SeaSPY2 Gradiometers

Quick Start Guide

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1 Introduction

The SeaSPY2 gradiometer system consists of two SeaSPY2 Overhauser marine magnetometers that can be used individually or as a gradiometer pair when mounted on a 1.5m-wide gradiometer frame (transverse gradiometer), or connected by the inter-fish cable (longitudinal gradiometer). Each of the magnetometer towfish may also be equipped with depth sensor, altimeter and leak detector.

The horizontal aluminum frame is light-weight and robust, while offering very low drag.

A Y-split tow cable adapter is used to connect the gradiometer pair to the common tow cable, or side scan sonar integration cable. When used independently, each SeaSPY2 magnetometer can be connected directly to either a tow cable or a side scan integration cable.

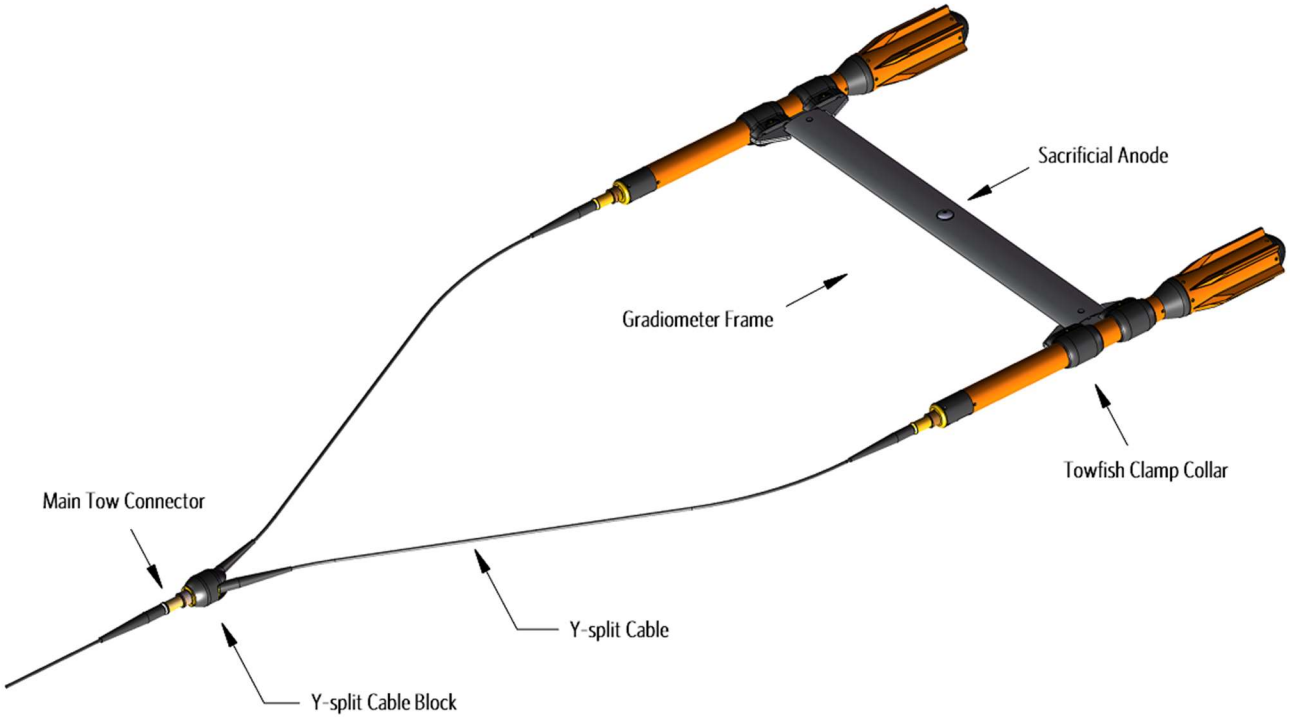


Figure 1-1 – SeaSPY2 Horizontal Transverse Gradiometer assembly

Each SeaSPY2 magnetometer may be equipped with a 200 kHz single-beam echo sounder altimeter. When two SeaSPY2 units are used as a pair, one of the SeaSPYs must be oriented such that its altimeter transducer points sideways or upwards to prevent mutual interference.

The communication interface for both transverse and longitudinal gradiometers is handled by the Isolation Transceiver configured to work in Gradiometer Mode. The Isolation Transceiver provides a stable and isolated power supply as well as a data telemetry link to the connected SeaSPY magnetometers.

When used in gradiometer mode, the transceiver does not distinguish between the transverse and longitudinal arrangements for the purpose of communication, and always refers to the two units as Forward/FT or Rear /RT, based on the unit serial numbers configured when setting up the gradiometer mode.

The transceiver also monitors the timing of the magnetometer readings and synchronizes the SeaSPY's to UTC/GPS time using the integrated GPS receiver.

2 System components

By default, all communication with the magnetometer towfish happens via the Isolation Transceiver, which inserts an intelligent layer between data logging software and the magnetometer. The transceiver supplies optimal power to the magnetometer, and assumes complete control over communication link over the tow cable, as well as time synchronization of the magnetometer's internal clock.

2.1 Transceiver RS232 Serial interface

The connection between the data logging computer and the Transceiver is via RS232 (or USB/Virtual COM port) interface, using:

- 115200 baud
- 8-N-1 (8 data bits, No parity, 1 stop bit)

Communication is full-duplex. Any commands that are sent to the SeaSPY2 while it is transmitting will not disrupt the transmission.

When using the supplied USB cable, the transceiver's integrated RS232-USB converter is used, which emulates a virtual COM port with the same settings.

When you send a command to transceiver, you may get a response even if there is no magnetometer connected. For example, you can query and set the transceiver's internal time and date without the magnetometer connected. As soon as you connect the magnetometer, the transceiver will recognize the towfish, and set its internal clock as necessary.

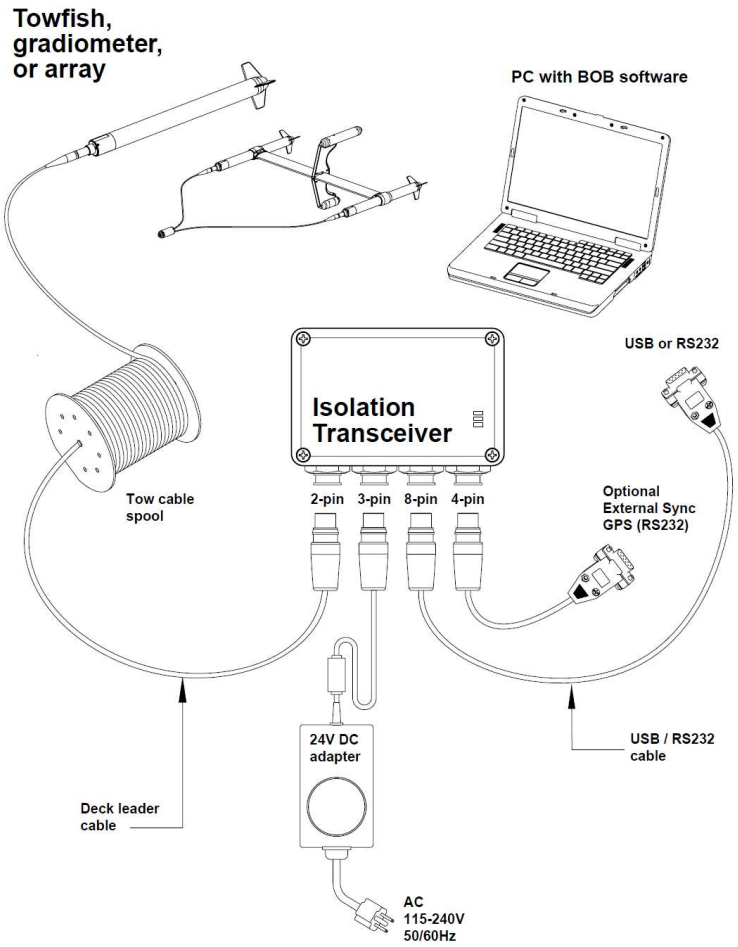


Figure 2-1 - Connection Diagram for surface towed applications. The 24V DC adapter is required to power the Isolation Transceiver at all times during system operation.

2.2 GPS-Enabled Isolation Transceiver

Since 2023 all Marine Magnetics Isolation Transceivers contain an integrated GPS receiver, which enables automatic sync between the magnetometer system and GPS/UTC time. A dedicated LED on the top cover indicates whenever GPS lock/fix is obtained. And internal battery-powered clock in the transceiver maintains the correct time for several days after a successful GPS sync. An additional 4th connector is also available for connecting the **optional external RS-232 GPS**, for time synchronization purpose.

NOTE: GPS position is not used by the transceiver or the towfish. The external RS232 GPS (supplied by the user) must use 9600 baud, and must be capable of GGA and RMC NMEA data output, at a rate of 1Hz or higher.

Transceiver Status LEDs

The Isolation Transceiver has three status LEDs, indicating power, communication with towfish, and GPS lock as follows:

Table 2-1 - Status indicators for the GPS-Enabled isolation transceiver

Power LED	Orange	Towfish not connected/detected.
	Green	Towfish is detected and powered.
	Red	Fault condition. Or Transceiver disabled power to towfish.
Communications LED	Blue (flashing)	Data is being transmitted.
GPS Lock LED*	Blue (flashing)	Searching for GPS signal. No satellite lock.
	Blue (solid)	GPS satellite signal lock is obtained, and the transceiver is able to synchronize itself and the connected towfish to the GPS time.

2.3 Checking connectivity and communication

When the transceiver is first powered up, the *Power* LED will glow orange and it will transmit a brief identification message to the PC's serial port terminal program. If a magnetometer is detected, then the LED will turn green and the magnetometer's own identification header will also be displayed in the terminal. You will notice the *Comm* LED will flicker blue as data is transmitted between the magnetometer and the transceiver. Upon detection of the magnetometer towfish, the transceiver will automatically set the magnetometer's internal time.

A good way to check communication status is by checking battery voltage at the magnetometer with the **d** command. The **d** command provides important information about the status of both the transceiver and the magnetometer.

```
>| d
>| Output 45.6V, 062mA, 02.8W int:Lock(10ms)
>| FT:d:S:009 B:52.3V T:+32.1C D:-0000.1m
>| RT:d:S:006 B:54.9V T:+31.7C D:-0000.2m
```

The first line of data comes from the transceiver and represents the output power being provided to the magnetometer. The second line of data comes from the magnetometer itself and reports the status of integrated sensors as well as the voltage at the towfish end of the tow cable. The voltage should be at least +30VDC, otherwise communication may be erratic, and the magnetometer may not operate properly. The voltage drop between the transceiver and the magnetometer will depend on the length of your tow cable. The last parameter displayed will be a GPS signal lock (NoLock or Lock) and a time difference (ms) between the GPS time and the transceiver time.

(`int:` internal GPS `ext:` external GPS)

2.4 Transceiver Gradiometer Mode

The Isolation Transceiver needs to be configured to work in Gradiometer Mode in order to interface with SeaSPY gradiometers.

When in gradiometer mode, the transceiver does not distinguish between the transverse and longitudinal arrangements for the purpose of communication, but always refers to the two units as Forward/FT or Rear /RT, based on the unit serial numbers configured when setting up the gradiometer mode.

The gradiometer data string always includes the Front/Port side data first, following by the Rear/Starboard side unit data:

Format:

```
*DATE/TIME F[front unit data] R[rear unit data] difference
```

Example:

```
*24.232/19:39:00.0 F[049446.120 165 0382 -0000.1 015.47 G__] R[048787.477 133 0277 -0000.2 599.99 G__] +00658.643
```

To enter or exit gradiometer mode, send the **c** command to the transceiver via the terminal.
The same command can also be used to check the current unit arrangement order.

Example:

Sending the **c** command to the transceiver shows that:
it is currently in GRAD mode,
and that SN 14997 is configured as the Front/Port/Left side unit,
while SN 14998 is configured as Rear/Starboard/Right side unit.

```
<| c
>|
>| Current mode: GRAD - 2 Towfish
>| F Towfish: 14997
>| R Towfish: 14998
>| Switch to MAG mode (Y/N)?
<| n
>| Still in GRAD mode
```

Transceiver Firmware Updates

Beginning with version 2.21, the Isolation Transceiver firmware can be updated by the user, with the help of the Firmware Installer tool. Please refer to the following web page: https://marinemagnetics.com/install/syfi/public/default.htm

NOTE: Older firmware versions (older than v 2.34) require that the gradiometer mode be turned off (be sure to switch from grad mode to mag mode) and the GPS signal to be blocked before updating the firmware.

3 Gradiometer unit naming convention

The communication interface for both transverse and longitudinal gradiometers is handled by the Gradiometer Mode in the Isolation Transceiver. The Transceiver does not distinguish between the transverse and longitudinal arrangements for the purpose of communication, and always refers to the two units as Forward/FT or Rear /RT, based on the unit serial numbers configured when setting up the gradiometer mode. Please refer to the illustrations below.

NOTE: It is important to make a note of which unit serial number (SN) is positioned at Front/Port side and which SN is at the Rear/Starboard side during the system assembly, so that the data logging software can interface to these units in the correct order.

Figure 3-1 - Forward/Rear unit designation for the longitudinal gradiometer

Figure 3-2 - Forward (Port) and Rear (Starboard) unit designation for the Transverse gradiometer

4 Gradiometer Frame Assembly

The horizontal transverse gradiometer assembly involves installing the SeaSPY magnetometers into the frame collars, aligning both SeaSPY to be at the same position relative to the frame, aligning the altimeter transducers (one to point downward, and the other to point toward the outside, or upward), and tightening the clamps (do not over-tighten!)

The frame is symmetrical and does not have a preferred forward orientation. However the towfish collars contain bolts for clamping over the towfish only on one side (see Figure 4-2), that may be more convenient to adjust when facing upwards.

The plastic support stand can be used to help point the altimeter transducer downwards before tightening the frame collar clamp.

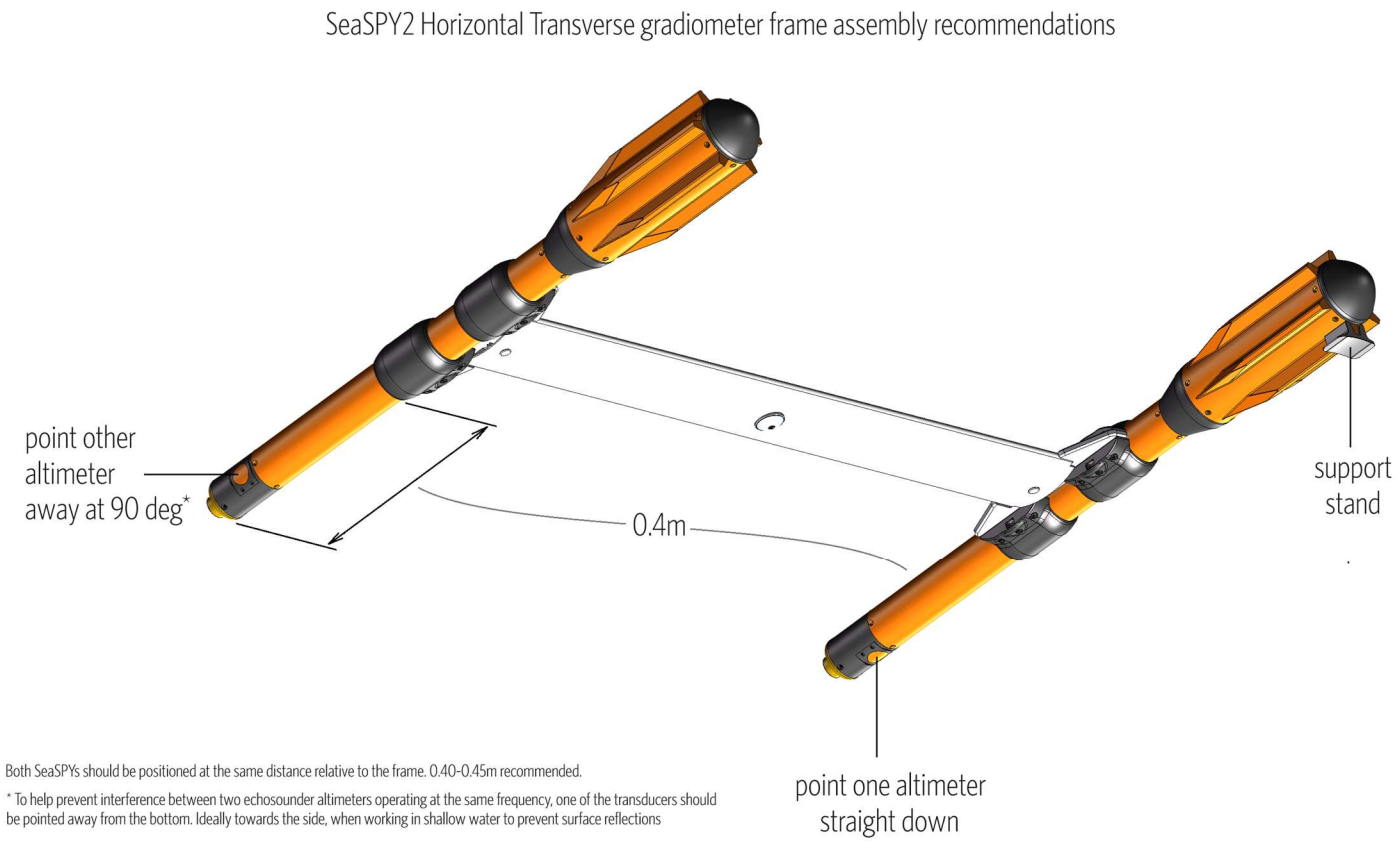


Figure 4-1 – Gradiometer frame assembly recommendations.

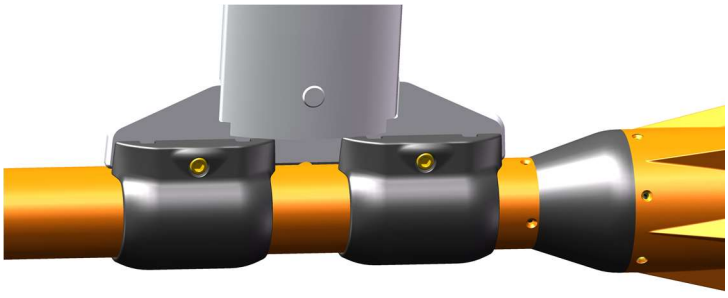


Figure 4-2 – Top side of each towfish collar clamp contains a single bolt (centered) that requires adjusting when clamping over the tube. The bottom side of the clamp has two bolts that affix the collar permanently to the frame and do not require adjusting.

The depth to which the SeaSPY gradiometer will sink when being towed through the water is controlled by the following factors:

1. Length of the tow cable deployed
2. Towing speed
3. Position of the SeaSPY relative to the frame (forward / back)
4. Weight of the tow cable (cable weights 3-10 kg can be used, positioned 10-30m ahead of the towfish).

The easiest way to help the gradiometer sink deeper during the survey is to deploy more tow cable, and to slow down the speed of towing (while monitoring the towfish altitude above bottom to help prevent striking the bottom and potentially causing damage to the system).

Frame position relative to the SeaSPY towfish can also be adjusted (at the time of frame assembly) to help modify the behavior of the gradiometer underwater. For most surveys, the recommended position of the frame on the towfish is 0.4m from the front of the brass nose cap to the front towfish collar clamp. This will ensure that the estimated depth to which the gradiometer will sink will be approximately 10% of the length of the tow cable when towed at a speed of 4 knots (8 km/h). (i.e. approximate depth = 5m when 50m tow cable is used).

Moving the SeaSPY forward relative to the frame will move the center of mass forward and ahead of the frame, and will help the gradiometer dive deeper, to a slightly lower equilibrium depth. Moving the SeaSPY back relative to the frame will move the center of mass behind the frame, angle the frame up, and help the gradiometer rise to a slightly shallower equilibrium depth.

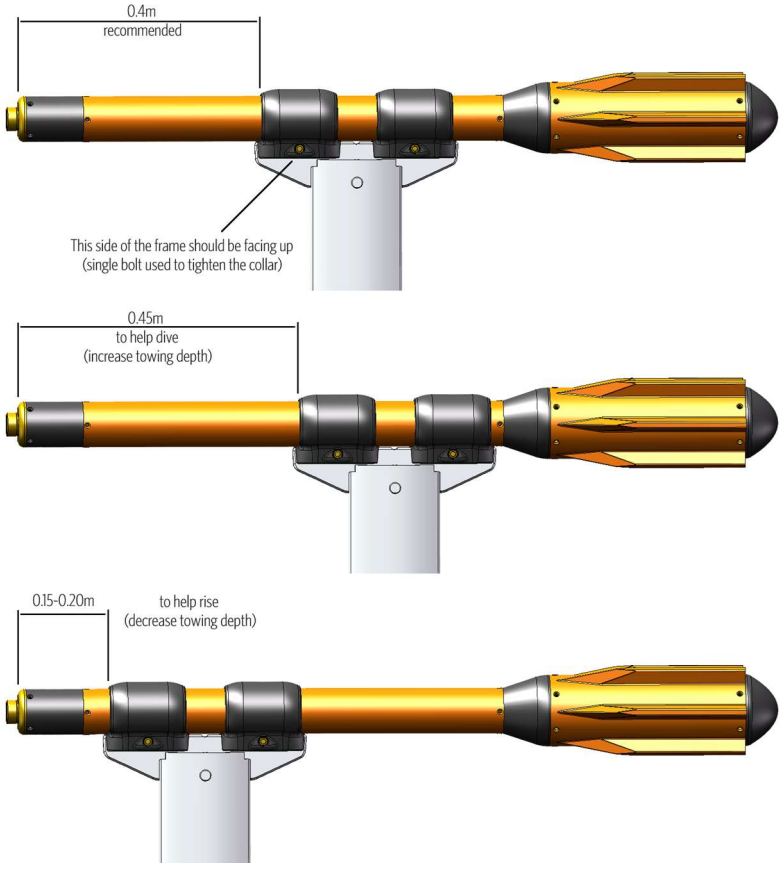


Figure 4-3

Figure 4-4 - Recommended frame positions for different towing depths

5 Operating the SeaSPY2 gradiometer system using BOB Software

Marine Magnetics BOB is the magnetometer interface software that provide data logging, survey planning and data corrections for all Marine Magnetics products. Additional processing and data visualization features can also be activated using the BOB Analytic Module (BAM) license. Free BOB software is available from the following URL: https://bob.marinemagnetics.com/

Described below are BOB Setup Assistant steps for configuring a new SeaSPY2 system survey.

5.1 Create a new survey and select the appropriate magnetometer type: SeaSPY2 Gradiometer

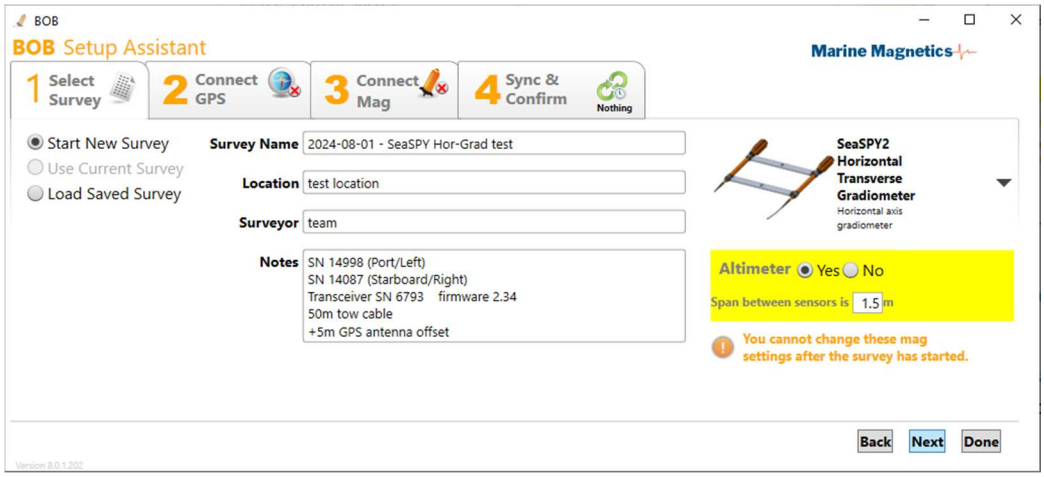


Figure 5-1 - Creating a new BOB survey project for the transverse gradiometer

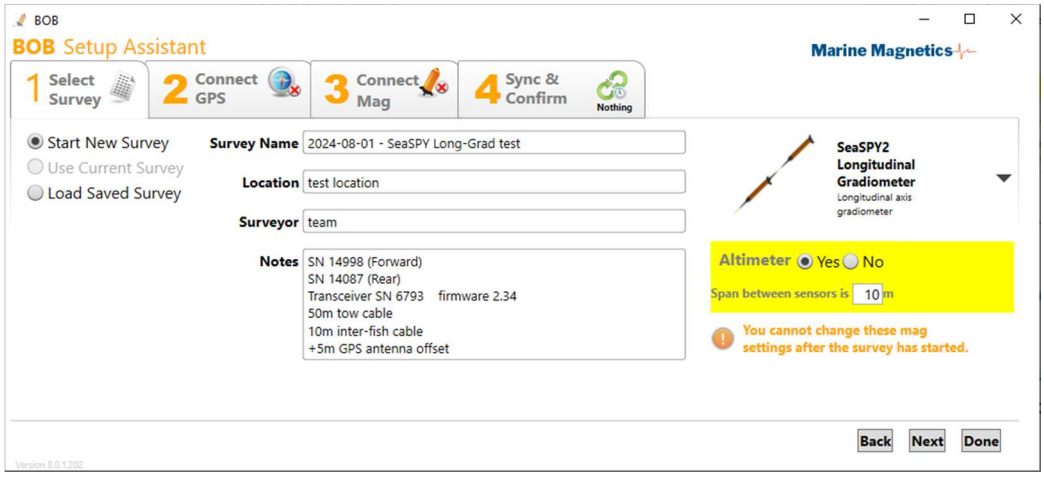


Figure 5-2 - Creating a new BOB survey project for the longitudinal gradiometer

NOTE: Gradiometer type and span cannot be changed after the survey has been created.

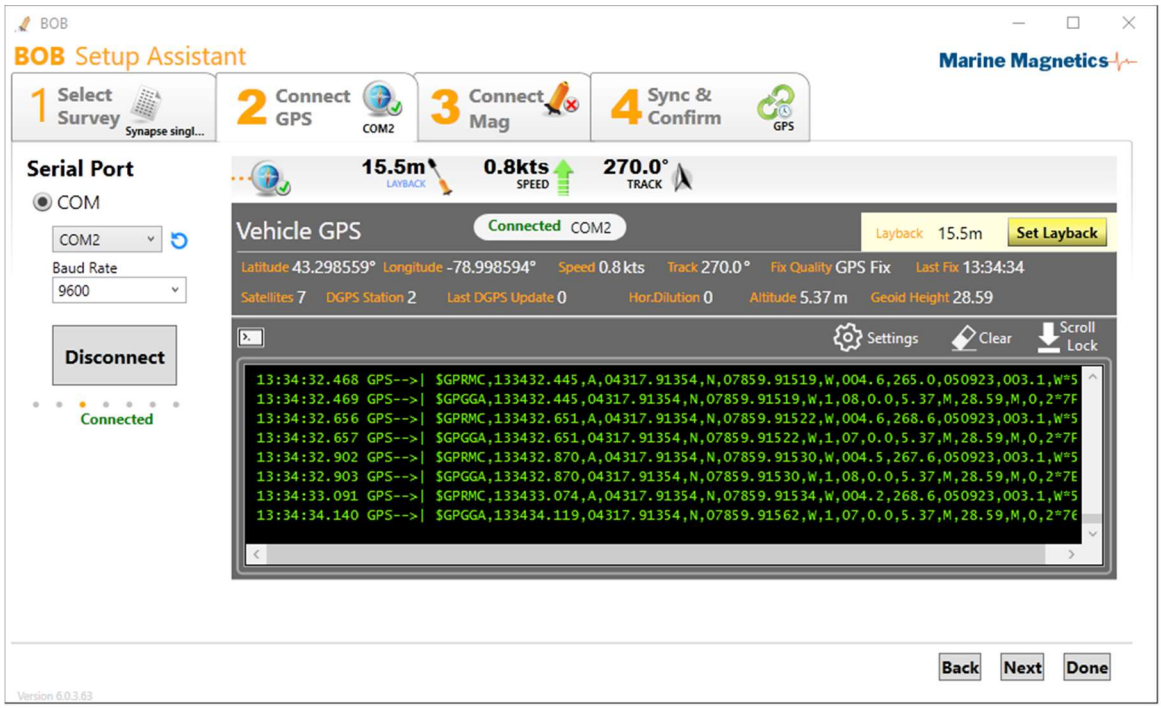
5.2 Connect to the survey GPS via COM port.

BOB supports RS-232 or USB (virtual COM port) GPS to capture vessel position data during the survey, and uses the layback offset to estimate the position of the towfish behind the vessel.

5Hz or higher update rate GPS is recommended for best response time during navigation.

Default Layback is set to 15.5m, and can be modified at this point or later via the BOB GeoPlot window, as well as during post-processing. Please refer to Section 0 for details on how Layback distance is determined.

NOTE: BOB uses only GGA and RMC NMEA data strings.



5.3 Layback distance estimation for optimal magnetometer positions

BOB software computes the position of the magnetometer sensor(s) during the survey using a combination of the fixed layback distance and the curve of the vessel's track. For gradiometers, BOB will also use the frame dimensions (or the inter-fish cable length) in order to compute individual positions of the units in a gradiometer. For best positional accuracy the lengths of all system components must be included when determining the total 'layback' distance between the GPS receiver mounted on the vessel, and the magnetometer sensor.

For all configurations, add the offset between the GPS receiver mounted on the vessel and the tow cable winch. For the transverse gradiometer, also add 2.5m for the Y-split adapter cable.

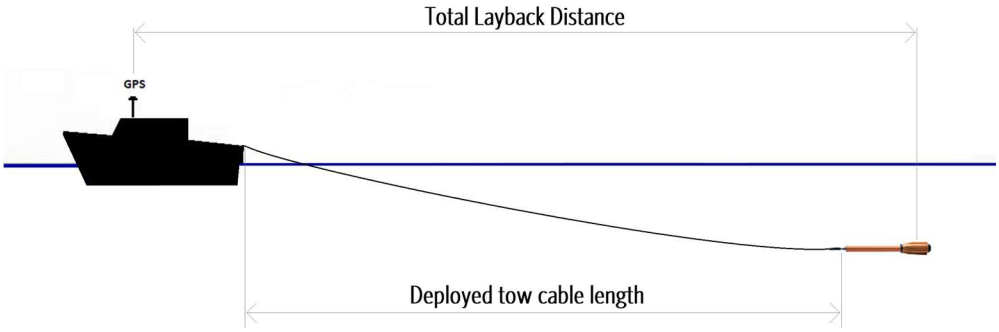


Table 5-1 – Layback distance estimation for surface towed magnetometers. Single magnetometer configuration shown. Add 2.5m offset for a transverse gradiometer with a Y-split cable.

When used in combination with a side scan sonar, the side scan integration cable length (5m-10m) needs to be combined with the length of the SeaSPY (1m) and the Y-split adapter cable (2.5m). The combined magnetometer offset from the side scan sonar tow connection point to the tail end of the magnetometer towfish (sensor location) amounts to 8.5m when the Y-split adapter cable is used with the gradiometer frame. When a single SeaSPY2 towfish is used without the Y-split adapter cable, the total magnetometer offset is 6m.

One additional unknown dimension must be accounted for in sidescan sonar integrations: the offset between the GPS receiver on the vessel, and the side scan integration cable tow point. If this distance can be approximated as a constant with an accuracy of +/- 0.5m, it may serve as sufficiently accurate initial estimate for layback calculations. Total layback can be fine-tuned during post-processing after initial magnetic field maps are generated, as part of the layback (lag) correction step.

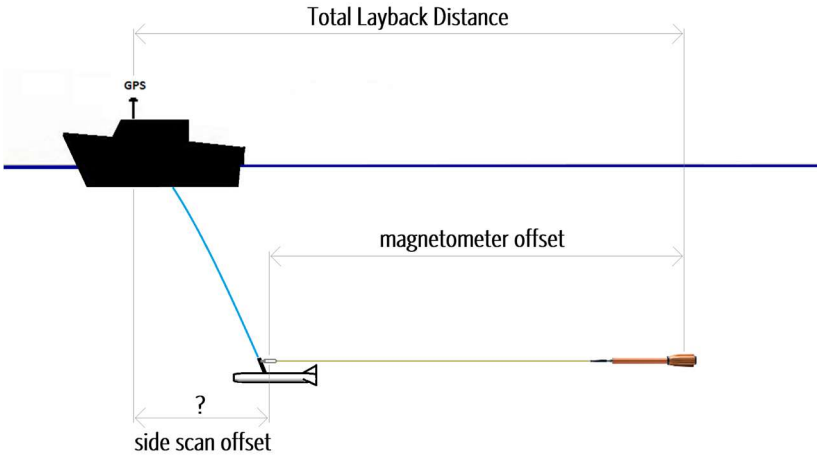


Table 5-2 - Layback distance estimation for side scan sonar integrations

5.4 Connect to the Magnetometer via COM port.

BOB supports RS-232 or USB (virtual COM port) connections, and communicates with the isolation transceiver. The isolation transceiver handles the communication with the towfish.

Use 115,200 baud rate for SeaSPY2 systems. Older isolation transceivers (prior to 2023) used 9600 baud rate. Refer to Section **Error! Reference source not found.** for details on RS-232 baud rate configuration.

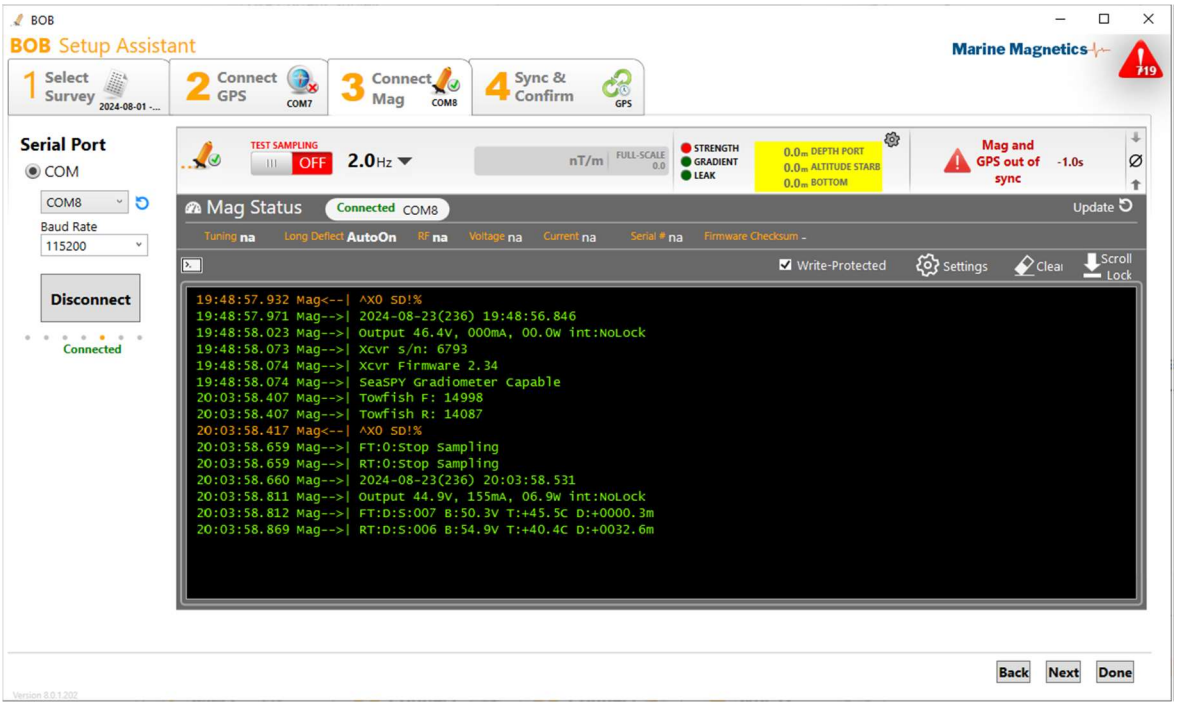


Figure 5-3 - Typical data output of a 2-node SeaSPY2 system during start-up

SeaSPY2 magnetometers will display a power-up header upon start-up, and may begin sending data readings automatically if sampling was enabled prior to the SeaSPY being last disconnected. Otherwise sampling needs to be stated by the operator.

The isolation transceiver can operate in one of two modes: MAG mode or GRAD mode.

In MAG mode, the transceiver expects to have one SeaSPY towfish connected to it, and the unit serial number isn't important.

In GRAD mode, the transceiver expects two SeaSPY towfish connected via a shared tow cable, and in this case it needs to know which serial numbers to use to communicate with the towfish.

Changing unit serial numbers:

Gradiometer systems come with GRAD mode enabled and pre-configured from the factory.
However it may be necessary to temporarily disable GRAD mode in some situations, or to change the unit serial numbers.
This can be accomplished by sending the **c** command to the transceiver via the mag terminal.

NOTE: If unit serial numbers aren't entered correctly, or if the tow cable is disconnected, the transceiver will display a "No data, check connection" message once per second as it polls the towfish connection.

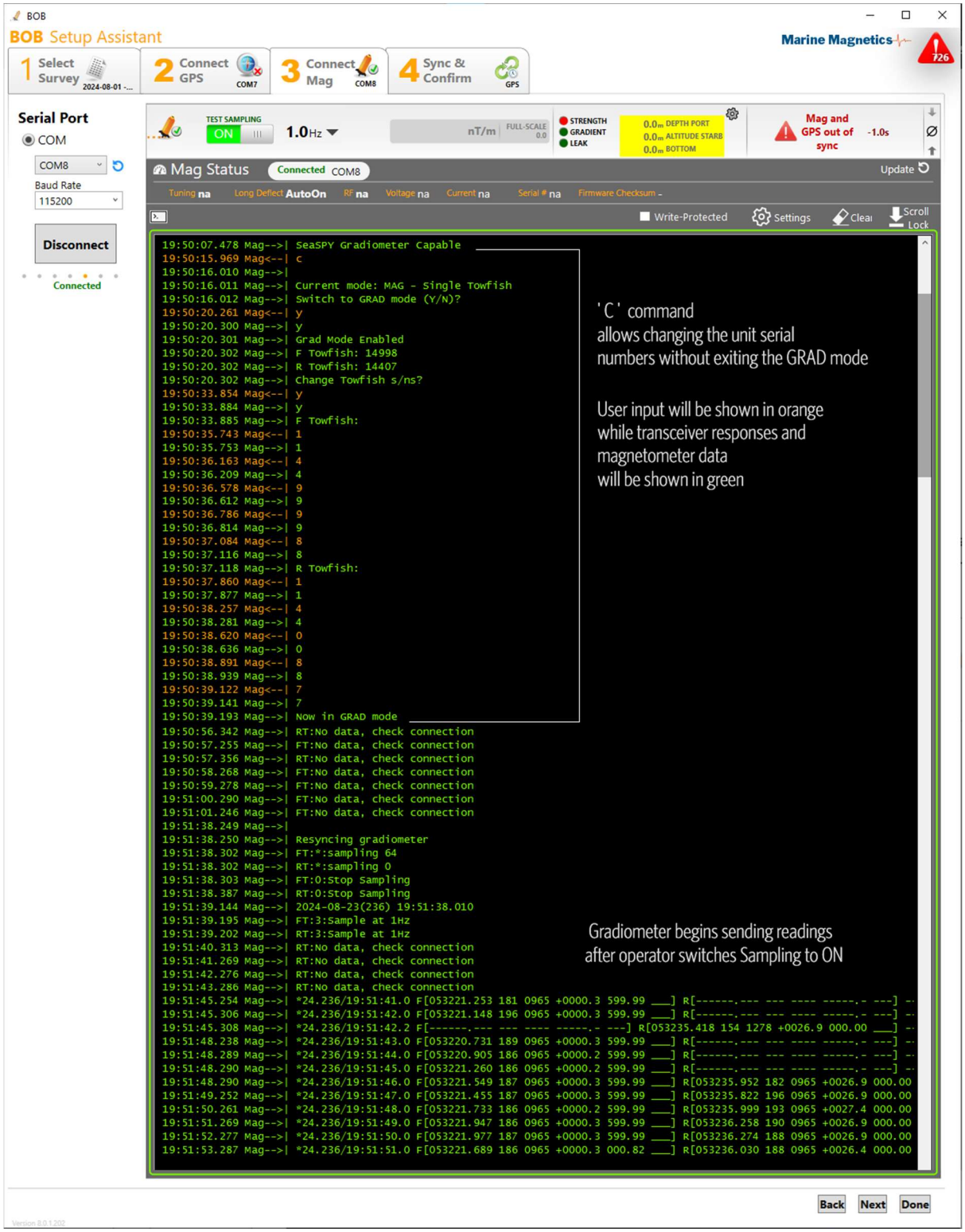


Figure 5-4 - Configuring unit serials numbers in GRAD mode using the command terminal

5.5 Checking auto-tuning and long deflect settings for gradiometers

When operating in GRAD mode, it is very important that the critical settings for both connected magnetometers are identical. This includes:

- Sampling rate (1, 2 or 4 Hz)
- Auto-tuning (On or Off)
- Long deflect (On, Off or Auto)

While the sampling rate is always consistent for both units, the auto-tuning and long deflect may be set differently between the two units prior to them being connected together as a gradiometer pair. To check that these settings are identical for both units in a gradiometer pair, use the following commands:

- 0 stop sampling (in case sampling is enabled). Alternatively: use the Sampling switch above the terminal.
- X enables auto-tuning (Recommended)
- Y disables auto-tuning
- K toggles through three possible states of the Long deflect (Auto is recommended)

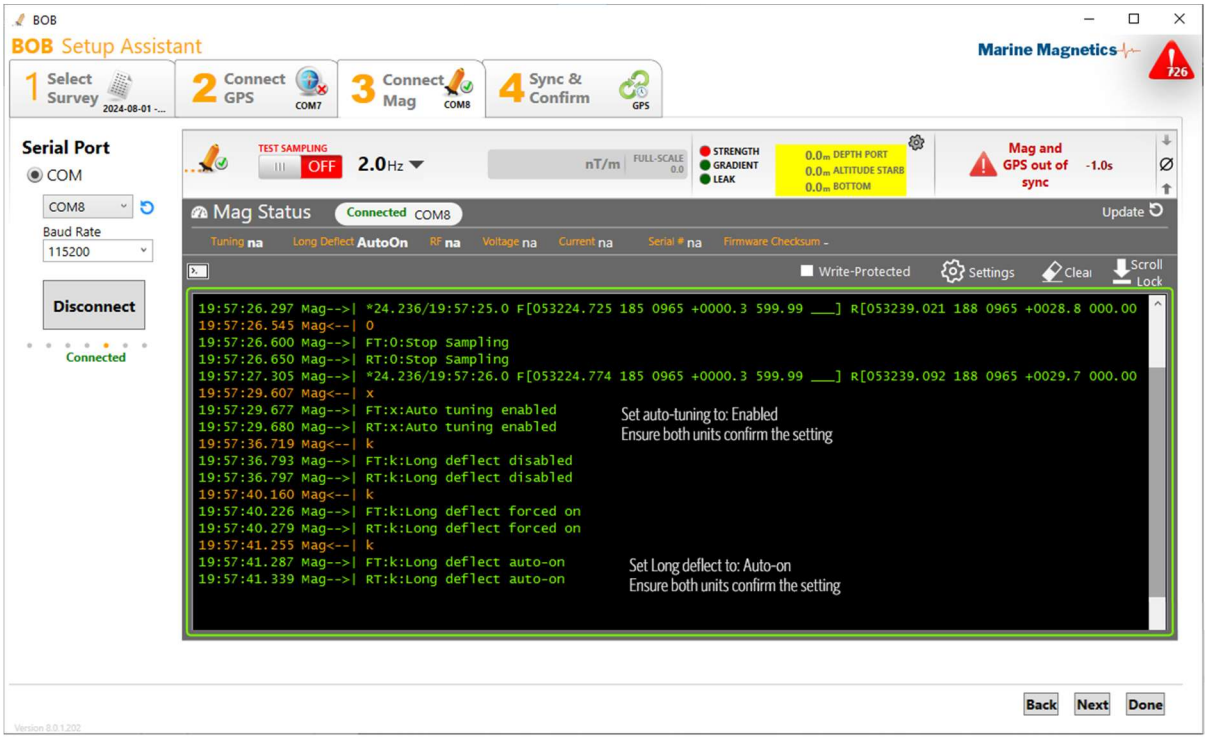


Figure 5-5 - Verify that the Long deflect settings are identical for both units in a gradiometer. The recommended setting for both is Auto-on. The Auto tuning should also be enabled.

Long deflect is a feature that enables the SeaSPY to operate in geographic regions with abnormally low typical magnetic field strength (35,000 nT or lower). In general Long deflect should be set to either Auto-on or Disabled for most geographic locations, where the typical magnetic field strength is 40,000 nT or higher. Long deflect should only be enabled for locations where magnetic field is very low.

If you notice that the Long deflect settings are different for the FT: and RT: towfish, you may need to exit GRAD mode and modify the Long Deflect setting for either Front (FT:) or Rear (RT:) towfish, before switching back to GRAD mode to verify that the settings are now identical between the two units.

For additional details on the Long deflect feature, please refer to the SeaSPY2 Operating manual.

5.6 Finalizing the configuration in BOB Setup Assistant

The final step 4 in BOB Setup Assistant presents a summary of the survey parameters and COM port connections, and offers options for time synchronization source for the magnetometer towfish.

For best results the magnetometer should always be synced to the GPS/UTC time. This requires a GPS connection.

In the absence of GPS connection, the Mag clock can be set to either PC time, or entered manually.

For best results ensure that your PC is configured to automatically sync its system time to the Internet.

Please note that time synchronization to UTC time is required whenever base station correction is intended to be applied during post-processing.

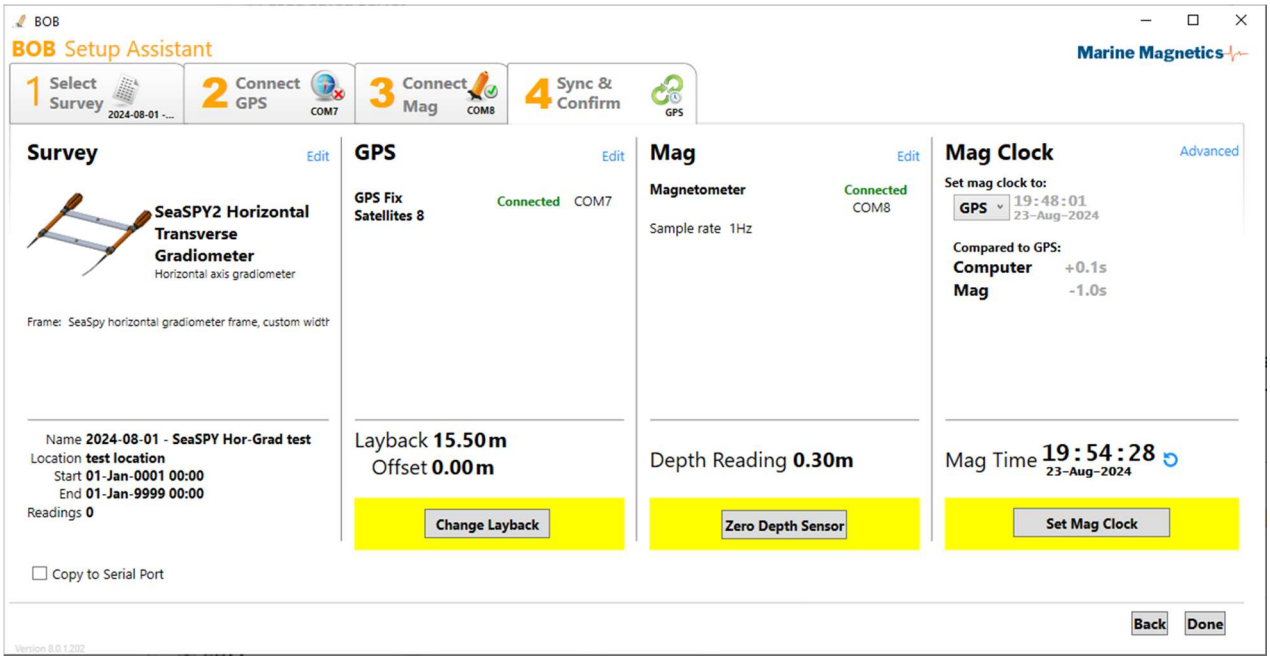


Figure 5-6 - Finalizing the survey setup settings in step 4

During survey data capture, BOB stores three sets of times with every magnetometer readings:

- System time: Windows PC clock at the time the reading was received by BOB
- GPS time: GPS time corresponding to when the magnetometer reading was received
- Mag time: Time stamp contained within the magnetometer data string (maintained by the transceiver)

Having all these time stamps available for each magnetometer reading provides the greatest data integrity and flexibility during data processing and analysis.

6 Magnetometer data display in BOB

BOB user interface is divided into two windows: Main BOB window containing the sensor profile graphs and a readings table below, and the GeoPlot window displaying the location of the survey equipment in a map view.

In the Main window the SeaSPY gradiometer data consists of the Fields, Positions and Signal Strength signal groups.

The profile traces on the graph itself can be dragged up and down with a mouse as well as scaled via the layers panel, for convenience and comparison. The profile graph vertical scale for each of the signal groups can be selected individually or as a group by selecting the group heading in the Layers panel and right-clicking on it. You can also multi-select individual components by holding down the *Ctrl* or *Shift* keys. The vertical slider to the left of the Layers panel can also be used to adjust the vertical scale.

The traces in the Position group can only be scaled, but not dragged, as they have predefined reference "0" positions. The depth zero reference level is the top of the graph, representing the surface of the water. The altitude zero reference level is bottom of the graph.

Sampling button found near top left of the toolbar also serves as the sampling indicator. A drop-down menu shows a selection of available sampling rates.

Current magnetometer time and magnetic gradient reading are displayed above the profile plot when sampling is enabled. Depth, Altitude and Bottom alert indicators can be configured by right-clicking and selecting min and max thresholds specific to each survey project and location.

To the right of the Depth and Altitude alert indicators are the Notifications icon, and the Depth sensor zero calibration button.

GeoPlot window features a multi-layered map view of the collected data and real-time magnetometer position. With a BAM license activated, the data can be visualized in a number of interpolated maps, including Total Field, Analytic Signal and Partial Gradient maps.

Please refer to the BOB User Manual for further details on all features and functions.

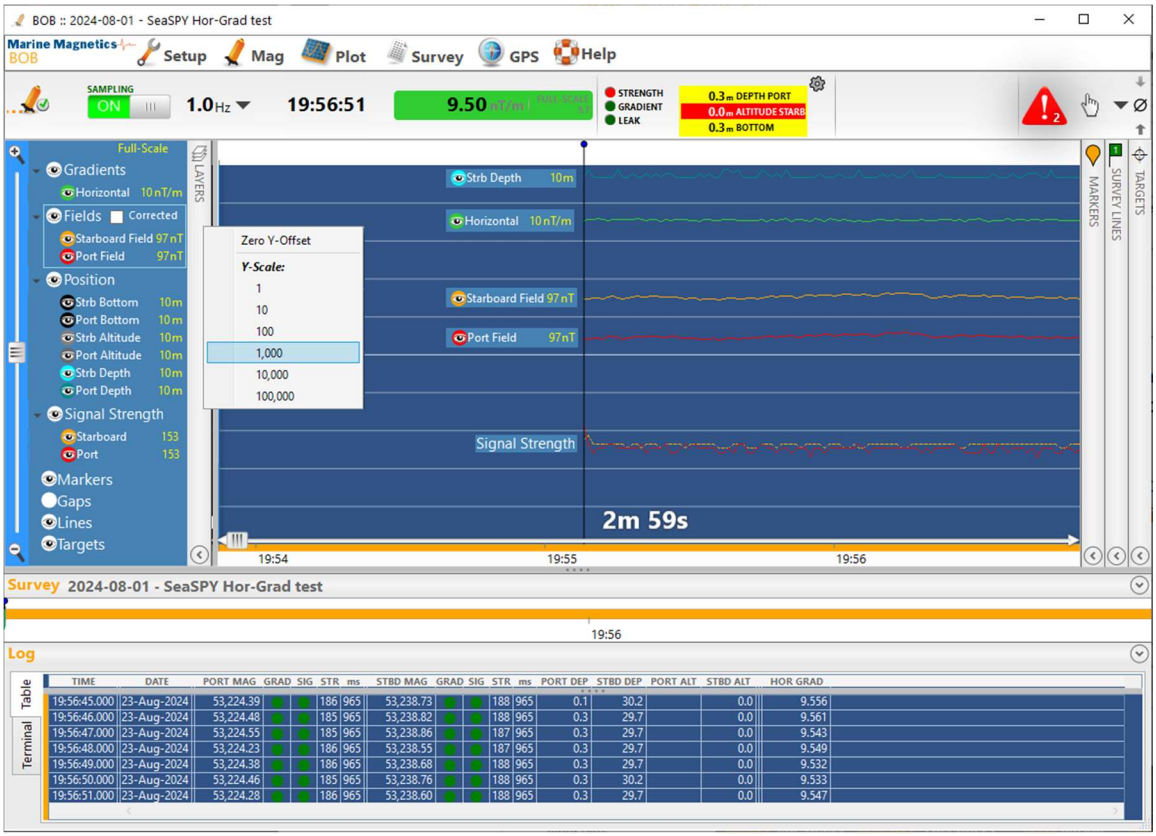


Figure 6-1 - Typical BOB user interface when recording SeaSPY Horizontal Gradiometer data. To modify the vertical scale for any group of signals, right-click on the group name in the Layers panel and select from the list of preset scale settings. Use the vertical slider to fine-tune the scale.

6.1 Real-time and Review panes of the Profile Plot

The Profile Plot window in BOB contains a vertical divider that can be used to split the view into Review pane (left) and Real-Time Readings pane (right). The Horizontal scale (time span) can be set separately for each pane using the horizontal slider at the bottom of each pane. The timeline bar below the profile plot will highlight the time interval currently displayed in the Review Pane.

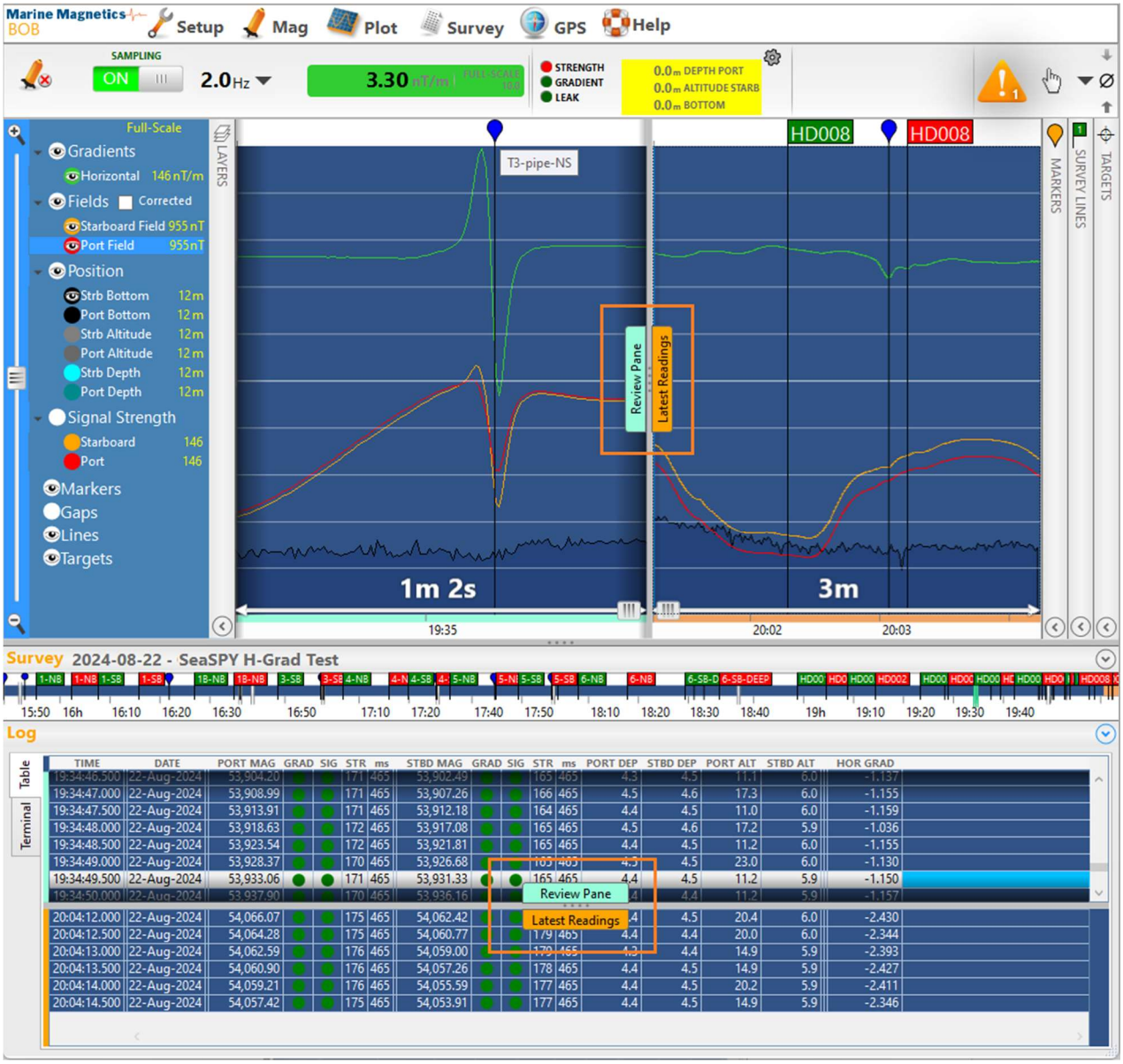


Figure 6-2 - BOB Profile Plot can be divided into Review (left) and Real-time (right) panes, with different time spans for each. The Log table below the plot can be similarly divided with a horizontal bar.

6.2 Calibrating the depth sensor zero level

Calibrating the zero-depth level of the pressure sensor should be done at the start of each survey, after allowing the magnetometer towfish to adjust to the water temperature and then bringing it out of the water to set the zero depth level.

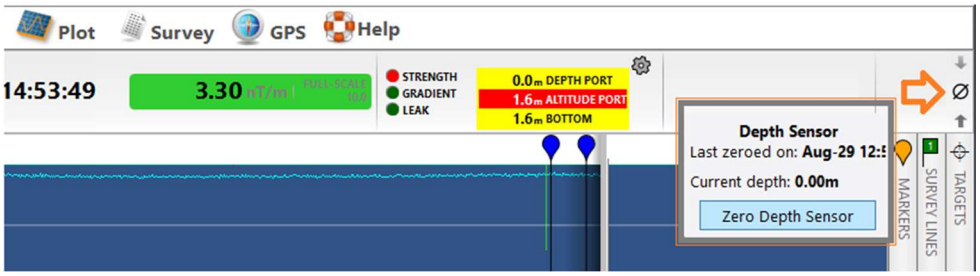


Figure 6-3 - The top-right corner of the main BOB window contains a button for setting the zero level of the depth sensor

6.3 Selecting which unit's depth and altimeter readings to monitor

Monitoring the depth and altitude readings throughout the survey is important to ensure good data quality and help avoid unwanted collisions with the bottom. BOB offers the ability to select which of the two connected units will be used to monitor the depth and altitude. For transverse gradiometers either Port or Starboard units can be selected. For longitudinal gradiometers it may be best to select the Rear unit, because it will be deeper compared to the front unit, and will be closer to the bottom.

Selecting the 'active unit' can be done either in the Main window or in GeoPlot, inside the NavAssist tab.

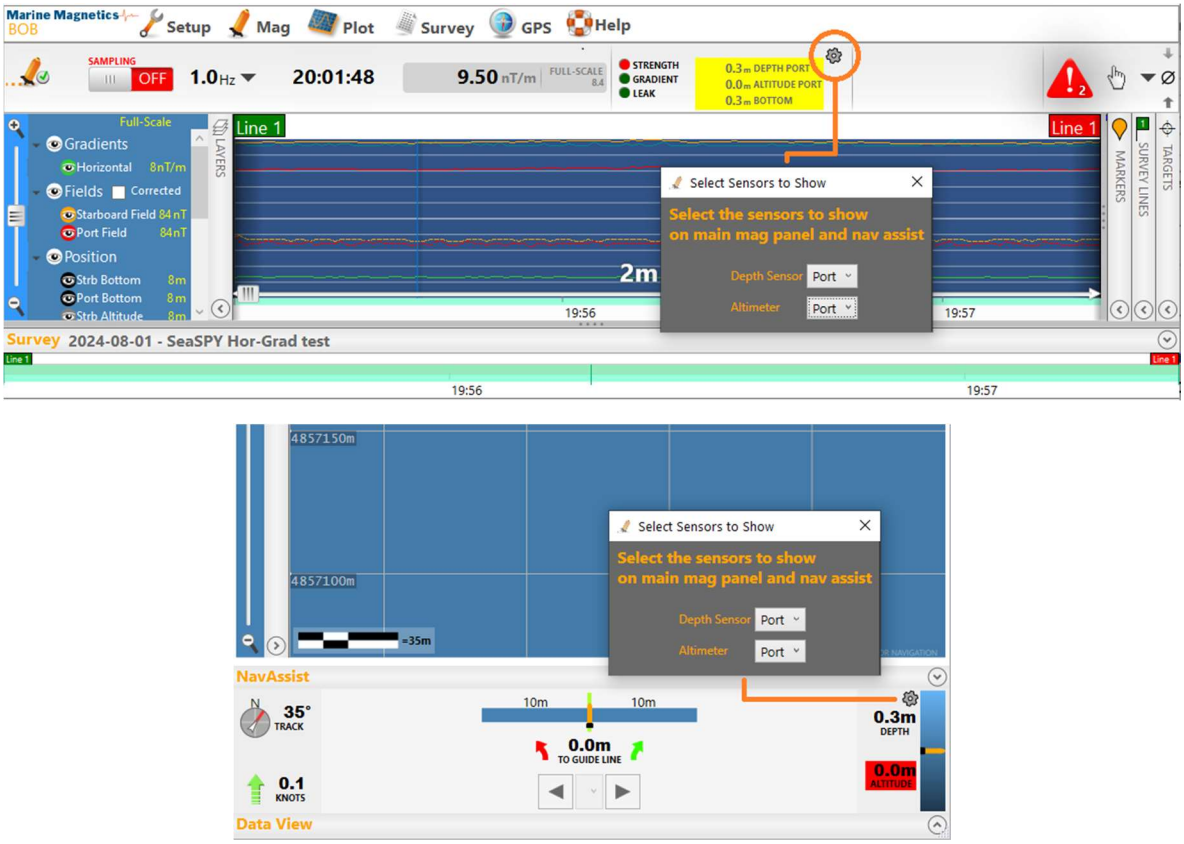


Figure 6-4 - The Settings icon seen beside the Depth and Altitude display can be used to select the unit whose sensors will be monitored

6.4 Saving and exporting survey data

All data collected by BOB are always stored in the BOB survey database whenever sampling is enabled. The database is stored internally and cannot be directly accessed, but it can be backed up to a file for archiving or exported in CSV format for processing in 3rd party software.

To create a backup copy of the BOB survey database after the survey is complete, use **Survey > Backup to File**. This will create a file with the extension **.MMS** that will contain all of the data that has been logged during the survey, including all markers, targets and BAM maps. This file can be imported into a BOB installation on another computer for sharing or post processing.

To export survey data as a CSV file for post-processing in 3rd party software, use the menu selection **Survey > Export Survey Log**. This option offers a flexible interface for selecting specific data channels and corrections to be applied and exported. The resulting file will be ASCII text formatted as CSV (Comma Separated Values), or a space-separated value file.

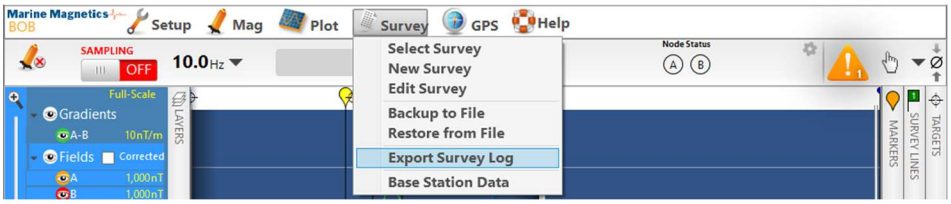


Figure 6-5 - Survey data can be backed up as a BOB-compatible backup (MMS) or exported as universal CSV format

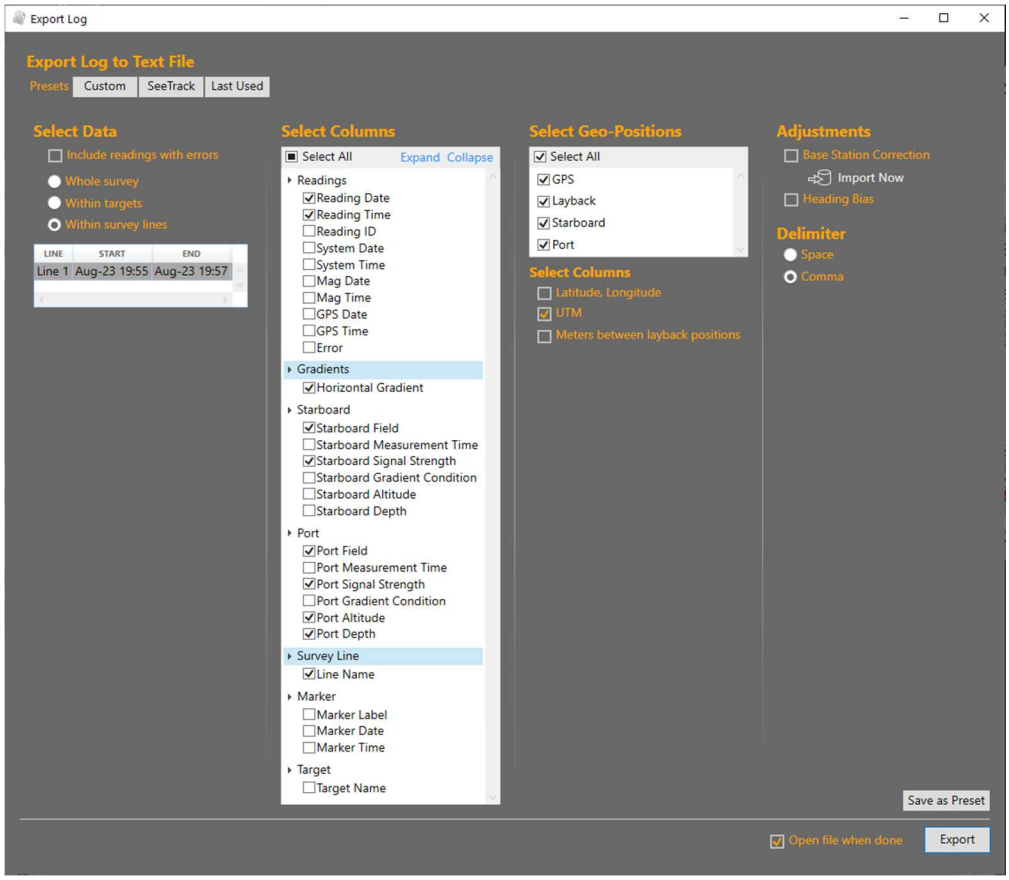


Figure 6-6 - Data export interface offers a flexible selection of available data channels, positions and corrections.
The Layback geo-position represents the end of the soft tow cable, as configured by the Layback setting in BOB. Gradiometer units will be automatically offset relative to layback point by the gradiometer configuration and sensor span.

7 Troubleshooting

For normal operation, the SeaSPY gradiometer system relies on the correct GRAD mode configuration in the isolation transceiver. The serial numbers of both connected units must be entered correctly.

The isolation transceiver should still communicate with the top-side data logger via RS-232 whether the towfish or tow cable are connected or not. If you are not able to communicate with the isolation transceiver (integrated into the side scan integration cable), check the baud rate and the power supply.

For additional support, please do not hesitate to contact Marine Magnetics and we will be happy to assist you!

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