

Chapter 18: USBL Acoustics

Ultra Short BaseLine (USBL) acoustic systems provide the means to measure to a subsurface acoustic beacon, providing the range, bearing, and depth from a surface-based hydrophone. This information can be used to position the ship, initiating the measurement using a fixed beacon (stationary with the position known). It can also be used to position a moving beacon and thus the underwater vehicle to which it is attached.

Note: the terms transducer, transceiver and hydrophone are often interchanged. In this chapter, unless otherwise noted, they refer to the hydrophone that is mounted on the reference vehicle.

WinFrog supports the input from USBL acoustic systems for real-time subsurface positioning applications. This chapter discusses the application of USBL devices and their associated data by WinFrog.

It is important to note that USBL systems require calibration. The reader is referred to the **LBL& USBL Calibrations** chapter.

The following are important factors to be noted and/or addressed prior to using a USBL system:

- The **Working Xponders** file must be loaded with the appropriate beacons configured. This is essential for operating the USBL system to position a vehicle from a fixed beacon. In the case of using the USBL system to track a dynamic beacon, though not required for operation it is recommended that the tracking beacons be entered to provide summary of all transponder and beacon information. In future developments the Working Xponders file will be checked to determine the type of tracking beacon is being used.
- It is not necessary that a **Working Velocities** file be present for USBL operations. The velocity information is input directly into the USBL system. WinFrog receives and uses the data as distances or distances and bearings, not travel times, as is the case for LBL operations.
Note the exception to this is if the travel time data provided by several USBL systems is to be used for calibrating the USBL beacon position. In this case, an appropriate velocity file must be loaded. Also, if a correction for ray bending is desired, a velocity profile, transponder file with the appropriate beacon and its turnaround time, and the use of the CSV surveyor's acoustic telegram from the Sonardyne USBL system is also required. Currently, only the Sonardyne USBL system is supported for ray bending.
- If an attitude sensor is present on the vehicle with the USBL hydrophone deck unit, it must be injected directly into the USBL system. WinFrog does not currently support application of attitude data to USBL data or sensor offsets. **Note:** this is the only device for which this is true, all other devices and offsets support application of attitude data.
- If the USBL system supports direct attitude data injection and internal offsets, the offsets from the USBL systems transducer to a reference point on the vessel must be

entered in the USBL system. In most cases, these are already present, as they are required to reference the data output to a Dynamic Positioning (DP) system, to the center of gravity (COG). If this is not the case, offsets to the same Common Reference Point (CRP) that will be used by WinFrog must be entered.

- The WinFrog CRP must be at the water line in order to correctly allow for reduction of acoustic data.
- Several USBL devices provide heading data in the associated telegrams that is specifically for the epoch of the USBL data. These devices can be configured to pass this heading to the vehicle for use in processing the data. If this option is selected for the USBL device, the associated processing uses this heading, specifically the application of offsets and the XYZ data is performed using this heading. In this case, this heading is also logged with the respective data to the calibration file as the vehicle heading for the calibration epoch. The advantage of using this option is that the heading data used is accurately matched to the XYZ data epoch. The disadvantage is that it is not possible to apply a heading correction to the data (not to be confused with a USBL calibration correction).

Note: there are surface-based systems that provide data similar to that data provided by the USBL systems, but for surface positioning applications. Due to the similarities, they have been grouped with the USBL devices. They are added to WinFrog and their data are applied in the same way as the USBL devices. These are noted where applicable.

Overview

Components

A USBL system is comprised of two main components:

- 1 Hydrophone and a deck unit.
- 2 Beacon

The hydrophone is attached to the reference vehicle and, with the deck unit, interrogates and receives signals from beacons. The beacons may be at a fixed location and/or they may be attached to a moving vehicle such as an ROV.

In the case of surface systems that operate in a similar manner, the hydrophone is replaced with a tracking instrument and the beacon with a target.

The Data

The signals received by the hydrophone from the beacon(s) are used to determine the relative spatial relationship between the hydrophone and the beacon(s). This information is then output. The data can be in one of several forms 1) **XYZ** data where **X** is the horizontal distance port/starboard from the hydrophone to the beacon, **Y** is the same for the fore/aft direction, and **Z** is the

vertical distance to the beacon from the hydrophone, 2) **RBD** where **R** is the horizontal range from the hydrophone to the beacon, **B** is the bearing from the hydrophone to the beacon relative to the reference vehicle's heading, and **D** is the depth from the hydrophone to the beacon, and 3) **l,m,twtt** where **l** is the athwart ships direction cosine, **m** is the along ships direction cosine and **twtt** is the two way travel time between the transceiver and beacon.

USBL systems output the depth component as positive. WinFrog converts this to a negative for application in the ship-based local reference coordinate frame.

Application

USBL systems are used for the following applications:

- 1 **Tracking** of a dynamic beacon from a reference vehicle. The beacon will likely be attached to an ROV (or diver) whose position is to be monitored. In this case, the position of the hydrophone is determined using another data source, such as DGPS, and the orientation of the vessel (and thus the hydrophone) is determined from a gyro. The USBL data can then be reduced to determine the position of the beacon.
- 2 **Positioning** of a reference vehicle from a fixed beacon. This is a standard **Dynamic Position (DP)** system application. In this application, the position of the fixed beacon is known and the USBL data are used, in conjunction with the orientation of the vessel and thus, the hydrophone, as determined from a gyro, to enable the computation of the hydrophone position.

Note: if the USBL system is to be used for positioning of the reference vehicle using a fixed beacon, a valid **Working Xponder** file must be available with the appropriate beacon entered and configured in it (see the **Working Files** chapter).

- 3 There is also an application that combines the above, sometimes referred to as **relative beacon tracking**. In this case, the position of the hydrophone is determined using data observed to a fixed beacon. The position of a dynamic beacon is then determined using the data to it. The concept behind this application is the elimination of errors due to local conditions that are inherent in observations to both beacons.

Note: for all applications of the USBL system, the hydrophone must be associated with a reference vehicle. The beacon is only associated with a vehicle if that vehicle is to be tracked.

Attitude Data and Offsets for the Hydrophone

If an attitude sensor is present for the vehicle the USBL hydrophone is on, if possible, it must be injected directly into the USBL system. The output data will

then be attitude-corrected. WinFrog does not currently support application of attitude data to the USBL data itself, nor the hydrophone sensor offsets. **Note:** this is the only device for which this is true, all other devices and offsets support application of attitude data.

Offsets from the USBL system’s hydrophone to a reference point on the vessel must be entered in the USBL system (if the USBL system supports this). In most cases, these are already present because they are required for data output to a **Dynamic Positioning (DP)** system. If this is not the case, offsets to the same **Common Reference Point (CRP)** used by WinFrog should be entered. The data output will then be attitude-corrected and referenced to an attitude-corrected, local, ship-based coordinate reference frame.

The offsets that are entered into the USBL system are also entered into WinFrog as are the standard WinFrog offsets from the CRP to the sensor. The WinFrog CRP must be at the water line in order to correctly allow for reduction of acoustic data.

In the case of surface systems that operate in a similar manner, the attitude is not applied either by the system or by WinFrog to the data itself or the tracking instrument offsets. For these systems, there are also no offsets entered directly into the system nor the corresponding WinFrog configuration.

Attitude Data and Offsets for the Beacon

WinFrog does support the application of the relevant attitude data to the beacon offsets on the vehicle to which the beacon is attached, though the USBL data used to determine the beacon position is not corrected by WinFrog for attitude at the reference vehicle.

USBL Data Types

The USBL devices provide the following data types, depending upon the data output available:

USBL Hydrophone	All devices provide this data type. It must be added to the reference vehicle.
Beacon	All devices provide this data type. It is added to a remote vehicle that is to be tracked and positioned with the USBL. The BEACON data type associated with any one USBL device can be added multiple times to the same or different vehicles. Each instance is then differentiated by the code assigned it during the configuration.

Attitude

Not all devices provide this data type, only those that support the direct injection of the attitude data from an attitude device and provide the output of the attitude data in the data telegram. It is associated with the attitude of the **USBL Hydrophone** vehicle. This data is only output with a beacon telegram and therefore only available at the USBL beacon tracking cycle time. Therefore, the update rate is very slow compared to a standard attitude device and considered to be insufficient for use as an attitude sensor for the reduction of other sensors and vehicle offsets. It should be added to the reference vehicle only to enable the logging of the data to the raw file.

Heading

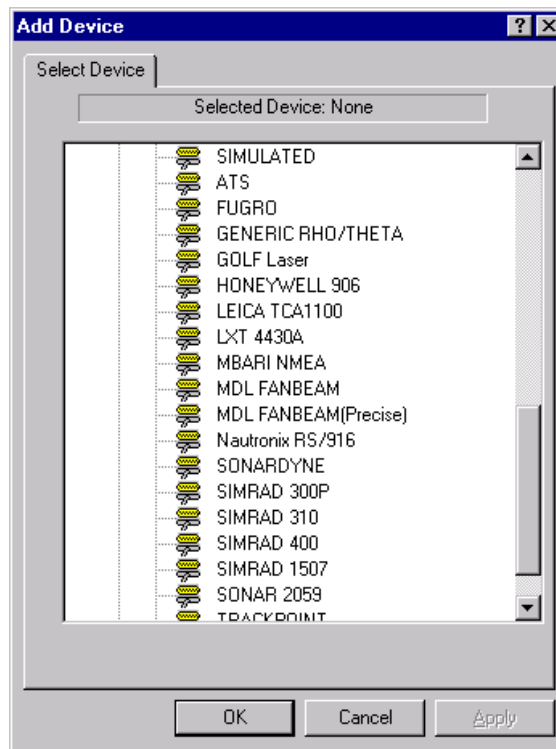
Not all devices provide this data type, only those that support the direct input of the heading data from a heading device and provide the output of the heading data in the data telegram. It is associated with the heading of the **USBL Hydrophone** vehicle. This data is only output with a beacon telegram and therefore only available at the USBL beacon tracking cycle time. Therefore, the update rate is slower than a standard heading device and considered to be insufficient for use as a primary heading sensor. However, where the heading in some operations can be fairly steady (DP operations) is available for use if no other heading data sources are available. It is added to the reference vehicle.

General USBL Setup

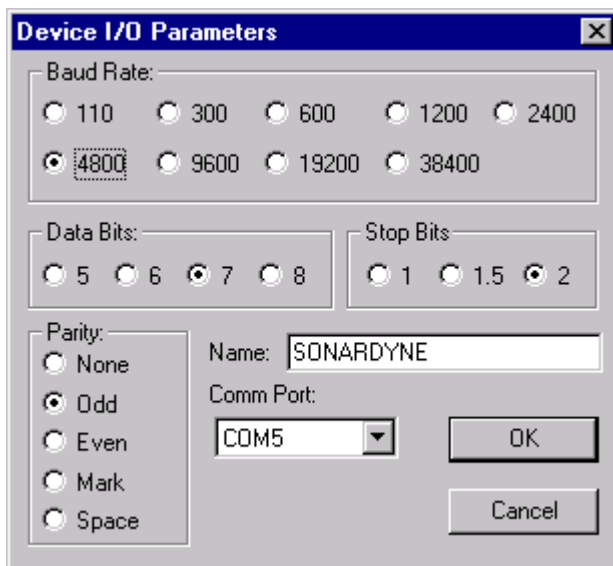
To Add the USBL Device to WinFrog

- 1 Connect the USBL system to a WinFrog com port or Digiboard port.
- 2 From the Main Menu, select **Configure > I/O Devices... Add**, or from within the **I/O Devices** window, click the right mouse button, and click on **Add Device** in the pop-up menu.

- 3 From the **Devices** tree, expand the **USBL** node (click the + next to **USBL** or double-click **USBL**) to display the list of available USBL (and similar) devices.



- 4 Select the appropriate device.
- 5 Click **OK**.



- 6 Enter an appropriate name for the device in the **Name:** field.
- 7 Set all of the communication parameters to match those of the USBL device.

8 Click **OK**.

At this point the USBL device has been added to WinFrog.

The data received from the USBL system are displayed in the **I/O Devices** window. The standard display shows the time of data reception, beacon ID, the age of the data shown, the X, Y, and Z values, and the error status. If available in the output, the heading and attitude data will be displayed.

To Generically Configure a USBL Device in WinFrog

As per many devices found in WinFrog's I/O Device list, some devices listed in the USBL category require a "generic" configuration before the device is added to a vehicle. Listed below are the USBL devices that require this "generic" configuration:

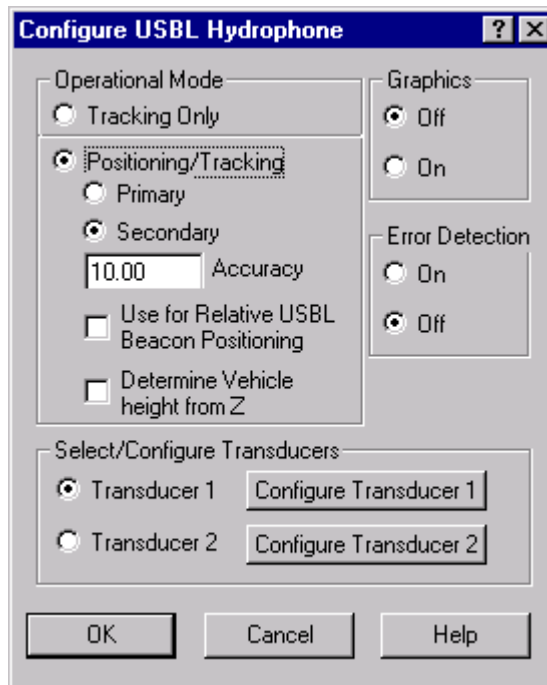
- ATS
- FUGRO
- Generic RHO/THETA
- MDLFanbeam (Precise)
- Simrad 400
- Trackpoint

In order to edit a device's "generic" configuration, highlight the device name in the **I/O Devices** window, right-click, and select **Configure Device**. If you are uncertain about how to proceed with configuring your particular USBL device, see the Appendix C documents, in PDF file format, on the software CD.

To Attach and Configure the USBL HYDROPHONE Data Type

The **USBL HYDROPHONE** data type must be attached to a vehicle for any USBL operation.

- 1 Access the **Configure Vehicle-Devices** dialog for the appropriate (reference/HYDROPHONE) vehicle.
- 2 Click the **Add** button.
- 3 Select the **USBL, *, USBL HYDROPHONE** data type from the **Available Data Items** list, where the * is the operator assigned name for the device.
- 4 Click **OK** to return to the **Configure Vehicle-Devices** dialog.
- 5 At the **Configure Vehicle-Devices** dialog, highlight the **USBL HYDROPHONE** data type.
- 6 Click **Edit**.



- 7 Configure the **USBL HYDROPHONE** data type as required:

Operational Mode

Tracking

Select this mode to perform only tracking of beacons from this vehicle. The position of the hydrophone is determined directly from this vehicle's CRP position (generally determined from a surface positioning system such as DGPS) and **HYDROPHONE** offsets. This hydrophone position is then used to determine the positions of the tracked beacons.

Positioning/Tracking

Select this mode to perform positioning of the vehicle from fixed beacons. It is necessary to have a valid **Working Xponder** file with the beacons entered (see the **Working Files** chapter). In this case, the position of the hydrophone is determined from the USBL data for the fixed beacons and their coordinates. This hydrophone position is then used by the vehicle accordingly (see **Primary** and **Secondary** below).

This mode is also selected if the Relative USBL Beacon Positioning mode is required.

	NOTE: When set to Positioning mode, WinFrog will still track dynamic beacons.
Primary	The position determined from the USBL is used to position the vehicle. If the Kalman Filter is enabled, this position is passed into it.
Secondary	The position is used to monitor the vehicle's Primary position, but not actually position the vehicle.
Accuracy	The expected accuracy for the system. It is important that this be set "pessimistically," i.e. 7-10 meters is a reasonable setting, even for the accurate systems.
Use for Relative USBL Beacon Positioning	Controls the use of the USBL positioning of the hydrophone from a fixed beacon for application for Relative USBL Beacon Positioning. In this mode, The difference between the hydrophone position as determined directly from observations to a fixed beacon is compared to the hydrophone position determined from other positioning sources (e.g. DGPS). This difference is then applied to the position determined for any tracked beacon. The concept is that any inherent errors due to local conditions, both environmental and mechanical, are cancelled out. This is independent of the Primary/Secondary setting.
Determine Vehicle Height from Z	If the USBL system is to be used to determine the height of the vehicle, check this box. This is independent of the Primary/Secondary setting. NOTE: this option is intended for accurate surface systems that are grouped with the USBL devices, such as the MDL Fanbeam (Precise) which is capable of utilizing barometric heighting to reduce the observations, though it will function for all devices grouped with the USBL that provide a height/depth component.

Graphics

On

Select this option to display the current (1 or 2) hydrophone's position in the **Graphics** windows. If in **Tracking** mode, the position will be based upon the vehicle's CRP and hydrophone offsets. If in **Positioning** mode, it will be the actual position determined directly from the beacon data and, as such, will reflect any fluctuation in position due to the data. This is a valuable tool to confirm the correct entry of the offset data.

Off

Select this mode to disable the display of the hydrophone's position in the **Graphics** windows. Once the offsets have been confirmed visually (see above) it is often confusing to have too much displayed in the **Graphics** window. The normal setting for this is **Off**.

Error Detection

On

Many USBL systems include an error status in the output telegram. Selecting this mode will cause WinFrog to check the error status of the beacon data and, if bad, the data will not be used.

Off

Disables the error checking, all data are used regardless of the error status.

NOTE: Regardless of this setting, when logging data for a USBL Calibration, if the error status is detected, the data is automatically de-weighted before being logged to the calibration data.

Select/Configure Transducers

Some USBL systems support multiple hydrophones. WinFrog supports 2 independently configured hydrophones.

NOTE: WinFrog does not automatically detect which hydrophone is being used. You must select the correct one.

Transducer1/2

Select the transducer that is currently being used for the USBL system.

Configure Transducer 1/2

Click this button to access the configuration dialog for each transducer. Exit the dialog with **OK** to use the configuration as set.

Configure USBL Transducer

Calibration Corrections

Range Scale Factor	Head Rotation Correction
1.00000	000.0
Pitch Correction	Roll Correction
0.00	0.00

NOTE: Corrections sign conventions are
Roll=(+)Stbd down; Pitch=(+)Stern down

USBL System Internal Offsets

Offsets from the point the data is related to, to the transducer. These values will be subtracted from the USBL output data to get data related to the transducer.

Fore/Aft	Port/Stbd	Z (down +)
5.00m	1.00m	11.00m

WinFrog Offsets, from CRP to Transducer

Fore/Aft	Port/Stbd	Depth (down +)
5.00m	1.00m	11.00m

OK Cancel Help

Note: the offsets entered into WinFrog are in the local, ship-based sub-surface oriented coordinate frame: forward to starboard and down are positive (+) values, while aft to port and up are negative (-). It should be noted that the vertical offset sign convention is the reverse of that used for surface positioning systems such as DGPS. The difference is indicated by the use of the term **Depth** versus **Height**.

In the example here, the offsets reflect the fact that the USBL system's reference point is the same point as the WinFrog vehicle's CRP.

Calibration Corrections

The results of a WinFrog USBL calibration (see the **LBL& USBL Calibration** chapter) are entered here exactly as presented in the calibration results. These allow WinFrog to apply corrections to the USBL data correcting for errors in the velocity as used in the USBL system (scale factor) and unaccounted errors in the alignment of the hydrophone itself with respect to the vehicle's local ship based coordinate reference frame (heading, pitch and roll corrections).

Note: do not enter the results of a USBL calibration into both the USBL system and WinFrog. If this is done, the data will be corrected by the USBL system prior to outputting it to WinFrog and then again by WinFrog. This will result in incorrect data.

Note: permanent USBL installations are often already calibrated and have these values entered into the system. WinFrog is then used to refine this calibration. In this case, the original calibration settings are left in the USBL system and the results of the WinFrog calibration are entered in WinFrog. This is especially true in the case where the orientation of the hydrophone is in error by 180° and a correction has been entered into the USBL system. The WinFrog USBL calibration can not resolve an error of this magnitude.

Range Scale Factor	Scale correction factor (value by which to multiply the USBL data) to correct for velocity errors. It is “unitless.” The default or zero setting is 1.0.
Head Rotation Correction	Correction to the orientation of the hydrophone with respect to the vehicle’s bow. It is entered in degrees. The default or zero setting is 0.0.
Pitch Correction	Correction to the verticality of the hydrophone in the fore/aft direction. It is entered in degrees. The default or zero setting is 0.0.
Roll Correction	Correction to the verticality of the hydrophone in the thwartships direction. It is entered in degrees. The default or zero setting is 0.0.

USBL System Internal Offsets

If the USBL system supports direct attitude data injection and internal offsets, the offsets to relate the USBL system’s transducer to a reference point on the vessel must be entered in the USBL system. In most cases, these are already present because they are required to reference the data output to a **Dynamic Positioning (DP)** system to the vessel’s center of gravity (COG). If this is not the case, offsets to the same Common Reference Point (CRP) that will be used by WinFrog must be entered into the USBL system.

These offsets, also then entered here in WinFrog, are measured from the reference point to the hydrophone.

Fore/Aft	The fore/aft distance from the reference point to the hydrophone.
Port/Stbd	The port/starboard distance from the reference point to the hydrophone.
Z	The vertical distance from the reference point to the hydrophone, down is positive (+).

WinFrog Offsets

These are the standard WinFrog sensor offsets, measured from the CRP to the sensor.

Note: the CRP must be at the water line in order to correctly use the depth component of the USBL data.

Fore/Aft	The fore/aft distance from the CRP to the hydrophone.
Port/Stbd	The port/starboard distance from the CRP to the sensor.
Depth	The vertical distance from the CRP to the hydrophone. Note that down is (+)ve.

- 8 Click **OK** to return to the **Configure Vehicle-Devices** dialog.
- 9 At the **Configure Vehicle-Devices** dialog, if the **USBL HYDROPHONE** data type is to be used to position the vehicle, it is recommended that the **Range Gate** option in this dialog be set to on (uncheck the **Off** box in the **Range Gate** panel) and an appropriate gating value entered (e.g. 10 to 20 meters).
- 10 Click **OK**.

To Attach and Configure the BEACON Data Type

In order to use the USBL system to track a moving vehicle, the appropriate **BEACON** data type must be attached to the vehicle and configured.

- 1 Access the **Configure Vehicle-Devices** dialog for the appropriate vehicle.
- 2 Click the **Add** button.
- 3 Select the **USBL, *, BEACON** data type from the **Available Data Items** list, where the * is the operator assigned name for the device.

Note: the **BEACON** must be associated with the same device as the reference vehicle's USBL HYDROPHONE.

- 4 Click **OK** to return to the **Configure Vehicle-Devices** dialog.
- 5 At the **Configure Vehicle-Devices** dialog, highlight the **BEACON** data type.
- 6 Click **Edit**.

7 Configure the **BEACON** data type as required:

Calculation

Primary

This USBL beacon will be used to determine a **Primary** position.

Secondary

This USBL beacon will be used to determine a **Secondary** position to monitor the **Primary** positioning source.

Note: more than one beacon can be attached to any given vehicle. They can be configured to **Primary** and/or **Secondary** (in any combination), bearing in mind that if none are set to **Primary**, the USBL will not contribute to the position of the vehicle. All beacons that are set to the **Primary** mode will impact the vehicle position. If multiple beacons are set to **Primary**, it is necessary that the **Kalman Filter** be used for the vehicle (in the **Configure Vehicle-Devices** dialog, make sure the **Kalman Filter Off** box is not checked).

If multiple beacons are used, it is possible to use them to determine the orientation of the vehicle to which they are attached. In the **Configure Vehicle-Devices** dialog, check the **Heading** box in the **Calculations** panel. The accuracy and steadiness of this heading determination depends upon the quality of the

USBL data and the baseline between the beacons. This is not recommended unless there is absolutely no other means to determine the heading.

Accuracy

Enter a “pessimistic” approximation for the accuracy of the system. A value between 7 to 15 meters is reasonable. This is a very important setting if other devices are to be implemented in the **Kalman Filter**, such as a **Doppler Speed Log**.

Error Detection

On

Many USBL systems include an error status in the output telegram. Selecting this mode will cause WinFrog to check the error status of the beacon data and, if bad, the data will not be used.

Off

Disables the error checking, all data are used regardless of the error status.

Deskewing Options

Deskew Beacon Timestamp

Future development.

Deskew Hydrophone Position

When positioning the beacon, WinFrog uses the last calculated position for the associated USBL hydrophone and the latest heading information for the USBL hydrophone vehicle and applies the USBL XYZ to determine the beacon position. The time of the last calculated hydrophone position depends upon the configuration of WinFrog. If the hydrophone vehicle is set to use the Kalman Filter and Dead Reckoning, the age of the last **predicted** position will be less than 200 milliseconds. If these settings are not used, the age could be as high as 1 second, depending upon the update cycle time of the surface positioning system. If this option is checked, the hydrophone position is deskewed to the beacon data epoch using the hydrophone vehicle’s speed and advance.

Note: It is recommended that this be checked.

Code

Enter the integer equivalent for the beacon identifier (code). In most cases, this is a direct entry of the code for the beacon to be used, such as 1. However, some systems refer to the beacons as shapes (Simrad HPR300), in which case it is necessary to determine the integer code for the shape.

If the code is incorrect, the data will not be matched and, therefore, will not be associated with this vehicle and the USBL will contribute its position.

Note: The Kongsberg Simrad HPR 400 and 500 systems and their software package APOS use codes with letters. These codes are entered directly as defined. For details, refer to the Simrad 400 document of Appendix C – Device Documentation.

ROV Depth from USBL

Yes

Uses the Z component of the USBL data for the vehicle height/depth.

No

The height/depth of the vehicle will be determined using another data type attached to the vehicle (i.e. depth sensor contained with the ROV instrumentation).

Note: This does not impact the horizontal component of the beacon position, nor is this other source depth output to the USBL system for its use as a constraint.

LBL Calibration

Use for Calibration

Enables the use of a vehicle with this beacon attached to it to be used as the calibration vehicle for an LBL calibration. This is not the usual configuration for an LBL calibration, but occurs if the calibration vehicle is a towed fish with an LBL transducer (i.e. Sonardyne Flower Pot transducer) mounted in it.

Graphics

On

Enables the display of the position of the beacon with its code, in the **Graphics** window. This is useful when monitoring the affect of the **Kalman Filter**, particularly if other sensors are involved such as a **Doppler Speed Log**.

Off

Disables the display of the beacon position in the **Graphics** window.

Offsets, from the CRP

These are the standard WinFrog sensor offsets, measured from the CRP to the sensor. The offsets are in the local, vehicle-based coordinate frame: forward to starboard and up are positive (+), while aft to port and down are negative (-) (note this differs from the **USBL HYDROPHONE** offsets).

Fore/Aft	The fore/aft distance from the CRP to the beacon.
Port/Stbd	The port/starboard distance from the CRP to the beacon.
Height	The vertical distance from the CRP to the beacon.

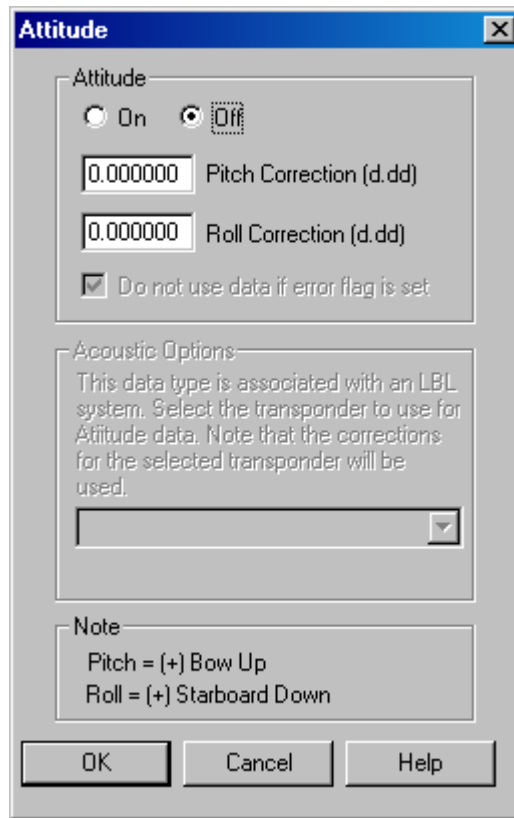
- 8 Click **OK** to return to the **Configure Vehicle-Devices** dialog.
- 9 It is recommended that the **Kalman Filter** be used, especially if other sensors will be involved in the positioning of the vehicle. Make sure the **Kalman Filter Off** box is **not** checked.
- 10 It is recommended that the range gating be applied. Make sure the **Range Gate Off** box is **not** checked. Enter a reasonable gate width for the USBL system and prevailing conditions, such as 10 to 20 meters.
- 11 Click **OK**.

To Attach and Configure the ATTITUDE Data Type

The **ATTITUDE** data type is attached and configured in the same manner as any **ATTITUDE** data type. It is attached to the reference/HYDROPHONE vehicle.

Note: As stated earlier in this chapter, the update rate of the attitude data available via the USBL system is insufficient for practical or reasonable application. However, attaching it to a vehicle does ensure that it is available for logging to raw data files.

- 1 Access the **Configure Vehicle-Devices** dialog for the appropriate (reference/HYDROPHONE) vehicle.
- 2 Click the **Add** button.
- 3 Select the **USBL, *, ATTITUDE** data type from the **Available Data Items** list, where the * is the operator assigned name for the device.
- 4 Click **OK** to return to the **Configure Vehicle-Devices** dialog.
- 5 At the original **Configure Vehicle-Devices** dialog, highlight the **ATTITUDE** data type.
- 6 Click **Edit**.



- 7 Enter the required pitch and roll corrections. These values are added to the raw data to obtain corrected pitch and roll data.

Note: these are corrections to the actual attitude sensor data and not those determined with a USBL calibration (see the **LBL&USBL Calibration** chapter), which address a combination of the attitude sensor error and the installation of the hydrophone.

- 8 Select **On** to use the **ATTITUDE** data to reduce the offsets of all sensors attached to this vehicle, except the USBL HYDROPHONE sensor, and all vehicle offsets. Select **Off** to prevent the use of the **ATTITUDE** data for any reductions.

Note: if the ATTITUDE data type is added to the vehicle, the raw data will be logged to the raw file regardless of being set to **On** or **Off**. This may be of benefit for post-processing issues.

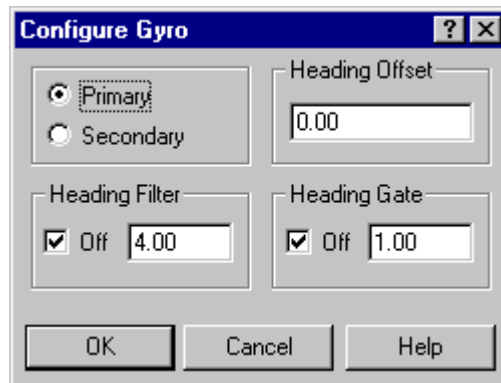
- 9 Click **OK** to return to the **Configure Vehicle-Devices** dialog.
- 10 At the original **Configure Vehicle-Devices** dialog, click **OK**.

To Attach and Configure the HEADING Data Type

The **HEADING** data type is attached and configured in the same manner as any HEADING data type. It is attached to the reference/HYDROPHONE vehicle.

Note: As stated earlier in this chapter, the update rate of the heading data available via the USBL system is insufficient for practical or reasonable application. However, in low dynamic situations where no other heading data source is available, it is available for use.

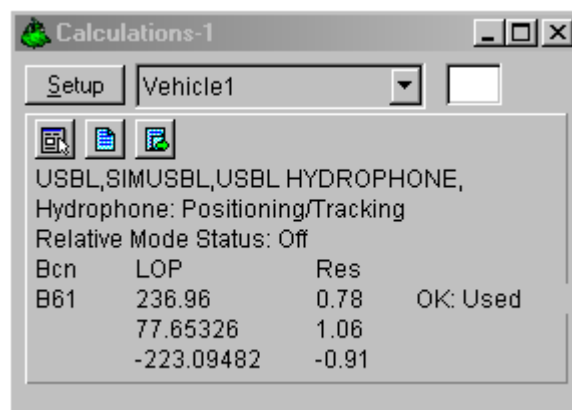
- 1 Access the **Configure Vehicle-Devices** dialog for the appropriate (reference/HYDROPHONE) vehicle.
- 2 Click the **Add** button.
- 3 Select the **USBL, *, HEADING** data type from the **Available Data Items** list, where the * is the operator assigned name for the device.
- 4 Click **OK** to return to the **Configure Vehicle-Devices** dialog.
- 5 At the original **Configure Vehicle-Devices** dialog, highlight the **HEADING** data type.
- 6 Click **Edit**.



- 7 Enter the **Heading Offset** value. This is added to the raw heading to obtain a corrected heading.
- 8 If you wish to filter the heading data, un-check the **Heading Filter Off** box and enter the desired filter length (number of sequential heading values to be used to filter the heading).
- 9 If you wish to gate the heading data, un-check the **Heading Gate Off** box and enter the desired gate width (in degrees).
- 10 Click **OK** to return to the **Configure Vehicle-Devices** dialog.
- 11 At the original **Configure Vehicle-Devices** dialog, click **OK**.

To Monitor the HYDROPHONE Data Type

- 1 Open a **Calculations** window via the main menu or the **Acoustic Window** (see **Operator Display Windows**).
- 2 Select the **HYDROPHONE** vehicle from the vehicle dropdown list.
- 3 Click the **Setup** button.
- 4 Check the **Data Item Text** box.
- 5 Select the **HYDROPHONE** data type and click the **On** button.
- 6 Click **OK** to return to the **Calculations** window.
- 7 This window displays the following information:
 - The device type, operator assigned name and data type
 - The **Operational Mode** (Tracking Only or Position/Tracking)
 - **Relative USBL Beacon Positioning** mode (On or Off)
 - If in **Relative USBL Beacon Positioning** mode, the Northing and Easting corrections that will be applied to any beacon positions. If the corrections are greater than 30 seconds old, a warning is flashed in red.
 - The USBL beacon code and data is displayed. The data can be displayed in two formats, controlled by toggling the right most of the group of three buttons in the calculation window. The formats are:
 - the **Reduced** (to the map projection) **XYZ** data and their associated status and residuals.
 - The raw and reduced XYZ data.

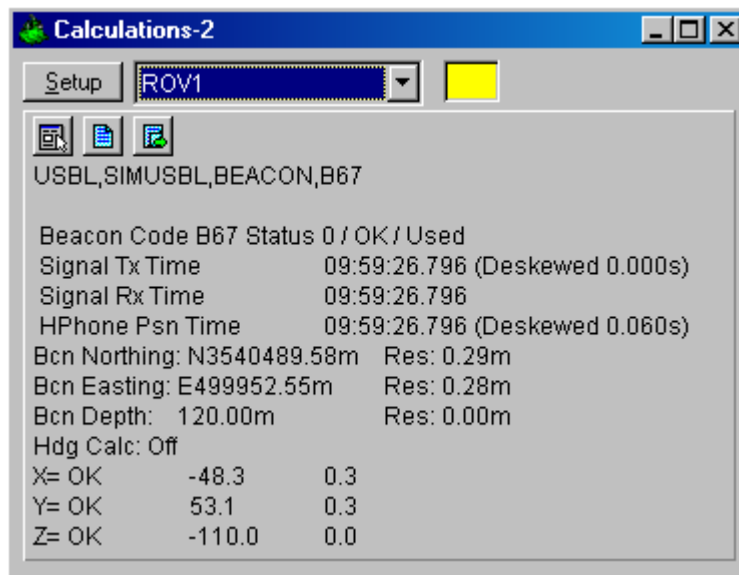


To Monitor the BEACON Data Type

- 1 Open a **Calculations** window via the main menu or the **Acoustic Window** (see **Operator Display Windows**).
- 2 Select the **BEACON** vehicle from the vehicle dropdown list.
- 3 Click the **Setup** button.
- 4 Check the **Data Item Text** box.
- 5 Select the **BEACON** data type and click the **On** button.
- 6 Click **OK** to return to the **Calculations** window.
- 7 This window displays the following information:
 - The device type, operator assigned name and data type, including the beacon code.
 - The pitch and roll for the beacon vehicle **not** the pitch and roll output by the USBL system.
 - The beacon code and the data error status
 - Calculated time of the beacon signal's transmission and the amount in seconds this differs from the time the signal was received (for future development)
 - Time WinFrog received the data from the USBL system, used as the signal receive time.
 - Time of the hydrophone position. If the **Deskew Hydrographic Position** option is checked, this will be the same time as the signal receive time and the amount of time in seconds that this was deskewed is given in brackets. If the **Deskew Hydrographic Position** option is not checked, the deskewed value will be 0.
 - The map projection Northing and Easting and the depth of the beacon based upon the last USBL update and the respective residuals. In this case, the Northing and Easting residuals are the difference between the actual vehicle CRP position used and the vehicle CRP position derived from the aforementioned calculated position. If the Kalman Filter is not active or there is no other beacon used with this vehicle that is set to Primary, these will be 0. In the case of the depth, if the depth of the vehicle is taken from this beacon data, this will always be 0.
 - The beacon data and its status. The residuals are shown but they are a repeat of the above residuals with the Northing residual associated with the Y data and the Easting residual associated with the X data. The status

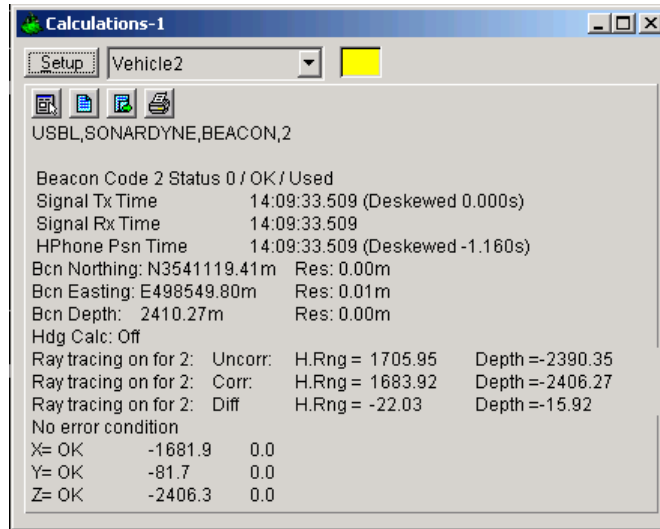
can be one of the following:

- OK, the USBL data had no error flags, was not gated and was successfully used in the solution.
- ER, the USBL data was flagged by the USBL system with an error condition.
- WN, the USBL data was flagged by the USBL system with a warning condition.
- NR, no data was received.
- NT, no hydrophone vehicle was available.
- GA, the data has been gated. If either the X or the Y component is gated, the beacon position solution is aborted.



- If the ray bending correction has been turned on, the following window is displayed. It includes four extra lines:
 - Ray Trace on for (beacon number)
 - Uncorr H.Rng is the uncorrected horizontal range and depth
 - Corr H.Rng is the horizontal range and depth with ray bending applied
 - Diff is the difference, which is essentially the effect of the ray bending
 - The forth line provides a status message, here it indicated no error.

Note that the depth on these three lines actually refers to the vertical distance between the beacon and the transceiver.



Specific USBL Setups

To Configure for Positioning the Hydrophone Vehicle

- 1 Ensure a valid Xponder file is created, opened, and set to **Working** (see the **Working Files** chapter).
- 2 Add a fixed USBL beacon(s) to the **Working Xponder** file, making sure the correct **Name**, **Depth**, **Position**, **Type** (USBL Mode: Fixed) and **USBL Code** are correctly entered and selected for the beacon to be used (see the Working Files chapter for details).
- 3 Add the **USBL** device to WinFrog (see the **To Add the USBL Device to WinFrog** section earlier in this chapter). Monitor the input in the **I/O Devices** window. Make sure the data are being correctly received for the appropriate beacons before proceeding.
- 4 Attach the **USBL HYDROPHONE** data type to the appropriate vehicle (see the **To Attach and Configure the USBL HYDROPHONE Data Type** section earlier in this chapter).
- 5 Configure the **USBL HYDROPHONE** data type as follows. (see the **To Attach and Configure the USBL HYDROPHONE Data Type** section):
 - A Set the **Operational Mode** to **Positioning/Tracking** and **Primary**
 - B **Accuracy = 10** (can be refined accordingly after monitoring performance)
 - C **Determine Vehicle height from Z = unchecked**
 - D Select the appropriate transducer and click the **Configure Transducer** button.

- Enter the appropriate **Calibration Corrections**
- Enter the **USBL System Internal Offsets** (Use the offsets that have been entered directly into the USBL system.)

Note: when entering the **USBL System Internal** offsets (**from** reference point **to** transducer), use the convention forward, starboard, and down are positive (+), while aft, port, and up are negative (-).

- Enter the **WinFrog Offsets** to relate the transducer to the CRP (the CRP should be at water level.)

Note: when entering the WinFrog offsets (**from** the CRP **to** the transducer) use the convention forward, starboard, and down are positive (+), while aft, port, and up are negative (-).

- Click **OK** to return to the **Configure USBL Hydrophone** dialog.

E Graphics/On to confirm offsets are correctly applied (position of hydrophone in the graphics window should appear close to actual location on the ship outline, though it may not be exact due to this display being the raw hydrophone position).

F Error Detection to be set as desired.

G Click **OK** to return to the **Configure Vehicle-Devices** dialog.

6 In the **Configure Vehicle-Devices** dialog, set the following:

A Kalman Filter Off - unchecked

B Kalman Filter = 0.10 (this can be refined after monitoring the performance)

C Dead Reckon - checked

D Range Gate Off - unchecked

E Range gate = 20m (or approximate equivalent in working units, this can be refined after monitoring the performance)

7 Click **OK** to exit the **Configure Vehicle-Devices** dialog.

8 Monitor the performance in the **Calculations** and **Graphics** windows. Turn **HYDROPHONE Graphics** off once offsets are confirmed.

To Configure for Only Tracking the Beacon Vehicle

- 1** Add the **USBL** device to WinFrog (see the **To Add the USBL Device to WinFrog** section earlier in this chapter). Monitor the input in the **I/O Devices** window.

Make sure the data are being correctly received for the appropriate beacons before proceeding.

- 2 Attach the **USBL HYDROPHONE** data type to the appropriate reference vehicle (see the **To Attach and Configure the USBL HYDROPHONE Data Type** section earlier in this chapter).

- 3 Configure the **USBL HYDROPHONE** data type as follows:

A Operational Mode/Tracking

B Accuracy - Not applicable

C Determine Vehicle height from Z - Not applicable

D Select the appropriate transducer and click the **Configure Transducer** button.

- Enter the appropriate **Calibration Corrections**.
- Enter the **USBL System Internal Offsets** (those offsets that have been entered directly into the USBL system - from CRP to the transducer)
- Enter the **WinFrog Offsets** to relate the transducer to the CRP (**from CRP to the transducer**) **Note:** the CRP should be at water level.

Note: when entering offsets remember to use the convention, forward, starboard, and down are positive (+), while aft, port, and up are negative (-).

- Click **OK** to return to the **Configure USBL Hydrophone** dialog.

E Graphics/On to confirm offsets are correctly applied.

F Error Detection - Not applicable.

G Click **OK** to return to the **Configure Vehicle-Devices** dialog.

- 4 In the HYDROPHONE vehicle's **Configure Vehicle-Devices dialog**, ensure all other settings are correct for the positioning of the vehicle.

- 5 Click **OK** to exit the **Configure Vehicle-Devices** dialog.

- 6 Add a **BEACON** to the remote vehicle (see the **To Attach and Configure the BEACON Data Type** section earlier in this chapter).

- 7 Configure the **BEACON** as follows:

A Calculation/Primary

B Accuracy = 10

C Code = beacon ID (for more information see the **To Attach and Configure the BEACON Data Type** section).

- D ROV Depth from USBL = Yes** (unless another depth source is available from another sensor, such as an ROV sensor suite).
 - E** Enter the **Offsets** to relate the beacon to the CRP, using the convention from CRP to the transducer: forward, starboard, and up are positive (+), while aft, port, and down are negative (-).
 - F LBL Calibration/Use for Calibration - unchecked.**
 - G Error Detection** - set as desired.
 - H Graphics - On** to confirm offsets are correctly applied (position of beacon in the graphics window should appear close to actual location on the vehicle outline, though it may not be exact due to this display being the raw beacon position).
 - I** Click **OK** to exit to the **Configure Vehicle-Devices** dialog.
- 8** In the **Configure Vehicle-Devices** dialog, set the following:
- A Kalman Filter Off - unchecked**
 - B Kalman Filter = 0.20** (this can be refined after monitoring the performance)
 - C Dead Reckon - checked**
 - D Range Gate Off - unchecked**
 - E Range Gate = 20m** (or approximate equivalent in working units, this can be refined after monitoring the performance)
- 9** Click **OK** to exit the **Configure Vehicle-Devices** dialog.
- 10** Monitor the performance in the **Calculations** and **Graphics** windows. Turn off **BEACON** and **HYDROPHONE** graphics once offsets are confirmed.

To Configure for Relative USBL Beacon Positioning for a Vehicle

- 1** Follow the steps outlined in **To Configure for Tracking the Beacon Vehicle**.
- 2** When configuring the **USBL HYDROPHONE** on the reference vehicle, set the **Operational Mode** to **Positioning**, **Secondary** or **Primary** and check the **Use for Relative USBL Beacon Positioning** box.
- 3** Continue with the remaining procedure unchanged.

To Configure for Ray Bending

To enable the ray bending calculation, check the box on the Sonardyne USBL device configuration. Only the Sonardyne USBL system sending the CSV surveyor's acoustic telegram that begins with 6,1 contains the necessary information to make the calculations. Also required is a velocity profile and the beacon must be present in the working transponder file along with its turnaround time.