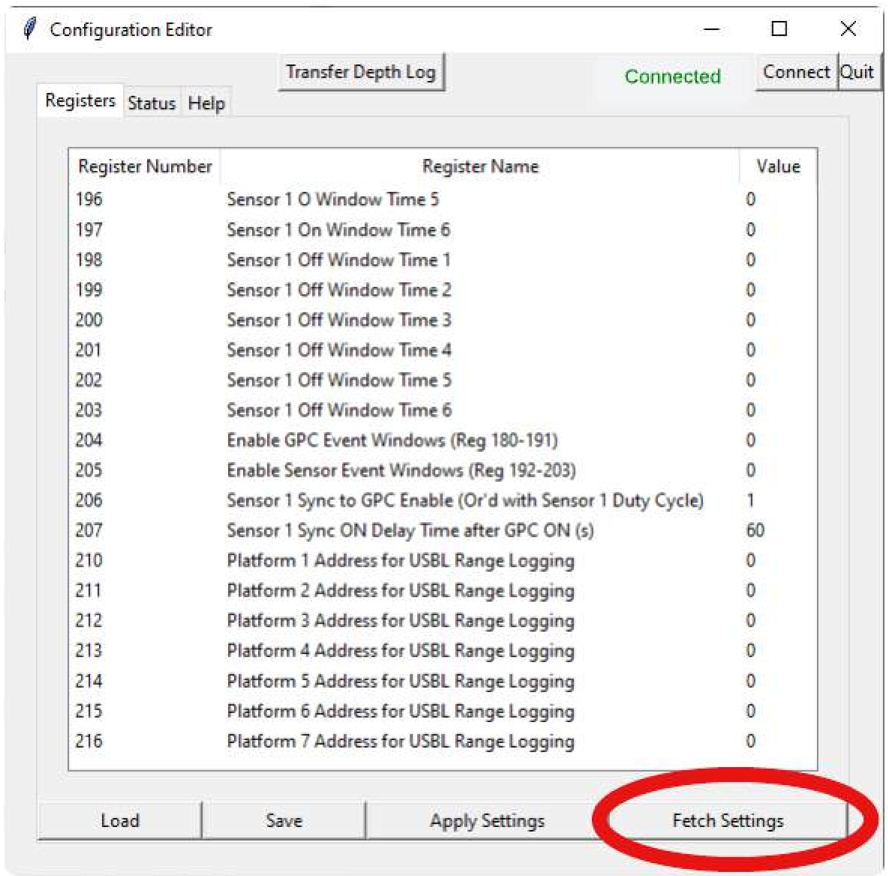


Figure 4.10: The Fetch Settings command is used to download the current register settings from the Drifter GPSP engine controller.

Apply Settings

The Apply Settings command is used to upload the current configuration settings from the Configuration Editor to the Drifter GPSP. Once a new profile has been created in the configuration editor it must be applied to the Drifter for it to execute that program after release of the magnet. To apply the new settings, connect to the Drifter platform as previously described (Section 4.2) and click Apply Settings. The process of uploading the settings may take several minutes during which time the Apply Settings button will remain depressed in the window. After settings have been applied it is recommended that the user Fetch Settings just to verify all settings have been correctly applied.

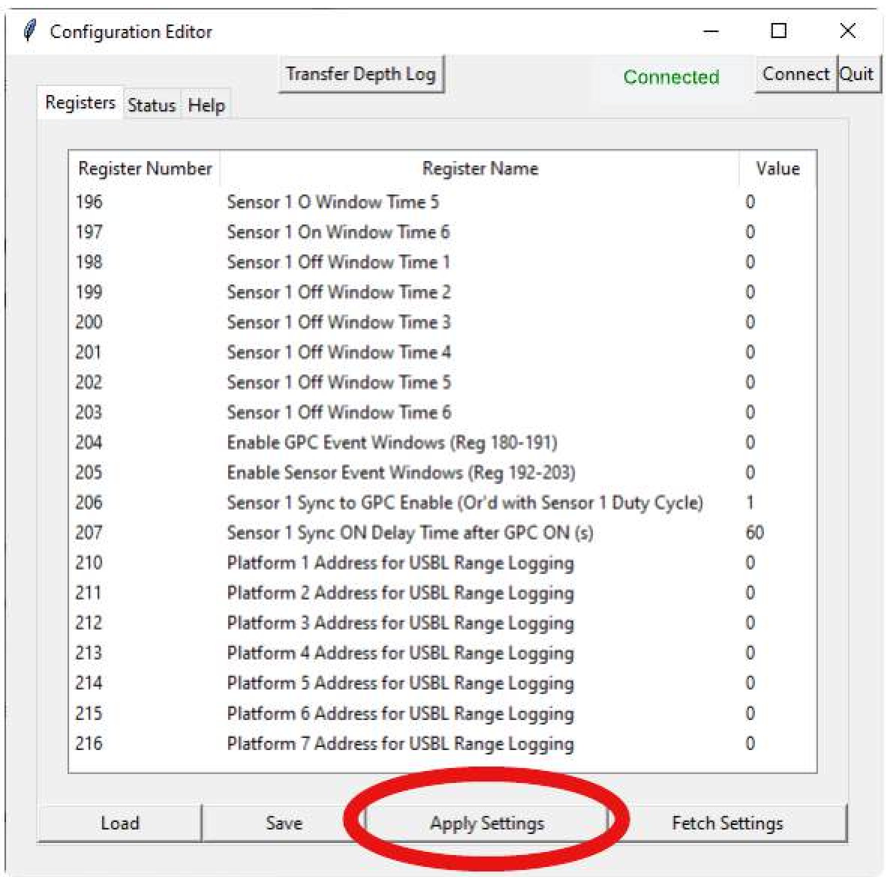


Figure 4.11: The Apply Settings command is used to upload the new register settings from the Configuration Editor to the Drifter GPSP engine controller.

4.10 Setting the Platform Clock

The onboard clock is used to synchronize all sensor values to a UTC-0 epoch timestamp. The clock is part of the drifter engine controller and the GPC automatically resets its time to the engine controller clock every time it is powered on to ensure time synchronization between the depth log and payload sensor data captured by the GPC. To set the clock please use the following procedure:

1. Connect the Charge cable to the Drifter's Charge port and remove the magnet switch to start the platform in Configuration mode
2. Connect an ethernet cable to the platform.
3. Start the Drifter platform by removing the magnet from the magnet switch holder and wait 1 minute for the platform to start up.
4. Start a PuTTY session and connect to the platform via the Ethernet cable using the Drifter's IP address 192.168.9.1
5. Log into the platform with the following credentials.
    a. User: ssr
    b. Password: Jameswebb18-
6. Start the Drifter terminal to allow direct command control of the buoyancy engine by typing 'drifterterm' and press enter to start the terminal program and press 'p' to enter the engine terminal interface.
7. Obtain the Unix Epoch Time from an online source like https://www.unixtimestamp.com/
8. Use the write to register command to set register 0 with the current unix epoch time. eg. 'w0 1718734536' <Enter>
9. Press 'd' <Enter> to view the system status including the time and date to ensure that it has been properly set.
10. To exit drifterterm press <Ctrl> + <A> and then <X> followed by <Enter>
11. Press <Enter> after exiting to shut down the platform and replace the magnet switch to depower it.

5. DEPLOYMENT

Deployment tasks involve placing the Drifter vehicle in the water. Deployment is a last chance to verify that the vehicle is ready to be deployed and is extremely critical to the success of a Drifter dive. Ensure all deck crew and staff have prior knowledge of the deployment procedure. The deployment procedure is as follows:

1. Ensure that the platform's initial adjustable volume is set to maximum displacement by pumping all of the oil into the external reservoir (see section *3.3 Ballast Adjustment*).
2. Power the previously rigged topside USBL beacon and verify its operation (see section *3.4 Rigging*).
3. Ensure that a fresh GTR with sufficient duration has been installed on the Drifter.
4. Connect a Charge cable to the Charge bulkhead.
5. Use a multimeter to verify that the Drifter battery is charged by measuring the voltage across the positive and negative for each charge connector. If the battery voltage is below 20 V, charge the battery.
6. Replace the Charge bulkhead dummy cover using Molykote.
7. Verify that the manometer reads an internal pressure of 1.5 to 2 psi to ensure that the Drifter does not have any leaks. If leaks are found, open the sphere and check all seals.
8. Set a VHF receiver to the frequency printed on the Drifter and start VHF and Iridium Beacon by removing the magnets (Figure 5.1). These will be used to verify that the VHF beacon is running and establish at least one Iridium fix.

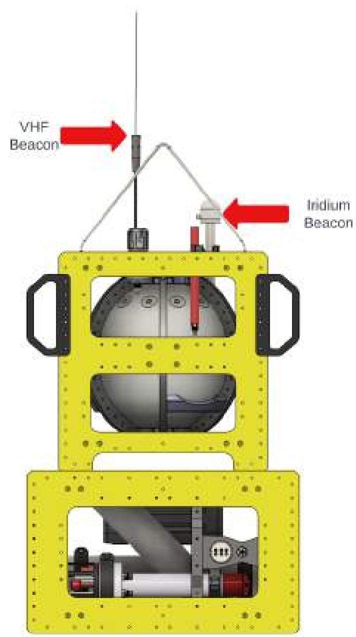


Figure 5.1: Separate magnets must be removed to start both the VHF beacon and the Iridium beacon.

9. Record Iridium IMEI numbers, and VHF frequencies for later recall.

Figure 5.2: Iridium IMEI numbers can be found on the side of the IBCn beacon used for satellite-based tracking.

10. Power the vehicle by removing the front magnet. Verify visually that the platform has started. A green light on the front of the buoyancy sphere will turn on initially indicating the platform is powered. The platform will beep three times indicating that it has entered pre-mission mode.
11. Store the magnets in a safe place as these will be needed after recovery.
12. Record the current time and position using a ship based or handheld GPS.
13. Carefully lower the Drifter into the water by hand or using a snap-release crane hook (Figure 5.3). Ensure that the vehicle is not dropped more than a few centimeters to avoid damaging sensitive internal components.

Figure 5.3: A photograph of a Drifter GPSP platform being lowered into the water with the use of a quick-release and a tag-line.

14. Observe that the platform is floating upright on the surface.
15. After the Drifter is released it will float on the surface waiting for the pre-mission timer to expire, when this happens it will begin to reduce volume for diving. During this process the Drifter will begin to sink. This process should take around 20-30 minutes after the pre-mission timer has expired.
16. If the Drifter does not sink after 60 minutes, recover it and perform the ballasting procedure again.
17. Record the time the Drifter sinks as well as its last surface position.

6. ACOUSTIC TRACKING AND COMMANDS

The platform is autonomous and can be deployed and allowed to operate untended. It is possible to track the platform, obtain platform status, and command new depths to the platform via wireless acoustic control. This is useful in the case of experimental payloads are being used or the platform is targeting specific depths based on other real-time sensor sources (eg. echosounder). Tracking and acoustic command operations consist of all the tasks to perform while the Drifter vehicle is underwater. To do this the operator must utilize two PC-based applications. The SeaTrac Pinpoint application is a mapping tool which utilizes the location of the topside beacon and the measured distance, depth, and azimuth angle of Drifters to plot their location on a chart. The MATLAB environment is used to command and request status from Drifters. These applications should be used side-by-side to track and communicate with any deployed Drifters (Figure 6.1).

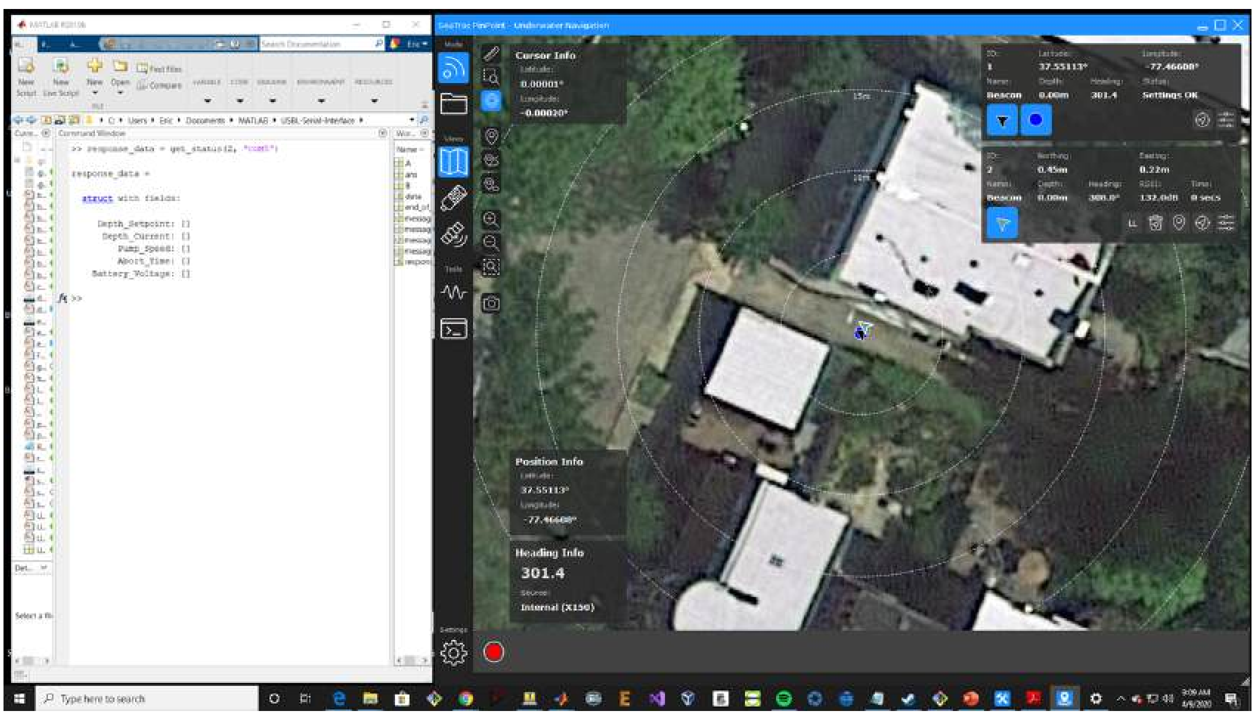


Figure 6.1: Operators of Drifters will use the MATLAB environment and the SeaTrac Pinpoint mapping tool to track and command multiple vehicles.

6.1 MATLAB Command Interface

A set of communications tools have been written for the MATLAB environment (Figure 6.2) to command Drifters and request status.

- **get_status** - This requests a status register from the Drifter.
- **set_depth** - Override the current depth setpoint and command the Drifter to another depth in meters.
- **set_velocity** - Override the current maximum absolute velocity to enable the Drifter to dive and ascend at a different speed.
- **set_abort_time** - Set the mission abort for the Drifter in seconds from present.

USBL communications tools can be requested directly from Second Star Robotics by e-mailing info@secondstarrobotics.com.

Start the MATLAB user environment and navigate to the folder where the tools were installed. Help on each function can be found by using the matlab help command. For example ‘help get_status’ will return the online help for the get_status command. While entering commands through the MATLAB environment, disconnect the beacon from the SeaTrac Pinpoint mapping tool as these applications cannot use the COM port at the same time.

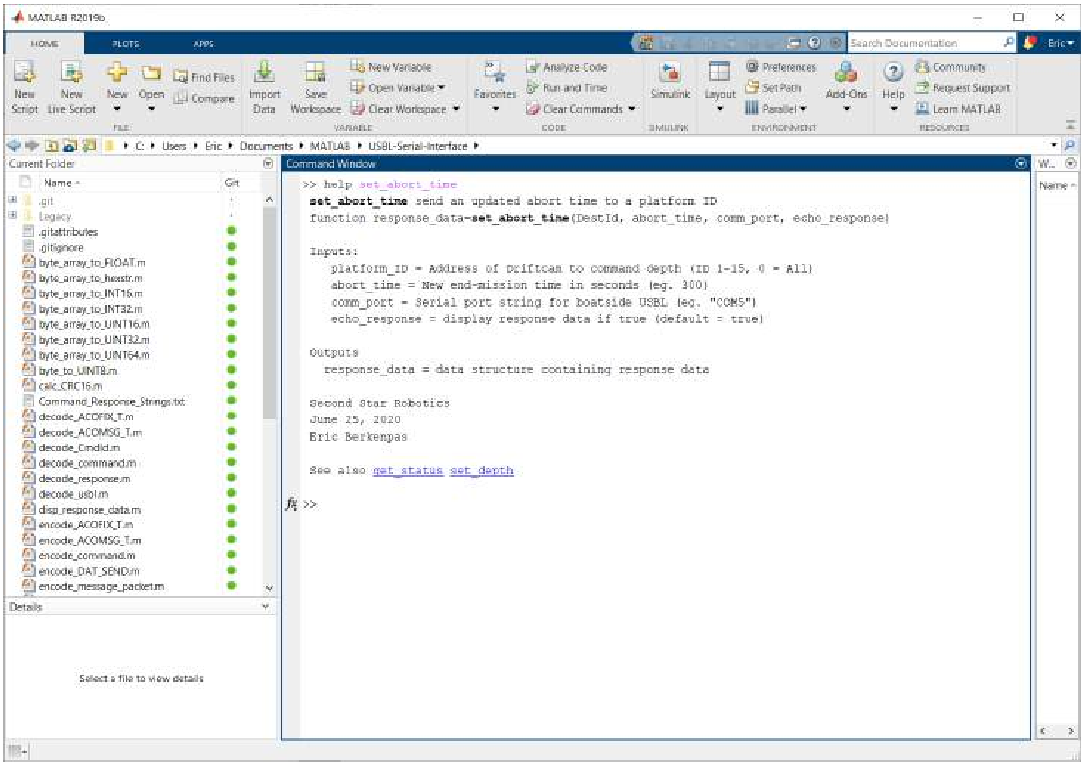


Figure 6.2: The MATLAB environment used to communicate with Drifters during operations.

Get Status

```
get_status get platform ID status register
function response_data=get_status(DestId, register, comm_port, echo_response)

Inputs:
   platform_ID = Address of Driftcam to command depth (ID 1-15, 0 = All)
   register = Address of general purpose register to return
   comm_port = Serial port string for boatside USBL (eg. "COM5")
   echo_response = display response data if true (default = true)

Outputs
   response_data = data structure containing response data

Second Star Robotics
June 25, 2020
Eric Berkenpas

See also set_depth set_abort_time
```

The get_status command requests the Drifters status and passes it to a function called response data. The function requests a set of standard response information and the contents of a register. Currently only register 0 is used and contains the water temperature. To use get_status simply pass the Drifter platform ID, the status register, the topside USBL beacon COM Port, and a true/false flag to display the response message.

For example to request the Drifter status register 0 from Drifter 3, using COM port 4 use the following syntax:

‘response_data = get_status(3, 0, “COM4”, true)’

Once the command is entered the beacon will send a message to Drifter 3 and wait 30s for a response. If no response is received it will pass an empty structure to response_data and display “Timeout: no response”.

If a message is received it will populate the response data structure with the following parameters:

- The Drifter ID
- The depth of the vehicle in meters
- The depth setpoint in meters
- The current buoyancy engine volume
- The current buoyancy engine pumping speed
- The time to abort mission
- The battery voltage
- The contents of a general purpose requested status register (see Table 6.1)

Table 6.1: A List of General Purpose system status values that can be requested by the get_status command

Address	Description	Units
0	Seawater Temperature	degrees C
1	Encoder Zero Adjust (DIAGNOSTIC)	Encoder Steps
2	Position (DIAGNOSTIC)	Stepper Position
3	Position_Zero (DIAGNOSTIC)	Encoder Steps
4	GPC Record State	T/F = 1/0
5	GPC Record Time	s
6	Sensor 1 Power State	T/F = 1/0
7	SG TST (DIAGNOSTIC)	T/F = 1/0
8	Engine Stroke Position (DIAGNOSTIC)	Encoder Pulses
9	Valve Index State (DIAGNOSTIC)	T/F = 1/0
10	vertical velocity	m/s
11	commanded vertical velocity	m/s
12	w_i (DIAGNOSTIC)	m
13	maximum absolute velocity	m/s
14	estimated volume displaced	mL
15	commanded volume displaced	mL
16	estimated compressible volume (DIAGNOSTIC)	mL
17	Nabla_p (DIAGNOSTIC)	mL
18	engine commanded flow rate	mL/s
19	Pitch	degrees
20	Roll	degrees
21	Yaw	degrees
22	Depth (full precision)	m

Set Depth

```
set_depth send a depth setpoint to a driftcam platform
function response_data=set_depth(DestId, depth, comm_port, echo_response)

Inputs:
   platform_ID = Address of Driftcam to command depth (ID 1-15, 0 = All)
   depth = Depth in meters (eg. 300)
   comm_port = Serial port string for boatside USBL (eg. "COM5")
   echo_response = display response data if true (default = true)

Outputs
   response_data = data structure containing response data

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June 25, 2020
Eric Berkenpas

See also get_status set_abort_time
```

The set_depth command is used to override the Drifter vehicle's current depth setpoint including its preprogrammed depth profile. The Drifter will continue to follow its preprogrammed profile but will ignore its previous depth setpoint in favor of the one passed by set_depth. If regular topside control is expected during a deployment (eg. tracking a scattering layer), then it is recommended to set a depth profile with only one depth which is set at the beginning. This will ensure that a preprogrammed depth profile does not continuously override a topside operator's commands. To use set_depth, pass the Drifter platform ID, depth in meters, topside USBL COM port, and response flag to the set_depth function.

For example, to command the Drifter with platform ID 3 to go to a depth of 350 meters using COM4 send the following command.

'response _data = set_depth(3, 350, "COM4", true)'

Once the command is entered, the beacon will send a message to Drifter 3 and wait 30s for a response. If no response is received it will pass an empty structure to response_data and display "Timeout: no response". If a message is received it will populate the response data structure with the same data structure listed in get_response. Note the Depth setpoint will be the previous setpoint and the register value will default to register 0 'Water Temperature'.

Set Velocity

```
set_velocity send a new maximum velocity to the Drifter
function response_data=set_velocity(DestId, velocity, comm_port, echo_response)

Inputs:
   platform_ID = Address of Driftcam to command depth (ID 1-15, 0 = All)
   velocity = Maximum Velocity in m/s (eg. 10)
   comm_port = Serial port string for boatside USBL (eg. "COM5")
   echo_response = display response data if true (default = true)

Outputs
   response_data = data structure containing response data

Second Star Robotics
May 9, 2022
Eric Berkenpas

See also get_status set_abort_time set_depth
```

The set_velocity command is used to override the Drifter vehicle's current absolute maximum velocity setpoint. The Drifter will continue towards its current depth setpoint but will limit the absolute maximum velocity to no more than the value commanded by set_velocity. If regular topside control is expected during a deployment (eg. tracking a scattering layer), then it is recommended to set a depth profile with only one velocity setpoint which is set at the beginning. This will ensure that a preprogrammed depth profile does not continuously override a topside operator's commands. To use set_velocity, pass the Drifter platform ID, velocity in m/s, USBL COM port, and response flag to the set_depth function.

For example, to command the Drifter with platform ID 3 to go to a depth of 1 cm/s (0.01 m/s) using COM4 send the following command.

'response _data = set_velocity(3, 0.01, "COM4", true)'

Once the command is entered, the beacon will send a message to Drifter 3 and wait 30s for a response. If no response is received it will pass an empty structure to response_data and display "Timeout: no response". The new velocity can be queried (both commanded and actual) using the get_status command. In general velocities faster than 10 cm/s are not recommended for nominal control settings and payloads. If high velocities are required please contact SSR.

Set Abort Time

```
set_abort_time send an updated abort time to a platform ID
function response_data=set_abort_time(DestId, abort_time, comm_port, echo_response)

Inputs:
   platform_ID = Address of Driftcam to command depth (ID 1-15, 0 = All)
   abort_time = New end-mission time in seconds (eg. 300)
   comm_port = Serial port string for boatside USBL (eg. "COM5")
   echo_response = display response data if true (default = true)

Outputs
  response_data = data structure containing response data

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June 25, 2020
Eric Berkenpas

See also get_status set_depth
```

The set_abort_time is used to override the preprogrammed end of mission time (register 5), by commanding the Drifter to extend or shorten its mission time. A value of 300 passed to the Drifter will command it to continue its mission for 300 seconds (or 5 min). The function will pass response data as in get_status and set_depth. To use the set_abort_time function, simply pass it the Drifter platform ID, the desired abort time, the USBL COM port, and the response echo flag.

For example, to send Drifter 4 an abort time of 1 hour (3600s) using COM port 5 simply use the following command:

‘response_data = set_abort_time (4, 3600, “COM4”, true)’

As with the get_status and set_depth commands, the set_abort_time function will wait for 30s for an acoustic response from the Drifter and once it is received pass the data to the response_data structure described in get_status. It should be noted that the Drifter will pass the previous abort_time and register 0 (water temperature) in its response.

6.2 SeaTrac Pinpoint Mapping Software

Seatrac PinPoint is a Windows software application that allows operators to track up to 14 Drifters, each fitted with a SeaTrac acoustic beacon, from a single topside USBL beacon (Figure 6.3).

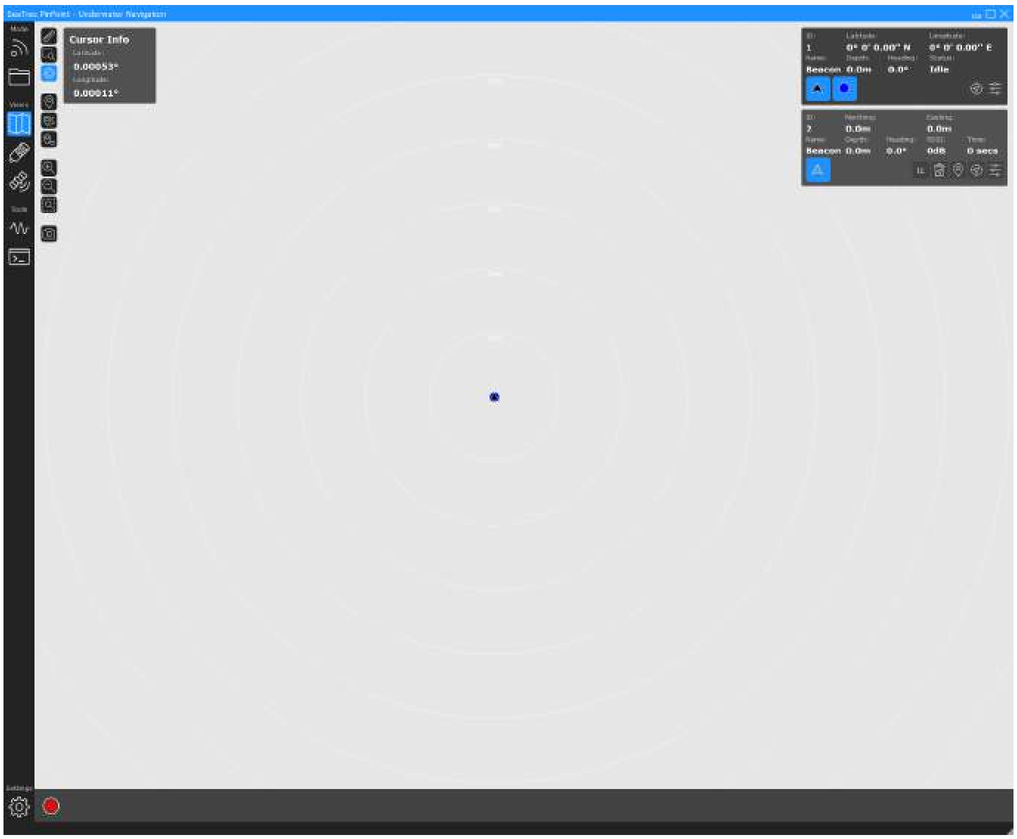


Figure 6.3: The PinPoint tracking and mapping tool.

PinPoint has a variety of features to help users perform positioning, navigation and survey tasks, including the logging and playback of operational data, interfaces to satellite positioning systems, geographic markers, waypoint and destination navigation information and real-time data output to other NEMA compatible systems.

Data logged during operations can be reviewed while a job is still in progress, and PinPoint can export geographic data in a variety of third party formats, including KML and CSV.

Operators should carefully read the SeaTrac Pinpoint users manual to configure the mapping platform as a supplement to this document.

Please note that the PinPoint tool and the MATLAB both need to communicate with the topside USBL beacon using the same COM port. For that reason the operator should disconnect the PinPoint tool from the USBL beacon while sending USBL commands in MATLAB. To do this un-highlight the 'Enter Live Tracking Mode' icon in the upper left-hand corner of the Pinpoint software (Figure 6.4). MATLAB commands only use the communications port while it is sending and receiving acoustic commands. To continue tracking highlight the same icon. In this way both applications can share the comm port and beacon without interfering with each other.

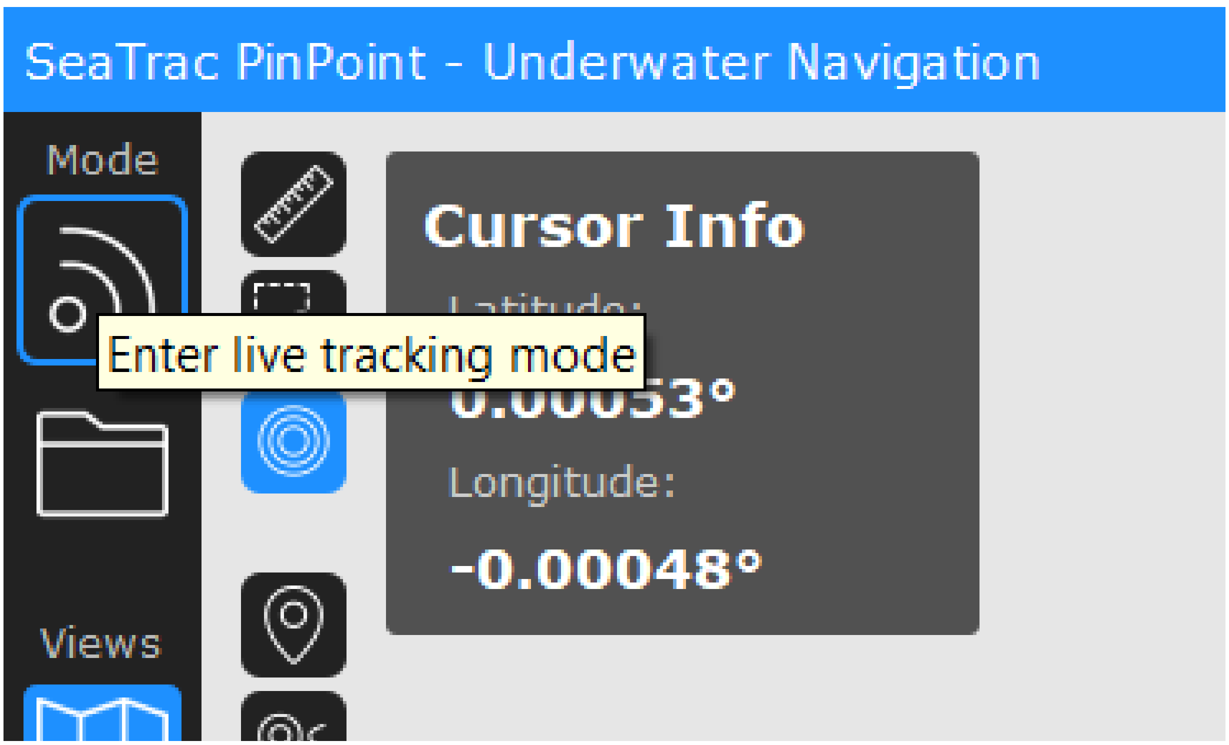


Figure 6.4: Un-highlight the "Enter Live Tracking Mode" icon to release the USBL beacon's COM port so that commands can be sent.

7. RECOVERY

Once the final surface recovery window has been achieved or the mission abort time has expired the Drifter will drive itself to the surface pumping all oil out of its internal reservoir into the external one and releasing its drop weight. If the weight has dropped it causes the platform to rapidly ascend at around 1 m/s. During Abort Mode it will not be possible to request status or send other acoustic commands, however the vehicle can be tracked using the Pinpoint mapping tool. It is important to recover the vehicle soon after it surfaces since wind driven surface current is typically faster than bulk currents. Recovery is aided by visual aides (flag), a VHF radio beacon, and an Iridium satellite beacon. To recover the Drifter use the following procedure.

1. Meet with the pilot or captain beforehand to go over what can be expected when recovering a Drifter platform.
2. Maintain good communication with the pilot or bridge of the tender vessel and regularly relay the undersea position of the Drifter vehicle using the PinPoint mapping tool (if in acoustic communications range).
    a. If there is a situation where the vessel cannot recover the Drifter immediately uses the set_abort time to keep it underwater until the vessel can return.
3. Instruct the crew and staff on deck to perform visual scans for the orange flag on the Drifter and update them on when it is likely to surface (to avoid search fatigue).
4. Assemble the VHF receiver and YAGI antenna and tune the receiver to the previously recorded VHF beacon frequency.

Figure 7.1: A VHF receiver tuned to a beacon at the frequency 150.1900 MHz.

5. Begin listening to the receiver. A loud ‘beep’ tone will appear once the vehicle surfaces (Figure 7.2).

Figure 7.2: An operator uses a VHF receiver and directional antenna to search for the Drifter on the surface.

6. Turn the gain up until you just begin to hear static, then turn the gain down slightly.
7. Rotate slowly in a circle, listening for changes in signal volume.
8. If no change in volume can be detected, turn the gain down a little and recheck for change in volume by slowly turning in a circle.
9. Choose a heading by determining the rough direction that the volume is loudest, and
10. Confirmed by where volume is softest (the two locations should be in opposite directions).
11. Once the Drifter has been visually spotted, ensure that the pilot or captain can see it and ask him or her to recover it carefully with a crane or small boat. Typically a gaff pole is helpful, but instruct the crew to be careful as the glass floating sphere can be damaged by blunt force.
12. Pull the Drifter out of the water using the top lift point and attempt to hook a second or third tag line on the platform to keep it from swinging. Use a gaff pole to fend the platform off and control its motion (see section *3.4 Rigging*)
    a. **Note: Avoid having deck crew work under the Drifter during recovery as the GTR may be significantly weakened by dissolving action during the dive.**
13. Once the platform is onboard, secure it to the deck and replace the magnets for the platform, VHF beacon, and Iridium beacon.
14. Rinse the Drifter with a fresh water hose and allow it to drip dry for about 5 minutes before attempting to uncover any electrical bulkheads.

8. DATA DOWNLOAD AND ANALYSIS

Data collected by the Drifter comes in two forms. The engine controller saves time stamped depth and other parameters to non-volatile storage, and the GPC can be configured to capture data from other sensing payloads. All platform data can be downloaded via the ethernet connector.

During the dive the platform records the depth log as well as a number of other parameters at a rate of 1 hz. Values are saved to non-volatile storage on the buoyancy engine controller for later retrieval. The engine depth log is overwritten every time the platform is started in Dive mode and thus must be transferred from the engine into a .csv file which can be copied off the platform.

The values saved by the engine controller are listed in Table 8.1

Table 8.1: Parameters Saved to the Drifter Depth Log

Column Number	Description	Unit
1	Epoch TImestamp: Seconds since UTC-0, January 1, 1970 ,00:00:00	s
2	depth setpoint	m
3	depth (0.1 resolution)	m
4	z_p (Control Diagnostic Signal)	m/s
5	z_i (Control Diagnostic Signal)	m/s
6	z_d (Control Diagnostic Signal)	m/s
7	w_command (Control Diagnostic Signal)	m/s
8	vertical velocity (w_actual, Control Diagnostic Signal)	m/s
9	w_i (Control Diagnostic Signal)	mL
10	Nabla_command (Control Diagnostic Signal)	mL
11	Displaced Adjustable Volume (Nabla_actual, Control Diagnostic Signal)	mL
12	Nabla_p (Control Diagnostic Signal)	mL/s
13	Nabla_i (Control Diagnostic Signal)	mL/s
14	Nabla_d (Control Diagnostic Signal)	mL/s
15	Engine flow rate (Qv_command, Control Diagnostic Signal)	mL/s
16	sps_command (Control Diagnostic Signal)	mL/s
17	Nabla_air (Control Diagnostic Signal)	mL
18	Roll	degrees

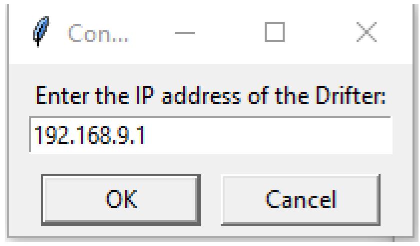
19	Pitch	degrees
20	Yaw	degrees
21	Internal Reservoir Volume	mL
22	Depth (raw)	m
23	Seawater Temperature	C
24	Battery Potential	V
25	Velocity of Sound (Estimated by Temperature and Depth)	m/s
26	Interplatform Range Time	s
27	Interplatform Range Distance	m
28	Interplatform Azimuth	degrees
29	Interplatform Elevation	degrees
30	Interplatform USBLFitError	Quality Factor
31	Interplatform Position Easting	m
32	Interplatform Position Northing	m
33	Interplatform Depth	m
34-43	Reserved for Future Use	-
44	Interplatform Source ID Address	1-15
45	Control State (Dive, Control, Hibernate, Dive, Surface, Surface Interval)	1-6
46	VALVE_INDEX (Control Diagnostic Signal)	1/0
47	Pump power state	1/0

8.1 Download the Depth Log

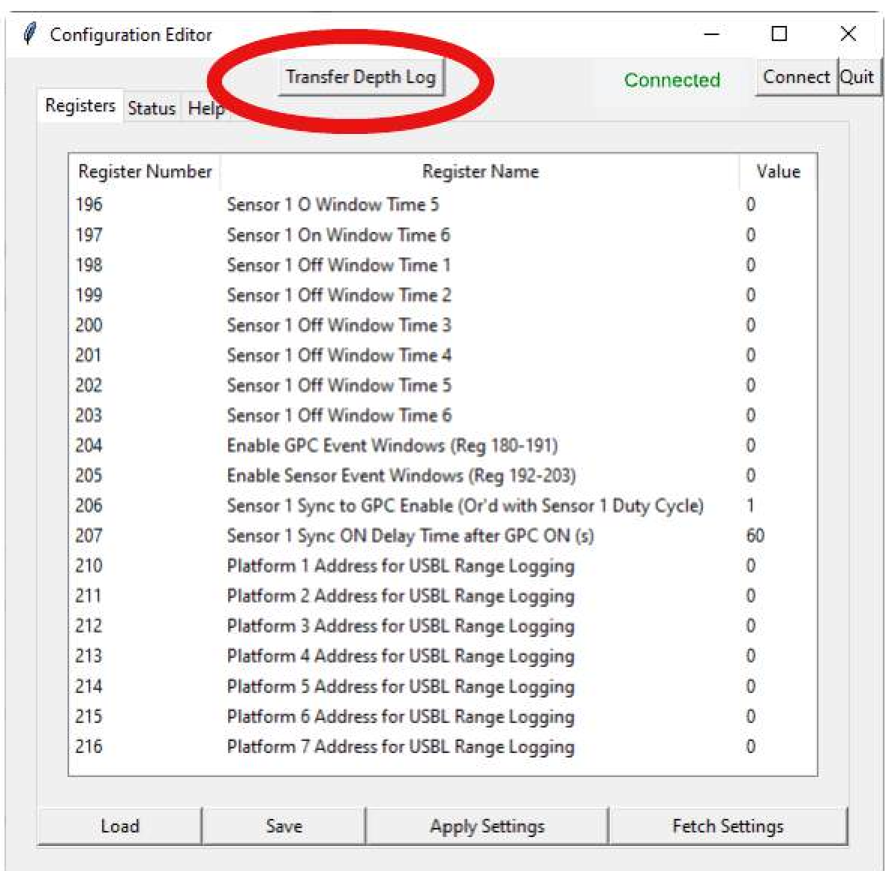
During the dive the platform records the depth log as well as a number of other parameters at a rate of 1 hz. Please use the following procedure to transfer the datalog from the engine controller and download it form the platform:

1. Starting with the Drifter's magnet switch in and the platform depowered. Connect the Charge cable to the Drifter's charge bulkhead.
2. Connect the Ethernet cable to the ethernet bulkhead and a laptop computer running the Configuration Editor.
3. Turn on the Drifter by removing the magnet switch and wait 1 minute for the platform to boot up in Configuration mode.
4. Start the Configuration Editor by executing the file Drifter-Configurator.exe.

5. Click Connect in the top right corner of the application and enter the platform's IP address 192.168.9.1 and click <Okay>.



6. The connection status in the top right corner of the application should change from "Disconnected" to "Connected"
7. Click "Transfer Depth Log". This will start the process of transferring the depth log from the engine controller to the a .csv file on the GPC. Depending on the length of the datalog saved onto the platform, this may take several hours to extract. It is recommended that the depth log be transferred while the platform is charging as these activities can occur concurrently and may take approximately the same amount of time.



8. The depth log will appear as a new .csv file created on a shared folder on the drifter platform. This file can be found by browsing to the network attached

directory. //192.168.9.1/Data/ and will have a filename time stamped with the time the transfer was started (eg. Depthlog_20240524-164550.csv).

9. Copy this file to the laptop computer via the network drive link into a folder. It is recommended that the associated .cfg file be transferred there as well for documentation purposes.
10. Other data may be saved in the //192.168.9.1/Data folder in addition to the depth log depending on the activity of the GPC. These files can be copied over as well.

8.2 Plotting Depth Log

A set of plotting tools have been provided to allow the user to load depth log data sets into the MATLAB computation environment and plot them. These tools can be found in the github repository:

https://github.com/Second-Star-Robotics/Drifter-GPSP-Support-Repository.git

The following functions can be used to load and plot data from a Drifter GPSP .csv datalog.

Load Drifter CSV

The LoadDrifterCSV function imports a drifter CSV depth log into a MATLAB data structure. After loading the .csv file it is recommended that the data be saved to .mat file for compressed file sharing.

```
loadDrifterCSV load drifter buoyancy engine data from a CSV file.
function [Data] = loadDrifterCSV(data_filename)
inputs:
   data_filename = string containing filename of data
outputs:
   Data = structure containing all BC Data.

Eric Berkenpas
09/20/2022

See also DOWNLOAD_DATA plot_Driftcam_data
```

Plot Drifter

The plotDrifter function generates a number of depth log plots which display platform activity during the course of the dive (eg. Figure 8.1).

```
plotDrifter plot data downloaded from Drifter
function h = plotDrifter(Data)
inputs:
   Data = Data structure generated by download_data.m

outputs:
   h = figure handle

dependencies:

Eric Berkenpas
09/20/2022

See also downloadDrifter
```

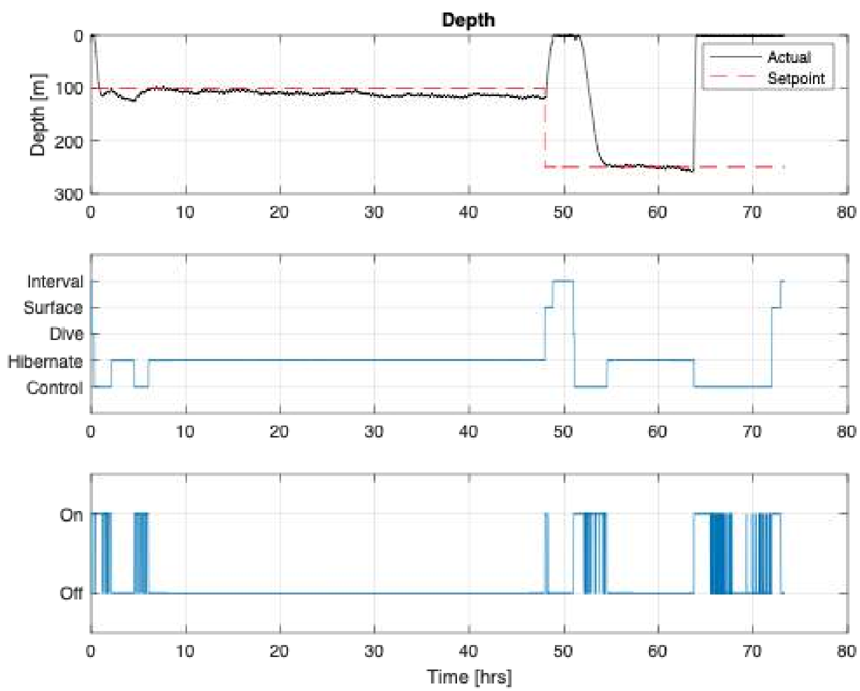


Figure 8.1: An example plot generated by plotDrifter indicating platform behavior during a field deployment.

8.3 Clearing Sensor Data

Once data has been downloaded from the platform and data integrity verified, the platform can be cleared for another deployment to ensure that sufficient storage space is available to capture the next dive.

Data can be cleared by simply deleting the files on the network attached storage drive //192.168.9.1/Data or by using PuTTY to log into the platform and delete the files within the Data folder. To use ssh to log into the platform please use the following procedure:

1. Connect the Charge cable to the Drifter’s Charge port and remove the magnet switch to start the platform in Configuration mode
2. Connect an ethernet cable to the platform.
3. Start the Drifter platform by removing the magnet from the magnet switch holder and wait 1 minute for the platform to start up.
4. Start a PuTTY session and connect to the platform via the Ethernet cable using the Drifter’s IP address 192.168.9.1
5. Log into the platform with the following credentials.
    a. User: ssr
    b. Password: Jameswebb18-
6. Change the directory to the shared Data directory on the GPC drive with the command: **cd /home/ssr/Share/Data**
7. Delete all files within the directory using the following command: **sudo rm -rf *** (use the GPC password: “Jameswebb18-”)

8.3 Data Fusion

Multisensor data from the Drifter can be fused with video data and data from other sources and instruments. These data sources may include CTD data or echosounder data. Together these can create a more holistic picture of what is occuring in scattering layer ecosystems. Figure 8.2 shows an example of Drifter depth data fused with echosounder data and video frames.

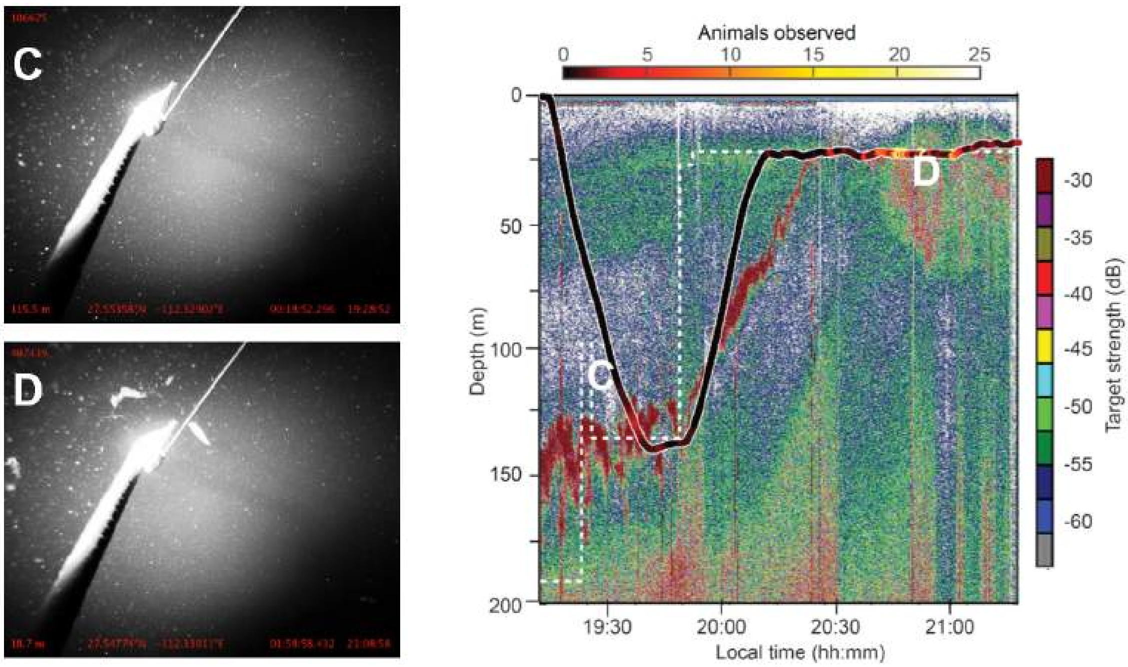


Figure 8.2: Drifter data can be fused with other datasets to create a richer picture of deep sea scattering layer ecosystems. In this figure, Drifter video data has been annotated and is shown in comparison to a migrating acoustically defined scattering layer.

9. SHIPPING

The platform has been designed to be rugged enough for long distance ground transport. The following considerations should be taken when preparing the Drifter GPSP for shipping.

- Inspect the inside of the buoyancy sphere for damage, leaks, contamination or any other signs of damage.
- Comply with all HAZMAT requirements regarding transport of the platform (see section *11. BATTERY SYSTEM AND SAFETY*).
- Ensure the sphere is tightly secured within the platform frame with all cabling plugged in or electrically isolated with insulating tape.
- The platform should be transported vertically (lift point up) or lying on its back. Transporting the platform in the wrong orientation could result in abrasion of the oil reservoir bladder and cause an oil leak (mineral oil is not hazardous and food safe). A shipping crate should be used to protect the platform while it is enroute.

Figure 9.1: A photograph of a Drifter platform being crated for shipment via ground transport.

- Set a long pre-mission timer to ensure that if the magnet is damaged or removed during shipping the platform will remain in a de-energized state. Either use the Configuration Editor as described in section *4: Programming* or use the following procedure.
    1. Connect the Charge cable to the Drifter's Charge port and remove the magnet switch to start the platform in Configuration mode
    2. Connect an ethernet cable to the platform.
    3. Start the Drifter platform by removing the magnet from the magnet switch holder and wait 1 minute for the platform to start up.
    4. Start a PuTTY session and connect to the platform via the Ethernet cable using the Drifter's IP address 192.168.9.1
    5.
    6. Start the Drifter terminal to allow direct command control of the buoyancy engine by typing 'drifterterm' and press enter to start the terminal program and press 'p' to enter the engine terminal interface.
    7. Set the "Pre Mission Delay" (register 3) to 10000000 by typing 'w3 100000000'.
    8. Log into the platform with the following credentials.
        a. User: ssr
        b. Password: Jameswebb18-
    9. Start the Drifter terminal to allow direct command control of the buoyancy engine by typing 'drifterterm' and press enter to start the terminal program and press 'p' to enter the engine terminal interface.
    10. To exit drifterterm press <Ctrl> + <A> and then <X> followed by <Enter>
    11. Press <Enter> after exiting to shut down the platform and replace the magnet switch to depower it.

- The platform should be shipped with all oil pumped to the external bladder using the following procedure:

1. Set the platform up vertically on level ground.
2. Starting with the Drifter's magnet switch in and the platform depowered. Connect the Charge cable to the Drifter's charge bulkhead.
3. Connect the Ethernet cable to the ethernet bulkhead and a laptop computer running the Configuration Editor.
4. Turn on the Drifter by removing the magnet switch and wait 1 minute for the platform to boot up in Configuration mode.
5. Start the Configuration Editor by executing the file Drifter-Configurator.exe.
6. Click Connect in the top right corner of the application and enter the platform's IP address 192.168.9.1 and click <Okay>.
7. The connection status in the top right corner of the application should change

from “Disconnected” to “Connected”. Select the “Status” tab in the Configuration Editor and click the “Pump Out” button. This will start the engine pump and transfer oil into the external reservoir.

8. Monitor the Internal Volume which should be decreasing as the oil is transferred to the external reservoir. If the scale was properly tared this should decrease to around 0 mL. The process of transferring the oil to the external reservoir could take 90 minutes.
9. Once the Internal Volume does not appear to be decreasing, stop the pump by clicking “Stop Pump”. If the internal volume is not within 10 mL of zero use this opportunity to re-zero the internal oil reservoir by clicking “Tare Volume”.
10. Replace the magnet to shut down the platform and click Quit on the Configuration Editor.

10. MAINTENANCE

Generally the platform is designed to be nearly maintenance free with an extremely long service life for all platform subsystems. Opening the sphere may be required in the case of making platform modifications, repairs, or upgrades..

10.1 Sphere Opening Procedure

It may be necessary to open the Drifter sphere. To do this follow the following procedure:

1. Plug in the Charge cable and remove the magnet to start the platform in Configuration Mode. This is important to keep the platform from pumping oil during the procedure
2. With the Drifter, remove fasteners holding the ribs on.
3. Loosen screws from top cap (Figure 10.1).

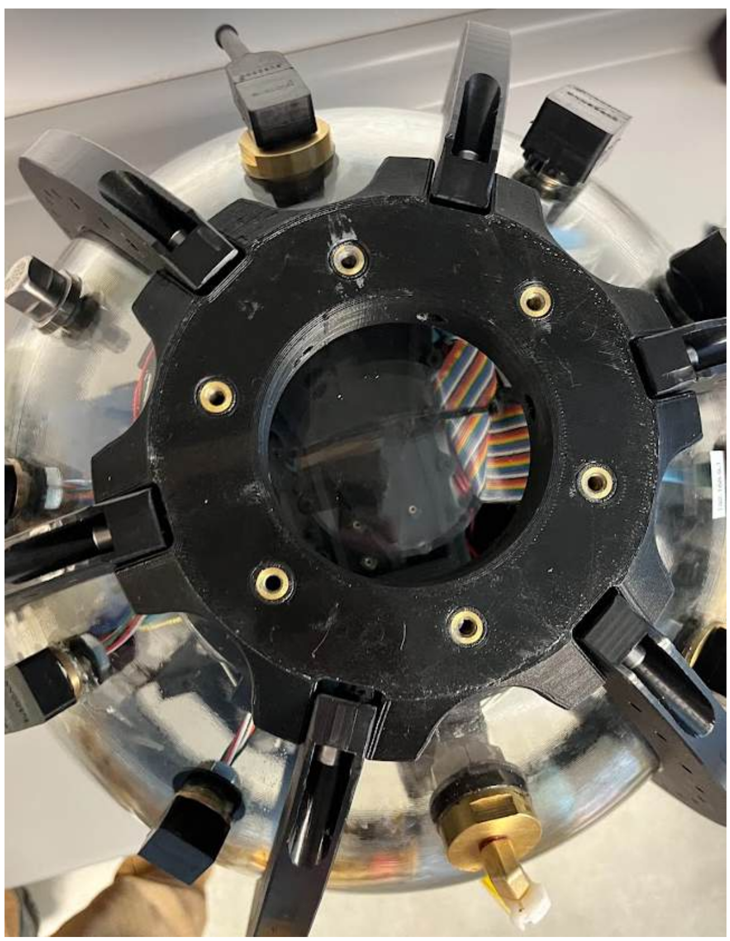


Figure 10.1: A photograph of the top joining component holding the ribs with 6 screws. These parts retain the glass pressure housing within the platform frame. A second joining component is found on the bottom pole of the sphere.

4. Remove frame ribs from the sphere and place the sphere onto a stand upside down. The joining component can be used as a stand but care should be made to ensure the sphere does not fall off the stand.

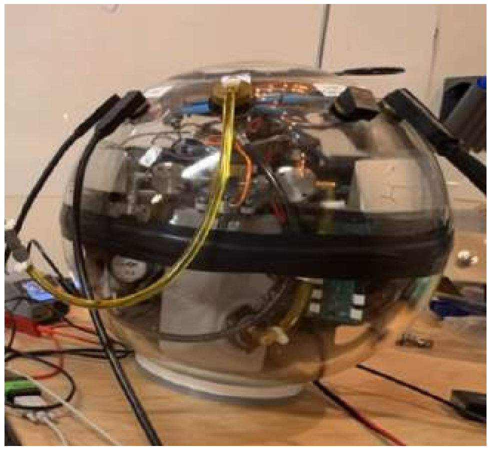


Figure 10.2: The control sphere removed from the ribs.

5. Remove vinyl tape.
6. Remove butyl rubber tape.
7. Release vacuum by opening the vacuum port and pressing the center valve button.
8. With the control sphere upside down. Carefully remove the bottom hemisphere and place it in a safe space.
9. Disconnect all electrical connections to the bulkheads from the Power Breakout Board.

Figure 10.3: The Control Sphere upside down with the bulkhead connections visible plugged into the Power Breakout Board and the bottom hemisphere removed.

10. Unclip the hydraulic connection and unscrew it from the engine high pressure port with a pair of crescent wrenches. A small amount of oil may drip from the high pressure port.

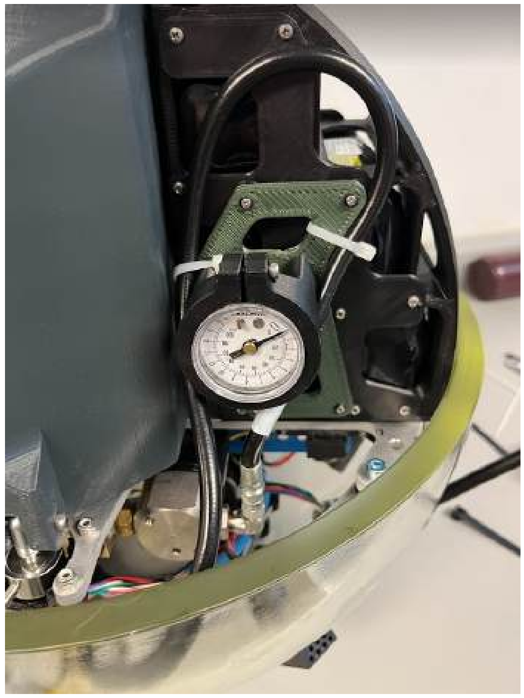


Figure 10.4: The high pressure port on the engine pump and high pressure hose are wrapped around the internal vacuum gauge secured with cable ties. To remove the internal assembly unclip the cable ties from the vacuum gauge.

11. Disconnect the ethernet cable from the coupler connecting the bulkhead to the GPC.
12. Unscrew the four retaining bolts which mount the internal assembly to the sphere and carefully lift the internal assembly out of the sphere.

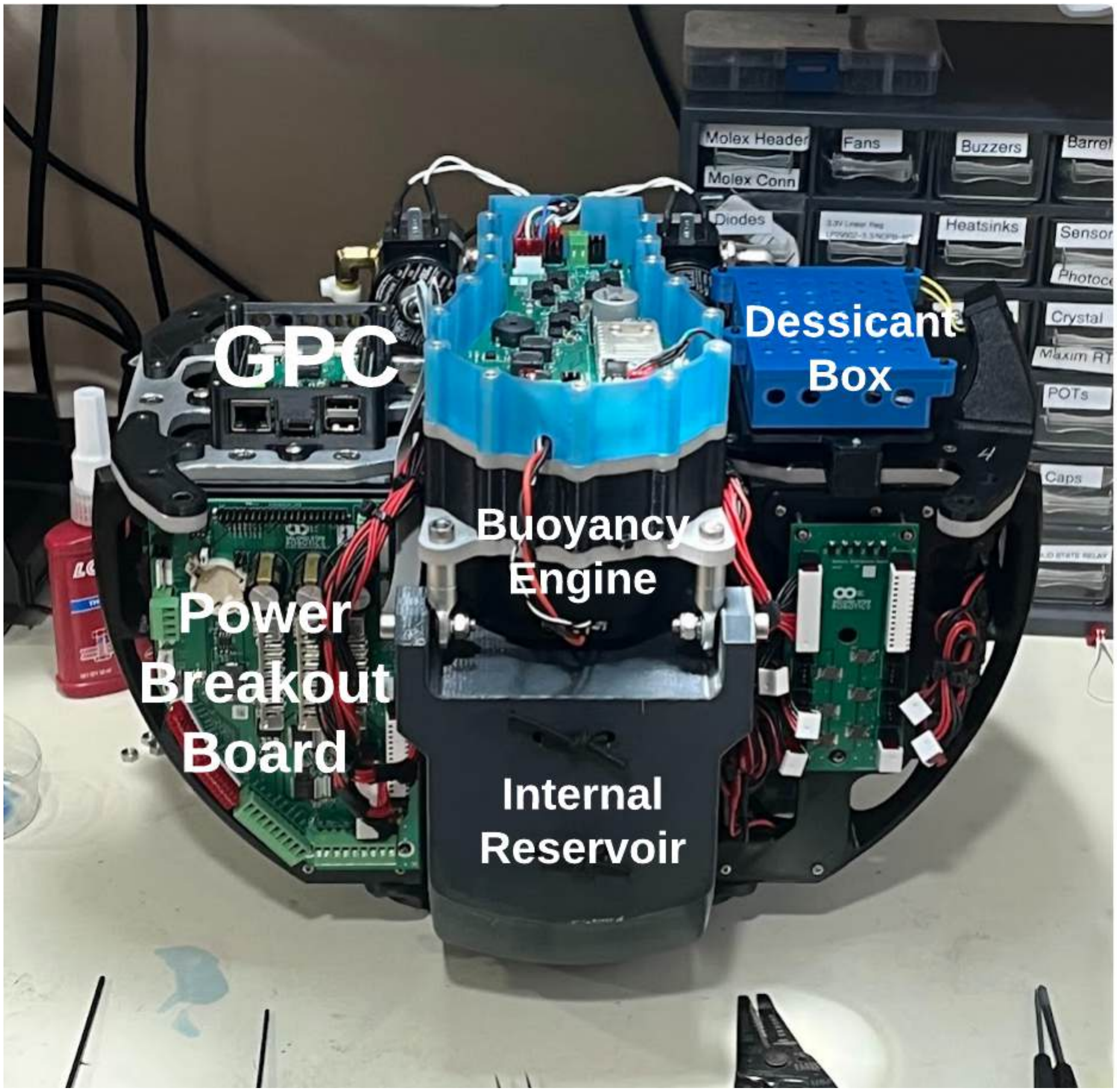


Figure 10.5: The internal assembly resting on a workbench with major components labeled.

10.2 Sphere Closing Procedure

It is important to carefully seal the sphere as the sphere provides floatation and protects sensitive internal components from the elements.

1. Clean glass interface with alcohol.
2. Replace desiccant inside the Desiccant Box (see Figure 10.5) with fresh desiccant.
3. Group bulkhead wiring together in the corner of the hemisphere as shown. Ensure all bulkhead cables are neatly bundled on the top mounting bracket.

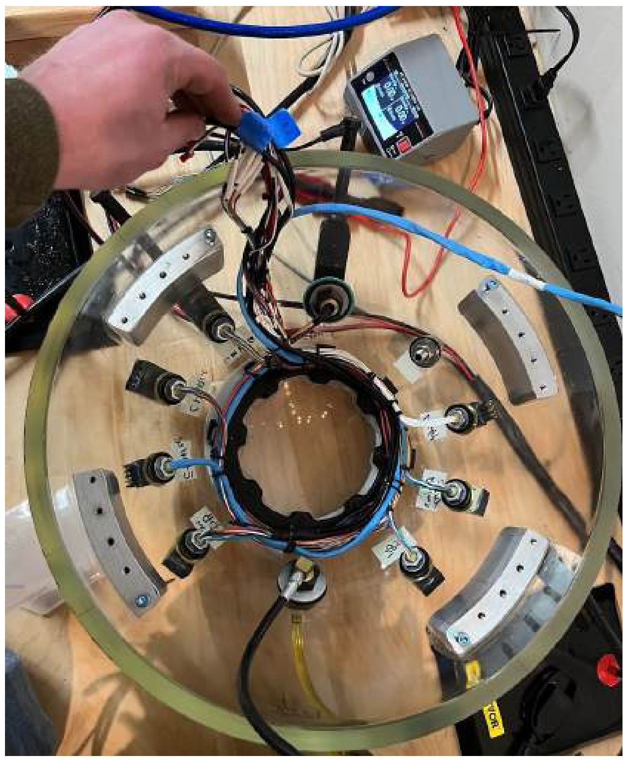


Figure 10.6: Bulkhead electrical cables should be bundled together in the front left corner of the top hemisphere.

4. Carefully place the internal assembly upside down onto the sphere hard mounts and align the bolt holes.
5. Apply loctite to the bolts and screw them into the sphere hard mounts to secure the assembly.
6. Reconnect the high pressure hose wrapping it around the pressure gauge securing it with cable ties as shown in Figure 10.4. Use two wrenches to tighten the high pressure hose onto the buoyancy engine's high pressure port. Ensure that the high pressure hose is not in contact with the Internal Reservoir as this could cause accuracy problems with the oil sensor.

7. Connect all bulkhead connectors to the Power Breakout Board ensuring that they are secure and not in contact with the Internal Reservoir.
8. Reconnect the ethernet cable through the couple to the GPC and lay it in front of the Internal Reservoir.
9. Clean glass hemisphere interface if needed and use compressed air to blow away dust on the internal assembly and sphere mating surfaces.
10. Mate sphere halves gently and adjusts alignment by making sure that the hemispheres are well centered over each other.
11. Pull vacuum until the internal manometer reads 5 psi. NEVER tape spheres before pulling vacuum.
    a. Release vacuum through the desiccant filter to dry the air at least three times through an air dryer if possible.
12. Adjust vacuum to 1.5 to 2 psi.
13. Wrap the interface with one layer of butyl rubber tape over the sphere interface with 3 cm overlap.
14. Wrap vinyl tape around the butyl rubber at least three times.
15. Reassemble the frame around the sphere. Using Anti-Seize on all fasteners and do not over tighten the joining elements as they are designed to accommodate a variation of sphere sizes. Tighten all bolts equally until the sphere no longer spins within the frame.

10.3 Procedure for Adding Mineral Oil

The buoyancy engine system is designed to accommodate 1 gallon of food grade mineral oil (McMaster Carr P/N 3190K628). It is recommended that this oil be degassed in vacuum over 24hrs to reduce dissolved gasses within the oil interfering with the buoyancy engine pump. In general it is best to avoid adding air to the oil system to allow the engine to function better under high pressure. The system is tolerant to some trapped air however. Please use the following procedure when adding new oil to the system:

1. Pump all oil out of the internal reservoir into the external reservoir using the procedure described in section 9: SHIPPING. Overfilling the system can cause the internal or external reservoir to rupture.
2. After all oil has been removed from the internal reservoir, disconnect the external reservoir from the buoyancy control sphere and drain into a bucket for disposal down the drain.
3. Siphon oil from a 1 gallon degassed oil container into the empty external reservoir. Use of a bubble trap is recommended but not required if care is used to keep air out of the system.
4. After oil has been added follow the ballasting procedure in section 3.3 Ballast Adjustment.

Figure 10.7: Oil being siphoned out of a 1 gallon jug into the external reservoir. Ensure that most of the oil has been added to the reservoir.

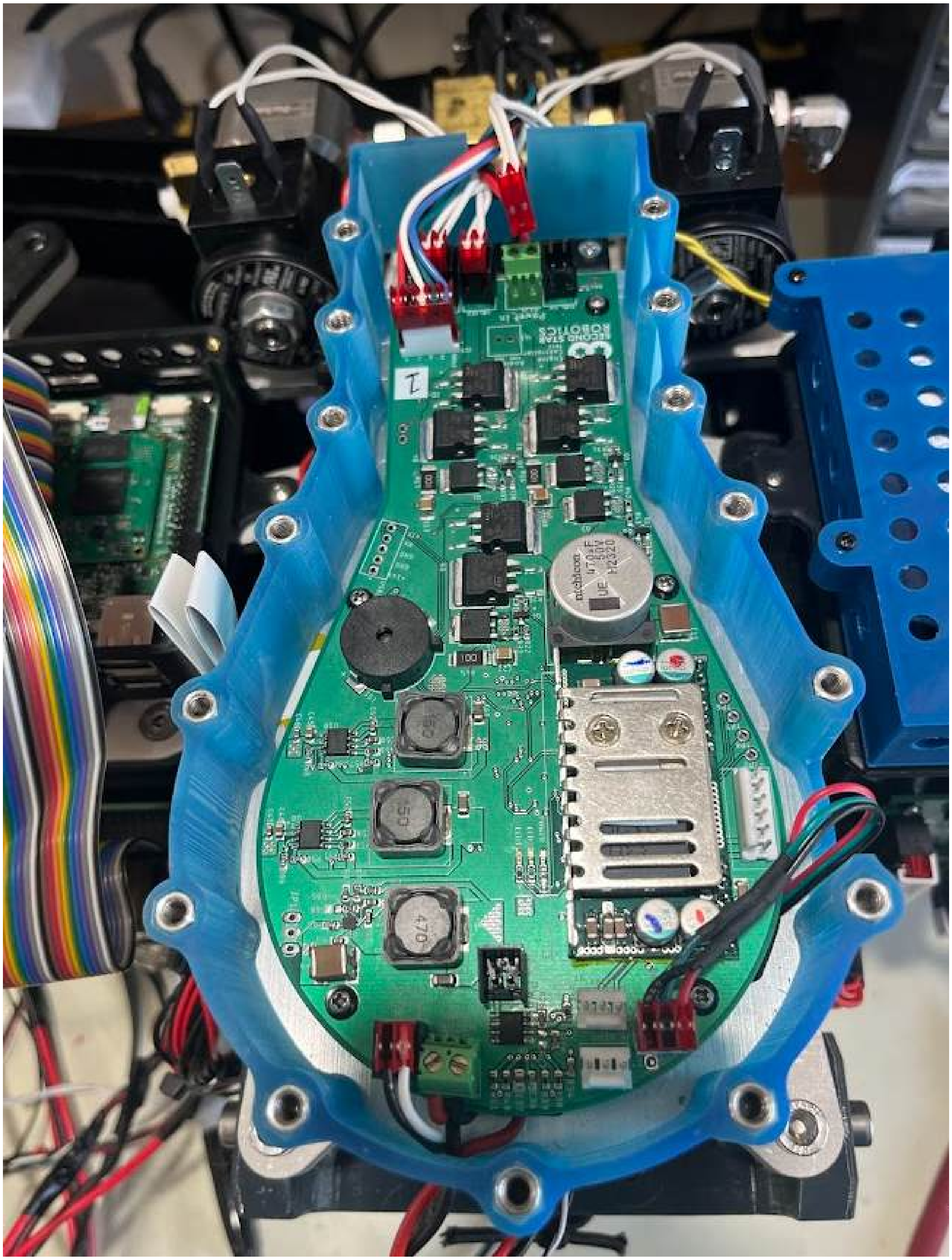


Figure 10.8: A reference photo of the engine controller showing all required electrical connections.

11. BATTERY SYSTEM AND SAFETY

The battery system for the Drifter is designed to allow safe, reliable use over the platform's service life. Because the battery system is costly and holds a large amount of stored energy, it is recommended that care be taken to avoid damage of equipment or injury. If seawater (not oil) or venting is observed within the sphere do not approach the platform. In general the following is recommended.

11.1 Storage

- Store batteries at room temperature avoiding extreme temperatures as they can reduce battery performance.
- Batteries will very slowly discharge over time. If the platform will not be in use utilize the "Storage" function on the smart charger which will maintain a 50% State of Charge to maximize battery cell life. Use the following procedure to connect the battery to the chargers in battery storage mode:

1. Connect both the high side and low side to battery smart chargers.
2. On each charger press the CH button to select Channel 1
3. Press the selection wheel to configure channel 1 on the charger and use the following settings to put the battery in storage mode.
    a. Task: Storage
    b. Battery Type: LiIon (for Lithium Ion)
    c. Cell Voltage: 4.15V
    d. Cell Count: 5S (18V)
    e. Current Setting: 1.0A
4. Press "Start Task" on each charger.
5. The charger will prompt "Perform Task Without Balancer". Press "Yes" as the battery system is self balancing.
6. Leave the chargers connected to the batteries in Storage mode for long term storage and battery maintenance.

11.2 Transport

- The battery system in the Drifter GPSP is large and when shipping the platform may be considered Hazmat. Comply with all regulations regarding transport of the battery system.
    - For air transport reference FAA regulations and International Air Transport Association (IATA) Regulations.

- For US Domestic Ground Transport refer to US Department of Transportation (DOT) hazardous materials regulations.
- For Sea Based Transport please refer to International Maritime Dangerous Goods (IMDG) regulations.

11.3 Charging Considerations

- Follow the procedure in 3.1 to ensure safe charging.
- Do not charge the batteries at a current greater than 5A to avoid triggering the overcurrent protection on the battery system.
- Do not charge the batteries in extreme cold or hot temperatures.
- Do not charge the batteries for long periods of time unsupervised.

11.4 Sea Water Ingress

Seawater ingress due to damage (eg. watercraft collision) or improper resealing of the sphere is a unique danger which requires extreme caution. Exposure of the Drifter's battery or electrical system to sea water may cause rapid hydrolysis and generation of hydrogen and oxygen with extreme risk for explosion. Symptoms are water (not oil) coupled low pressure on the internal vacuum gauge indicating the housing seal has been compromised.

Great care should be taken before deployment of the platform during sphere sealing or bulkhead o-ring replacement to ensure that the sphere is properly sealed and the vacuum is not compromised.

If seawater ingress is suspected, use extreme caution when handling the platform and check the status of the vacuum gauge. Although this failure mode is unlikely, it is recommended that users, deck crew, and folks in charge be made aware of the danger, and a protocol be put in place in the case of seawater ingress.

Example Safety Protocol:

> If seawater ingress is suspected or detected upon recovery of the platform, return the platform to the water or if that is not possible evacuate the immediate area around the platform.

11.5 Low Battery Charging and Battery Protection Reset

It is recommended that the user not fully discharge the system as this stresses the cells and reduces the cycle life and performance of the battery. If the battery system has been fully discharged it may be in a protection fault condition. This is a normal function of the battery to protect the battery system's cells from discharging to a level that will damage the cells. Please follow the following procedure to reset the battery protection system. To complete this procedure you will need the Drifter GPSP, the battery power supply adapter (XT60H Male), charge cable, and constant current/voltage DC regulated power supply. This procedure is recommended any time the battery system has been fully discharged:

1. Set the voltage on the DC supply to 20.75V.
2. Set the DC supply to constant current mode and set the current to 0.1A.
    a. Normally this is done by adjusting the current to 0A and shorting the output terminals of the supply while adjusting the current up to a level of 0.1A.
3. Using the battery connector adapter, connect the battery to the power supply with the correct polarity (reversing the battery polarity on the supply could damage both the supply and the battery).
4. Power the supply and note the battery voltage and current.
    a. A supply voltage of >12V at 0.1A indicates that the battery protection system has reset and the battery system is taking a charge.
    b. If the battery system does not reset please contact Second Star Robotics.
5. Allow the battery to charge on the power supply for 5 minutes.
6. Disconnect the battery from the supply and connect it to a Smart Charger.
7. On the battery charger press the CH button to select Channel 1
8. Press the selection wheel to configure channel 1 on the charger. When the battery is fully discharged the cells may be out of balance. It is recommended that the battery be recharged at a low rate to allow the cells to balance.
    a. Task: Charge
    b. Battery Type: LiIon (for Lithium Ion)
    c. Cell Voltage: 4.15V
    d. Cell Count: 5S (18V)
    e. **Current Setting: 0.1A**
9. Press "Start Task" on each charger.
10. The charger will prompt "Perform Task Without Balancer". Press "Yes" as the battery system is self balancing.
    a. If the battery charger issues a fault condition, it may require additional time on the power supply.
11. Allow the battery to charge slowly at 0.1A.

APPENDIX A: CONFIGURATION REGISTERS

Register Address	Register Name	Example	Size [Bytes]
0	Date		4
1	PlatformId	8	4
2	Mission Start Date	0	4
3	Mission Start Timer	300	4
4	End Mission Setpoint	0	4
5	End Mission Timer	3600	4
6	TopsideId	15	4
7	HIL Mode Enable	0	4
8	max_freq	200000	4
9	Enable Sensor 1 (Duty Cycle)	0	4
10	Ton Sensor 1	2700	4
11	Toff Sensor 1	900	4
12	Enable GPC	1	4
13	Enable GPC Record	1	4
14	Ton GPC	2700	4
15	Toff GPC	900	4
16	Enable Release	0	4
17	Ton Release	0	4
18	Toff Release	0	4
19	Data Backed Up	1	4
20	Depth 1 Start Timer	0	4
21	Depth 2 Start Timer	-1	4
22	Depth 3 Start Timer	-1	4
23	Depth 4 Start Timer	-1	4
24	Depth 5 Start Timer	-1	4
25	Depth 6 Start Timer	-1	4
26	Depth 7 Start Timer	-1	4
27	Depth 8 Start Timer	-1	4
28	Depth 9 Start Timer	-1	4
29	Depth 10 Start Timer	-1	4
30	Depth 11 Start Timer	-1	4
31	Depth 12 Start Timer	-1	4
32	Depth 13 Start Timer	-1	4
33	Depth 14 Start Timer	-1	4
34	Depth 15 Start Timer	-1	4
35	Surface 1 Start Timer	7200	4
36	Surface 2 Start Timer	18000	4
37	Surface 3 Start Timer	27700	4
38	Surface 4 Start Timer	-1	4
39	Surface 5 Start Timer	-1	4
40	Surface 6 Start Timer	-1	4
41	Surface 7 Start Timer	-1	4
42	Surface 8 Start Timer	-1	4
43	Surface 9 Start Timer	-1	4
44	Surface 10 Star Timer	-1	4
45	Surface Interval 1	1800	4
46	Surface Interval 2	1800	4
47	Surface Interval 3	1800	4
48	Surface Interval 4	0	4
49	Surface Interval 5	0	4

Register Address	Register Name	Example	Size [Bytes]
50	Surface Interval 6	0	4
51	Surface Interval 7	0	4
52	Surface Interval 8	0	4
53	Surface Interval 9	0	4
54	Surface Interval 10	0	4
55			4
56	Depth Mission Start Enable	0	4
57	Depth Mission Start Low Threshold	0	4
58	Depth Mission Start High Threshold	0	4
59	Depth End Mission Enable	1	4
60	Depth End Mission Low Threshold	800	4
61	Depth End Mission High Threshold	32768	4
62			4
63			4
64			4
65			4
66			4
67			4
68			4
69			4
70			4
71	Depth Release Enable	0	4
72	Depth Release Low Threshold	0	4
73	Depth Release High Threshold	0	4
74			4
75			4
76			4
77			4
78			4
79			4
80			4
81			4
82			4
83			4
84			4
85			4
86			4
87			4
88			4
89			4
90			4
91			4
92	Battery Mission Start Enable	0	4
93	Battery Mission Start Low Threshold	0	4
94	Battery Mission Start High Threshold	0	4
95	Battery End Mission Enable	1	4
96	Battery End Mission Low Threshold	0	4
97	Battery End Mission High Threshold	3021	4
98			4
99			4
100			4

Register Address	Register Name	Example	Size [Bytes]
101			4
102			4
103			4
104			4
105			4
106			4
107	Battery Release Enable	0	4
108	Battery Release Low Threshold	0	4
109	Battery Release High Threshold	0	4
110			4
111			4
112			4
113			4
114			4
115			4
116			4
117			4
118			4
119			4
120			4
121			4
122			4
123			4
124			4
125			4
126	Hard Release Time	600	4
127	Release Depth	65535	4
128	Release Time	2800	4
129	DST	0	4
130	Time Zone	0	4
131	Mission End Time of Day	0	4
132	Mission Start Time of Day	0	4
133			4
134			4
135			4
136			4
137			4
138			4
139			4
140			4
141			4
142			4
143			4
144			4
145			4
146			4
147			4
148			4
149			4
150			4
151	Camera Record Time End Mission Enabl	0	4

Register Address	Register Name	Example	Size [Bytes]
152	Camera Total Record Time	86200	4
153	GPC Daily Window A Enable	0	4
154	GPC Daily Window A Start Time	0	4
155	GPC Daily Window A End Time	0	4
156	GPC Daily Window B Enable	0	4
157	GPC Daily Window B Start Time	0	4
158	GPC Daily Window B End Time	0	4
159	Sensor 1 Total On Time	0	4
160	Sensor 1 Daily Window A Enable	0	4
161	Sensor 1 Daily Window A Start Time	0	4
162	Sensor 1 Daily Window A End Time	0	4
163	Sensor 1 Daily Window B Enable	0	4
164	Sensor 1 Daily Window B Start Time	0	4
165	Sensor 1 Daily Window B End Time	0	4
166	Record Length	0	4
167			4
168	Verbose Mode		4
169	Start Mission Sensor Delay Timer	0	4
170	Beacon Pre Mission Enable	0	4
171	Beacon Mission Enable	0	4
172	Beacon Post Mission Enable	0	4
173	Beacon Pulse Time	100	4
174	Beacon Time Between Pulses	5	4
175			4
176			4
177			4
178			4
179			4
180	GPC On Time 1	0	4
181	GPC On Time 2	0	4
182	GPC On Time 3	0	4
183	GPC On Time 4	0	4
184	GPC On Time 5	0	4
185	GPC On Time 6	0	4
186	GPC Off Time 1	0	4
187	GPC Off Time 2	0	4
188	GPC Off Time 3	0	4
189	GPC Off Time 4	0	4
190	GPC Off Time 5	0	4
191	GPC Off Time 6	0	4
192	Sensor 1 On Time 1	0	4
193	Sensor 1 On Time 2	0	4
194	Sensor 1 On Time 3	0	4
195	Sensor 1 On Time 4	0	4
196	Sensor 1 On Time 5	0	4
197	Sensor 1 On Time 6	0	4
198	Sensor 1 Off Time 1	0	4
199	Sensor 1 Off Time 2	0	4
200	Sensor 1 Off Time 3	0	4
201	Sensor 1 Off Time 4	0	4
202	Sensor 1 Off Time 5	0	4

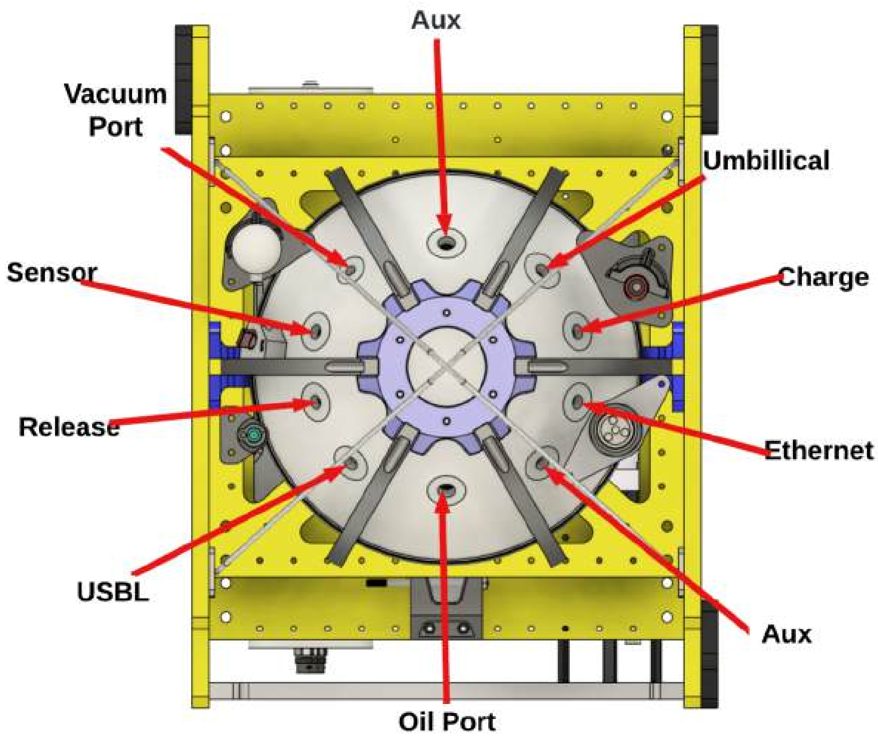
Register Address	Register Name	Example	Size [Bytes]
203	Sensor 1 Off Time 6	0	4
204	Enable GPC Event Windows	0	4
205	Enable Sensor 1 Event Windows	0	4
206	Sensor 1 to GPC Synch Enable	0	4
207	Sensor 1 Synch on Delay Time	0	4
208			4
209			4
210	Platform 1 Address		4
211	Platform 2 Address		4
212	Platform 3 Address		4
213	Platform 4 Address		4
214	Platform 5 Address		4
215	Platform 6 Address		4
216	Platform 7 Address		4
217	Platform 8 Address		4
218	Platform 9 Address		4
219	Platform 10 Address		4
220	Platform 11 Address		4
221	Platform 12 Address		4
222	Platform 13 Address		4
223	Platform 14 Address		4
224	Platform 15 Address		4
225	USBL Fix Period		4
226	USLB Fix Start Delay		4
227			4
228			4
229			4
230			4
231			4
232			4
233			4
234			4
235			4
236	Saved Position	0	4
237			4
238			4
239			4
240			4
241			4
242			4
243			4
244			4
245			4
246			4
247			4
248			4
249			4
250			4
251			4
252			4
253	Encoder Position		4

Register Address	Register Name	Example	Size [Bytes]
254	Position		4
255	Motor Speed		4
256	Depth 1	100	4
257	Depth 2	-10	4
258	Depth 3	-10	4
259	Depth 4	-10	4
260	Depth 5	-10	4
261	Depth 6	-10	4
262	Depth 7	-10	4
263	Depth 8	-10	4
264	Depth 9	-10	4
265	Depth 10	-10	4
266	Depth 11	-10	4
267	Depth 12	-10	4
268	Depth 13	-10	4
269	Depth 14	-10	4
270	Depth 15	-10	4
271	Velocity 1	0.04	4
272	Velocity 2	0.04	4
273	Velocity 3	0.04	4
274	Velocity 4	0.04	4
275	Velocity 5	0.04	4
276	Velocity 6	0.04	4
277	Velocity 7	0.04	4
278	Velocity 8	0.04	4
279	Velocity 9	0.04	4
280	Velocity 10	0.04	4
281	Velocity 11	0.04	4
282	Velocity 12	0.04	4
283	Velocity 13	0.04	4
284	Velocity 14	0.04	4
285	Velocity 15	0.04	4
286			4
287			4
288			4
289			4
290			4
291			4
292			4
293			4
294			4
295			4
296			4
297			4
298			4
299	dt	1	4
300	Kp_z	0.001	4
301	Ki_z	0	4
302	Kd_z	0	4
303	i_window_z	100	4
304	epsilon_z	0	4

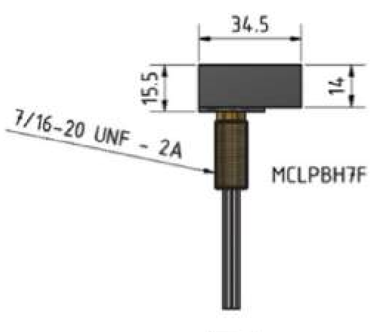
Register Address	Register Name	Example	Size [Bytes]
305	max_w	0.04	4
306	min_w	-0.04	4
307	min_ctrl_z	0	4
308			4
309			4
310			4
311			4
312			4
313			4
314			4
315			4
316			4
317			4
318			4
319			4
320	Ki_w	-5	4
321	max_Nabla	3600	4
322	min_Nabla	0	4
323	Zw	-5	4
324	Zww	0	4
325	rho	1.02	4
326	ag	9.8	4
327	min_err_accum_w	1	4
328	off_adjust_thresh_w	1	4
329	Zw_i	0	4
330	Zww_i	0	4
331			4
332			4
333			4
334			4
335			4
336			4
337			4
338			4
339			4
340	Kp_Nabla	0.25	4
341	Ki_Nabla	0	4
342	Kd_Nabla	0	4
343	i_window_Nabla	0	4
344	epsilon_Nabla	0	4
345	max_Qv_Nabla	0.555	4
346	min_Qv_Nabla	-0.555	4
347	min_ctrl_Nabla	0.0005	4
348	Nabla_b0	0	4
349	Nabla_P0	101.3199	4
350			4
351			4
352			4
353			4
354			4
355			4

Register Address	Register Name	Example	Size [Bytes]
356			4
357			4
358			4
359			4
360	Control to Hibernate depth threshold	1	4
361	Control to Hibernate velocity threshold	0.001	4
362	Hibernate to Control depth threshold	52	4
363	Dive to Control depth threshold	4	4
364	Surface to Interval depth threshold	2	4
365	Interval to Fault depth threshold	20	4
366	oil_low_thresh	500	4
367	oil_high_thresh	2800	4
368			4
369			4
370	2nd order Oil Calibration Constant (a)		4
371	1st order Oil Tare Offset (b)		4
372	Oil Cabiration Offset (c)		4
373			4
374			4
375			4
376			4
377			4
378			4
379			4
380			4
381			4
382	Command Displaced Volume		4
383	Set Displaced Volume		4
384			16384
385			16384
386			16384
387			16384
388			16384
389			16384
390			16384
391			16384
392			16384
393			16384
394			16384
395			16384
396			16384
397			16384
398			16384
399			16384
400			16384
401			16384
402			16384
403			16384
404	**Data Header**	text here	512
405	**Data Sample 1**		512
406			512

APPENDIX B: BULKHEAD PINOUTS

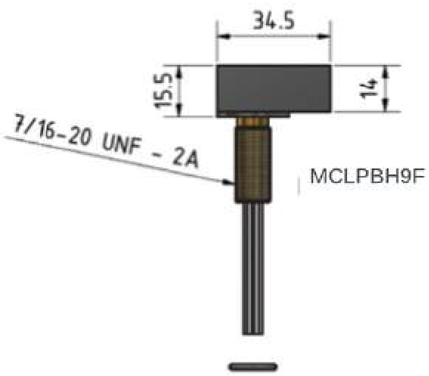


T2 USBL



Bulkhead Connections	Drifter Breakout Board Connections
1: Black	U1TX (USBL Pin 5)
2: White	U1RX (USBL Pin 4)
3: Red	N/C
4: Green	GND (USBL Pin 2)
5: Orange	+14V (USBL Pin1)
6: Blue	N/C
7: White/black	N/C
8: Red/black*	N/C
9: Green/black	N/C
10: Orange/black**	N/C

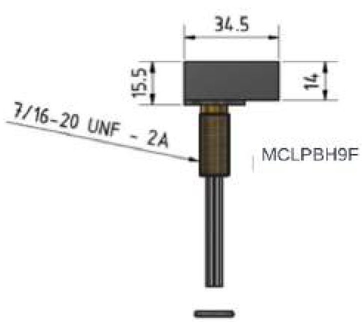
T3 RELEASE/JTAG



Bulkhead Connections	Drifter Breakout Board Connections
1: Black	NO-CONNECTION - 6
2: White	PGC-5
3: Red	PGD-4
4: Green	VSS (GND) -3
5: Orange	VDD (TARGET VOLTAGE) -2
6: Blue	MCLR-1
7: White/black	+V_RELEASE
8: Red/black*	GND
9: Green/black	N/C
10: Orange/black**	N/C

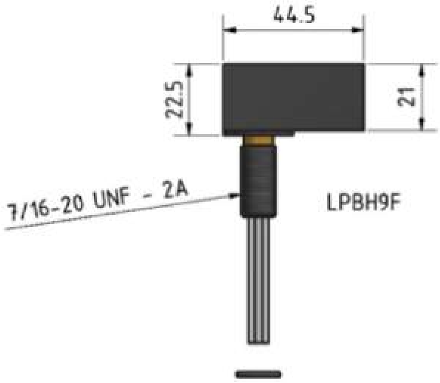
T4 SENSOR PAYLOAD 1

Electrically Connected to T6 pins



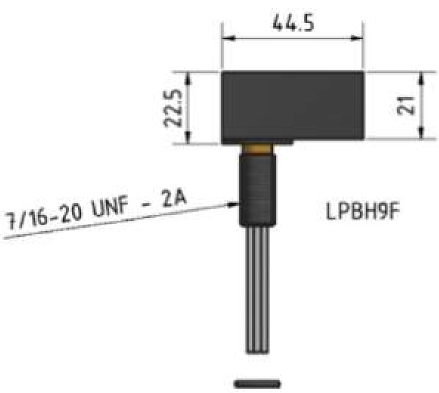
Bulkhead Connections	Drifter Breakout Board Connections
1: Black	GPC UART2 TX
2: White	GPC UART2 RX
3: Red	GPC UART4 TX
4: Green	GND
5: Orange	GPC UART4 RX
6: Blue	V Payload 1 (12V)
7: White/black	V Payload 2 (12V)
8: Red/black*	GND
9: Green/black	GND
10: Orange/black**	N/C

T7 UMBILLICAL



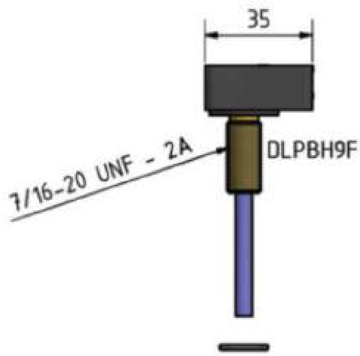
Inline cable colour code	Drifter Breakout J1 Umbillical Header
1: Black	GND1
2: White	GND2
3: Red	+VBATT_EXT1
4: Green	+VBATT_EXT2
5: Orange	VPP_CS1
6: Blue	VPP_CS2
7: White/black	AUX0
8: Red/black	AUX1
9: Green/black	AUX2

T8 CHARGE



Inline cable colour code	Drifter Breakout J2 Charge Prog Header
1: Black	GND1
2: White	GND2
3: Red	+VBATT1
4: Green	+VBATT2
5: Orange	BATTERY_SPLIT1
6: Blue	CABLE_DETECT
7: White/black	U2TX_PROG
8: Red/black	U2RX_PROG
9: Green/black	VPP

T9 ETHERNET



Face view (male)

Inline cable colour code

1-2: Brown, Brown/white*
3-4: Blue, Blue/white*
5-6: Orange, Orange/white*
7-8: Green, Green/white*
9: Screen (orange wire on bulkhead)