Chapter EM3a: LBL Acoustics

Overview

Long Baseline (LBL) acoustics provides the means to position surface and subsurface vehicles using ranges determined by acoustic signals.

The basic principle of LBL acoustic positioning starts with the observation of the two-way travel time (**TWTT**) of an acoustic signal between two points. This TWTT is reduced to a range by first subtracting any delays in the signal's travel time, i.e. the time between the second point receiving the signal and then re-transmitting a return signal (known as turn-around-time or **TAT**). The result is then divided by two to produce the one-way travel time and multiplied by the velocity of sound in water to derive a distance.

Note: a valid **Working Velocity** file must be created and loaded before any LBL operations can take place. This must be updated as required throughout the operation. See the **Working File** chapter for details.

The standard application of LBL acoustics involves observations of this type between a single transceiver or smart transponder mounted on a moving vehicle or structure and a network or array of transponders located at known fixed positions in the work area, generally on the floor of the body of water. The resulting range data is used in a rigorous Least Squares range/range adjustment to solve for the position of the single transceiver or smart transponder. This solution can be three-dimensional (**3D solution**) or two-dimensional (**2D solution**). In the case of a 3D solution, the known points must be located to provide strong horizontal and vertical geometry. The 2D solution is often used because the height component for the unknown point can be obtained either directly or from other sensors thus eliminating the need to solve for it.

The LBL system can also be used to monitor structures once they are in place for subsidence.

Note: a valid **Working Xponder** file must be created and loaded before any LBL operations can take place. See the **Working File** chapter for details.

An alternative application is Inverted LBL. This application differs from the aforementioned in that the transponder array is mounted on the moving vessel or structure that is to be positioned and multiple transceivers and smart transponders are located at the known fixed locations. The spatial relationships between the transponder array are accurately known and are applied as constraints in the least squares adjustment solving for the transponder array positions.

This section discusses how WinFrog uses LBL systems.

The reader is referred to the documentation for the respective LBL systems to determine how they are operated and what options they provide that WinFrog will use.

Components

Transponders are self-contained units with their own electronics and transducer. These units listen for an interrogation signal and, upon detecting one, respond with a reply signal. They provide ranging capabilities.

The **transceiver** is a transducer connected directly to the LBL system's control unit, the electronics that control the LBL system. The control unit is in turn interfaced directly to WinFrog. This transceiver is used to interrogate the transponders. It should be noted that the transceiver is not necessarily attached to the same vehicle on which the control unit resides. The transceiver is also required for communications with **smart transponders**.

Smart transponders are transponders that are capable of more than simply responding to an interrogation signal. Upon receiving special pulses or specific instruction telegrams transmitted by the control unit, a smart transponder can execute an interrogation of a specific transponder or array of transponders, an internal sensor observation or a preprogrammed series of interrogations and/or observations. If required by the instruction type, the results are telemetered back to the transceiver. A special case of a smart transponder is a **responder**, a transmit-only unit that is connected to the deck unit via a cable and controlled directly via the deck unit.

The actual configuration and capabilities are dependent upon the LBL system type. The reader should refer to the relevant LBL system documentation for a complete description of how that system can be used.

The Data

The basic observable of an LBL system is travel time, the time it takes for an acoustic signal to travel between transducers, plus any delays introduced by the units involved. This is reduced to a distance observation by removing the known delays (relevant transponder turn-around-time or TATs), dividing by two if the observation is a TWTT (exceptions to this are the signal received by the transceiver from a responder, and the sing-around signal initiated by a responder or relay transponder, see Operational Modes) and multiplying by the velocity of sound to derive a distance measurement.

In addition, smart transponders are capable of providing the following types of data depending upon their configurations:

- Depth from strain gauge and digiquartz sensors
- Attitude from inclinometers
- Temperature
- Salinity

Fixed Transponder Arrays and the Working Xponder File

Standard LBL acoustic operations require a minimum of three transponders located at known points. These form the LBL transponder network or array. Measurements to these transponders from transceivers or smart transponders provide the ranges required to perform a Least Squares adjustment and solve for the position of the interrogating transceiver or smart transponder. The design of this array is critical to the application of the LBL.

An entry for each station in the array must be made in the Working Xponder file as a Fixed LBL Transponder. Refer to the **Working Files** chapter for more information.

The intricacies of network design are beyond the scope of this manual. However, the following points must be considered in the design of the array and be provided by the array:

- Provide a strong geometrical solution for the work area. Strong geometry can usually be obtained by creating quadrilaterals with sides of nearly equal lengths. If 3D solutions are required, the vertical geometry must also be considered.

- Minimize the possibility of ranges of the same length during the positioning. (If unavoidable, these instances must be addressed by altering transponder TATs).
- Transponder mounting arrangements. For general operations, the transponders can be tethered to anchor weights with a short strop. If the work is in very deep water with long baselines, these strops may need to be longer to overcome the affects of ray bending. They may also need to be lengthened due to the seafloor topology to avoid physical blockage of the signals. If high accuracy is required combined with the requirement of redeployment/replacement of transponders throughout the project, tripods with buckets for placing the transponders in may be required.
- Evaluate structures in the area that may cause blockage or reflection of the acoustic signals.
- Ensure the safety of the transponders. Be aware of operations in the area that may result in damage to transponders, such as anchoring operations resulting in anchor chains being dragged through an array.
- Determine if there are other acoustic operations in the area and the impact they will have on the LBL acoustics, such as frequency interference.

For additional information, refer to Survey textbooks on the subject of network design.

The determination of the positions of the transponders in an array is accomplished with an LBL Calibration. This is covered in the **LBL Calibration** chapter.

Non-Fixed Transponders and the Working Xponder File

Not all the transponders used for LBL operations are fixed. These are generally smart transponders and can be Relay transponders, Responders, Simultaneous transponders, Cyclic transponders and Sequential transponders. It should also be noted that the transponders themselves are often the same type, but operated in different modes. It is the mode that is referred to here. These transponders are generally attached to the vehicle that is to be tracked.

Any transponders that are to be attached to vehicles or structures to enable these to be tracked and positioned must also be added to the **Working Xponder** file. In their case, the positions are not required. All other configuration settings must be entered.

Refer to the **Working Files** chapter for more information on Xponder files.

Inverted LBL and the Working Xponder File

Static Transceivers, Static Simultaneous transponders and Dynamic Array transponders are the terms used for the units involved in Inverted LBL operations. These must be entered in the **Working Xponder** file.

Refer to the **Working Files** chapter for more information on Xponder files.

Velocity Files

LBL acoustics require the application of a velocity of sound in water value to the observed travel time in order to reduce this observation to the distance required for the position adjustment. WinFrog uses a velocity file whose records contain a depth and velocity of sound at that depth. The depths of the acoustics units involved in an observation are used in conjunction with the velocity file to determine a velocity of sound through the relevant portion of the water column. This velocity value is then used to reduce the observed travel to a distance.

Velocity data is usually gathered by lowering and raising a velocity probe through the water column in the work area. This is referred to as a velocity cast. This is usually performed twice whenever it is done. Velocity casts are performed throughout the acoustic work as often as is deemed necessary given the conditions of the work area. Some areas are very stable with respect to water temperature, pressure and salinity, factors that affect the velocity, whereas others are not. To optimize the results of the acoustic calculations, velocity probes should be performed as required to ensure that WinFrog is using velocity data that represents the prevailing conditions.

The velocity file in use at any time by WinFrog is called the **Working Velocity** file. If a velocity file is not created/opened and set to be the **Working Velocity** file, the LBL will still function. However, the data will be reduced using a default velocity of 1485 m/s which, depending on the actual prevailing velocity of sound, can result in large errors.

It is recommended that the option to display the name of the **Working Velocity** file in the **Vehicle Text** window be used. In addition, flashing warnings are displayed in the following windows if a **Working Velocity** file is not loaded:

- I/O Device window, in the raw data panel if an LBL device is selected in the device panel.
- Calculation window, when the Data Item text option is selected for an LBL data item.
- Vehicle Text window, if the Velocity File name item is selected for display.

In addition, messages as to the validity of the **Working Velocity** file with respect to providing data for the full water depth required are also presented in the Calculation Window when the Data Item text option is selected for an LBL data item.

Please refer to the **Working Files** chapter for more information on velocity files.

Operational Modes

WinFrog supports the application of LBL in the following modes:

- Standard range/range positioning mode where the direct simultaneous interrogation of all fixed transponders is performed by the transceiver. The resulting observations are used to position the transceiver. This mode is generally used for positioning a surface vessel, an ROV using a specially built small transceiver connected to the LBL control unit via the ROV’s umbilical and an ROV using a specially built LBL control unit that is mounted directly on the ROV and interfaced back to WinFrog via the ROV’s umbilical.
- Responder positioning mode. A responder is a transmit-only unit that is connected directly to the control unit via a cable. The control unit and its transceiver are usually located on a surface vessel. The responder transmits a signal that is received by the transceiver connected to the same control unit. In addition, this signal is also received by the fixed transponders in the array which each then transmit their own signals that are received by the aforementioned transceiver. A subsequent direct interrogation of the fixed transponders by the transceiver completes the data collection cycle. By combining the observations,

WinFrog derives the ranges from the fixed transponders to the responder in addition to the range from the transceiver to the responder. These are then used to solve for the position of the responder. The responder is usually located on an ROV and is connected to the control unit via the ROV's umbilical.

- Relay positioning, or sing-around mode. A relay transponder is a smart transponder. This application is similar to that described for the responder positioning except that the relay transponder is not attached to the control unit. It receives its instruction to transmit via an acoustic signal from the transceiver. The rest of the process is the same as described above for the responder. The relay transponder is usually located on an ROV.
- Simultaneous positioning mode. This requires a smart transponder that is able to perform its own interrogation of the fixed transponders when instructed by the control unit via an acoustic signal. The observed TWTTs are then acoustically telemetered to the control unit. The observations are reduced to ranges enabling the solution of the smart transponder's position.
- Monitoring mode. This requires one or more transponders equipped with either a digiquartz depth sensor or inclinometer. These are interrogated for attitude and depth only. This information can then be used to monitor the subsidence of structures after placement.

The fact that these LBL positioning modes are available within a package already providing multiple surface and subsurface positioning, monitoring and viewing capabilities results in a powerful LBL application.

Data Items

The LBL devices provide the following data items:

LBL TRANSCEIVER

This is added to a vehicle that has a transceiver that is connected to either the standard or special underwater control unit mounted on it that is to use the acoustic data for positioning.

If not specifically being used for positioning itself, this need not be added to a reference vehicle in order to be able to use the other data items associated with the LBL device.

XPONDER

The XPONDER data item is associated with those non-fixed transponders entered in the transponder file: **Relay**, **Responder**, **Simultaneous and Cyclic**. If there are no such transponders available in the transponder file, though this data item can be attached to a vehicle, it will not be configurable.

The XPONDER is added to a remote vehicle that is to be tracked and positioned. The Xponder data item associated with any one LBL device can be added multiple times to the same or different vehicles.

FIXED XPONDER

The FIXED XPONDER data item is associated with fixed transponders as entered in the transponder file. If there are no such transponders available in the transponder file, though this data item can be attached to a vehicle, it will not be configurable.

The FIXED XPONDER need only be added to one vehicle regardless of how many vehicles may be configured to use the associated data. The selected transponder is then interrogated for depth that can then be used in a Differential Depth application for a more precise monitoring of the relative depth of other transponders.

ATTITUDE

The ATTITUDE data item is associated with those transponders equipped with an inclinometer. These transponders are capable of being interrogated for pitch and roll data which is then available for adding to a vehicle, or more usually a structure, being positioned.

ELEVATION

The ELEVATION data item is associated with those transponders or LBL Transceivers that can determine their depth. For those transponders that send the depth as part of the range message (e.g., SI) this data item does not need to be added to the vehicle. If the depth is obtained by its own command then it does need to be added to the vehicle.

INVERTED TRANSCEIVER

The INVERTED TRANSCEIVER data item is associated with the Static Transceivers entered in the transponder file. Though the units themselves are not physically attached to the structure being positioned, the associated data item is. This data item is attached to the sub-surface vehicle that is to be tracked with the INVERTED LBL option.

INVERTED XPONDER

The INVERTED XPONDER data item is associated with the Static Simultaneous units entered in the transponder file. Though the units themselves are not physically attached to the structure being positioned, the associated data item is. This data item is attached to a sub-surface vehicle that is to be tracked with the INVERTED LBL option.

STATIC VEHICLE

The STATIC VEHICLE data item is associated with the Inverted LBL device. This option allows you to use the Static Transceiver and Static Simultaneous units in the Working Xponder file to configure and set the position of a static vehicle or structure.

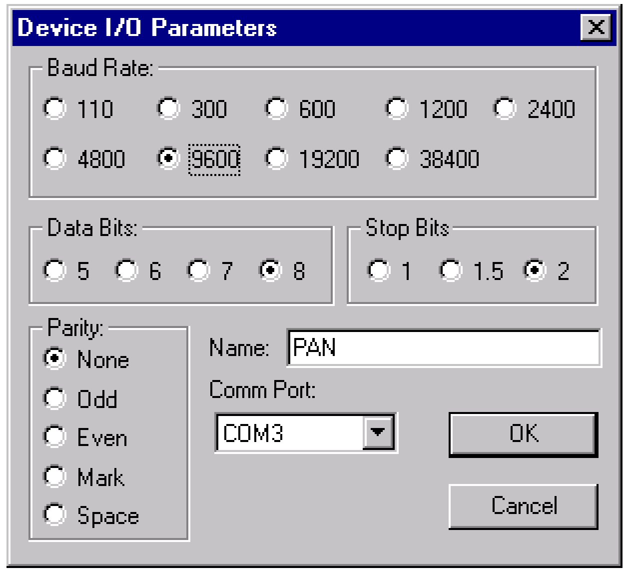
Standard LBL Setup

To Add the LBL Device to WinFrog

1 Connect the LBL system to a WinFrog com or Digiboard™ port.

2 From the main menu, select **Configure > I/O Devices… > Add,** or from within the **I/O Devices** window, right-click and choose **Add Device** from the pop-up menu.

3 From the **Devices** tree, expand the LBL node (click the **+** next to LBL or double-click LBL) to display the list of available LBL 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 LBL device.

8 Click **OK**.

At this point the LBL device has been added to WinFrog. Depending upon the LBL device added, WinFrog may start transmitting the initialization telegrams to the device based upon default parameters. These can be monitored in the **I/O Devices** window.

The data received from the LBL system will be displayed in the **I/O Devices** window. The display format depends upon the LBL device added.

To Configure the LBL Device

LBL Device configuration is system dependent and requires configuration at this point. Use the dialog boxes to appropriately configure your specific device.

For additional information on the configuration of specific devices, see the Appendix C documents, in PDF file format, on the software CD.

To Attach and Configure the LBL TRANSCEIVER Data Item

The LBL TRANCEIVER data item does not need to be added to a vehicle if it is not required to be positioned.

The LBL TRANSCEIVER data item for a given Sonardyne device may be added to more than one vehicle, or multiple times to the same vehicle. This supports the use of multiple transducers connected to a single control unit. The subsequent configuration of each instance of the data item determines which transducer is used.

1 Access the **Configure Vehicle-Devices** dialog for the appropriate vehicle.

2 Click the **Add** button.

3 Select the **LBL, *, LBL TRANSCEIVER** data item 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.

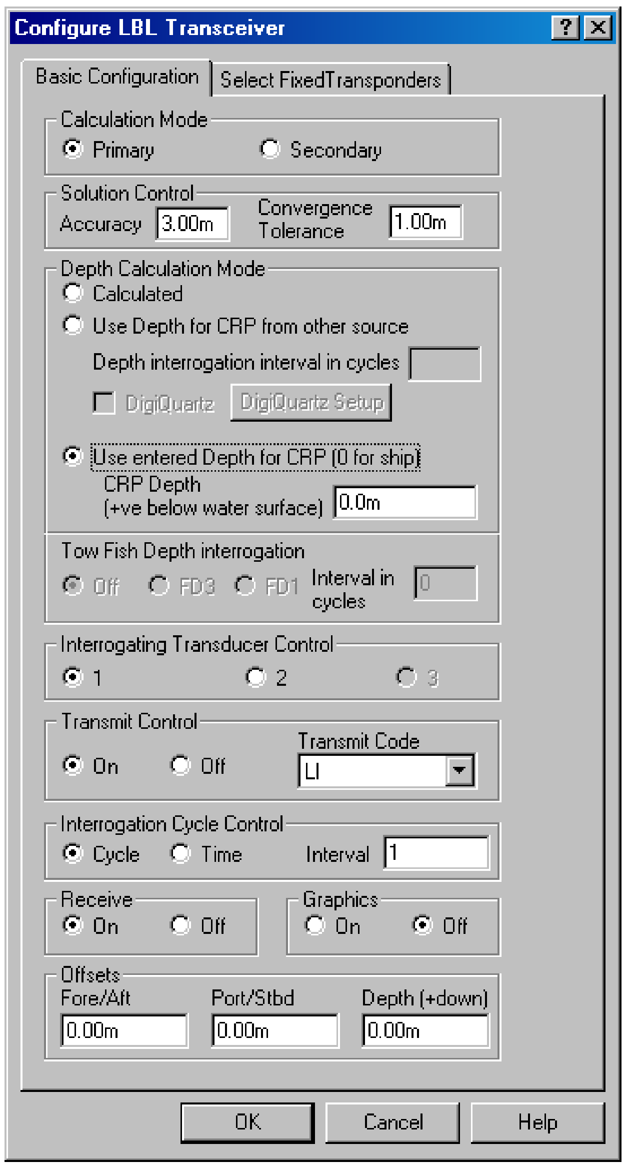
5 At the **Configure Vehicle-Devices** dialog, highlight the **LBL TRANSCEIVER** data item.

6 Click **Edit**.

7 Configure the LBL TRANSCEIVER data item as required:

Basic Configuration Tab

The configuration of how the transceiver is to operate as attached to this vehicle is edited using this tab.



Calculation

Primary
If available, the range data observed directly by the transceiver are used to determine the position of the transceiver. This is then corrected to the CRP and used in the vehicle's primary position determination.

Secondary
If available, the range data observed directly by the transceiver are used to determine the position of the transceiver. This is then corrected to the CRP and used as one of the vehicle's secondary positions.

Solution Control

Accuracy
The standard deviation of the ranges observed directly by the transceiver. This will depend upon frequency of the acoustics. **Note:** the accuracy is entered in the default distance units, not milliseconds.

Convergence Tolerance
The position calculation is a least squares solution. The process is an iterative one where the least squares actually determines and applies a correction to a position estimate to arrive at the final position solution. Given reasonable data, this correction will become smaller every iteration, i.e. the solution will converge. The process is considered complete when the correction is less than a specified convergence tolerance. You can edit this tolerance to match the accuracy of the acoustics being used, i.e. the tolerance for EHF can be set to a small value, such as 1 cm., to optimize the data. The tolerance is entered in the default distance units.

Depth Calculation Mode

This refers to the method of determining the depth of the transceiver, specifically those transceivers mounted on subsurface vehicles such as ROVs. In the case of the transceiver being mounted on a surface vehicle, the Use entered Depth for CRP option must be selected.

Calculated
The depth will be calculated using the observed ranges.

Use Depth for CRP from other source
To use this there must be another device attached to this vehicle that can determine the vehicle's depth, i.e., some ROV sensors/devices provide a depth of the vehicle. When this option is selected, the respective device's ELEVATION data item must be added to the vehicle and configured.

Alternatively, several of the LBL systems are able to provide the depths for their transceivers.

PAN: In the case of a PAN, whose transducer is interfaced to a tow fish, select this option and then configure the interrogation as per the **Tow Fish Depth Interrogation** section below.

RovNav MK3: In the case of a ROVNAV MK 3, enter the depth interrogation interval in the **Depth interrogation interval in cycles** in this group.

RovNav MK4: In the case of a ROVNAV MK 4, enter the depth interrogation interval the **Depth interrogation interval in cycles** in this group. If the ROVNAV MK 4 is fitted with a Digiquartz, select the checkbox and click the Digiquartz Setup button to enter the parameters, observation time, water density and atmospheric pressure. Note that the sensor depth rating is not required because the data is automatically scaled to reflect the shallower type. If the MK4 is fitted with a strain gauge, leave the Digiquartz checkbox unchecked and click the MK4 Depth Setup button to enter the water density (because the MK4 strain gauge returns gauge pressure, the atmospheric pressure is not required).

RovNav MK5: In the case of a MK 5, enter the depth interrogation interval in the **Depth interrogation interval in cycles** in this group. The MK5 can be equipped with either a digiquartz or a strain gauge sensor. If it has a digiquartz, the respective coefficients are already uploaded to the MK 5 unit and it can provide the resulting pressure directly. Therefore WinFrog treats both sensors as the same and simply interrogates for the pressure. Note that the pressure provided regardless of sensor type is absolute pressure. Leave the Digiquartz checkbox unchecked and click the MK5 Depth Setup button to allow entry of the water density and atmospheric pressure.

RovNav Mini: This unit does not currently support a depth query.

For details on the digiquartz parameters, refer to the section **Editing Standard Xponders, Supporting Configuration Options: Sensor Setup Button** in Chapter 5.

For details on the configuration and application of the option, including the associated ELEVATION data item, refer to the respective device documents in **Appendix C: Device Documentation-LBL.**

Use entered Depth for CRP This is a manually entered depth for the vehicle's CRP (not the transceiver). This will be used as the vehicle's CRP elevation. The offsets between the transceiver and the CRP (see below) will be applied to derive the sensor depth for the position calculation.

Tow Fish Depth Interrogation If a PAN's transducer is interfaced with a tow fish and the **Use Depth for CRP from other source** option is selected, use this group box to set the command and depth interrogation frequency. FD3 is used for the production model of the tow fish while FD1 is used for the pre-production model. These two commands request scaled data, i.e. depth in meters.

Interrogating transducer Control

1/2/3 Some LBL equipment have more than one transducer port; this controls which transducer is to be used for this transceiver.

Transmit

On This must be selected when the transceiver is used for any operations.

Off The transceiver is disabled for all uses.

Code This is the command or code required by the device to initiate range observations. Different manufacturer's equipment requires a different command or code to be entered here. For some LBL systems, this entry is designed to present only the available choices. For others, you will need to know the specific code, frequency and/or command to enter. If the transceiver is not to be used for positioning the vehicle leave this blank (or select **None**).

Interrogation Cycle Control

You can control the primary interrogation cycle interval for this data item to provide improved control when multiple LBL operations are being performed, each with a different update requirement. Note that the depth interrogation intervals are based upon the primary interrogations, that is, they monitor the number of primary interrogations to determine when to interrogate for depth.

Cycle Selecting this option dictates that the primary interrogation control interval will be based upon complete cycles through all LBL interrogations, including all synchronized devices.

Time Selecting this option dictates that the primary interrogation control interval will be based upon elapsed time between interrogations. Note that the interrogations will not necessarily occur precisely at the entered interval, but at the first opportunity after the interval has elapsed.

Interval This is the desired interval for the primary interrogations in either cycles or seconds, depending upon the above selection.

Receive

On/Off Reserved for future development.

Graphics

On/Off Controls the display in the **Graphics** window of the transceiver position on the vehicle. In the case of using the transceiver to position the vehicle (primary or secondary), the position displayed is the actual computed position. Due to the relatively slow update rate of acoustics, this position may appear to lag behind the vehicle because it is only updated when new acoustic data are received and a position calculation is performed.

Offsets

Fore/Aft

Port/Starboard

Depth These values are from the CRP to the transceiver. The depth (draft) of the transceiver is entered as positive if the transceiver is below the CRP and negative if it is above.

Note: if the transceiver is attached to a surface vehicle, the CRP must be at the water line.

Special Cases

Positioning or Monitoring of a Smart Transponder

If using the LBL to position a smart transponder (Relay, Responder, Simultaneous or Cyclic) unless also being used to position this transceiver, the Transmit Code is set to None or left blank. All required configuration is associated with the XPONDER data item attached to the appropriate vehicle (see To Attach and Configure the XPONDER Data Item).

Positioning using the Sequential Option - Transceiver

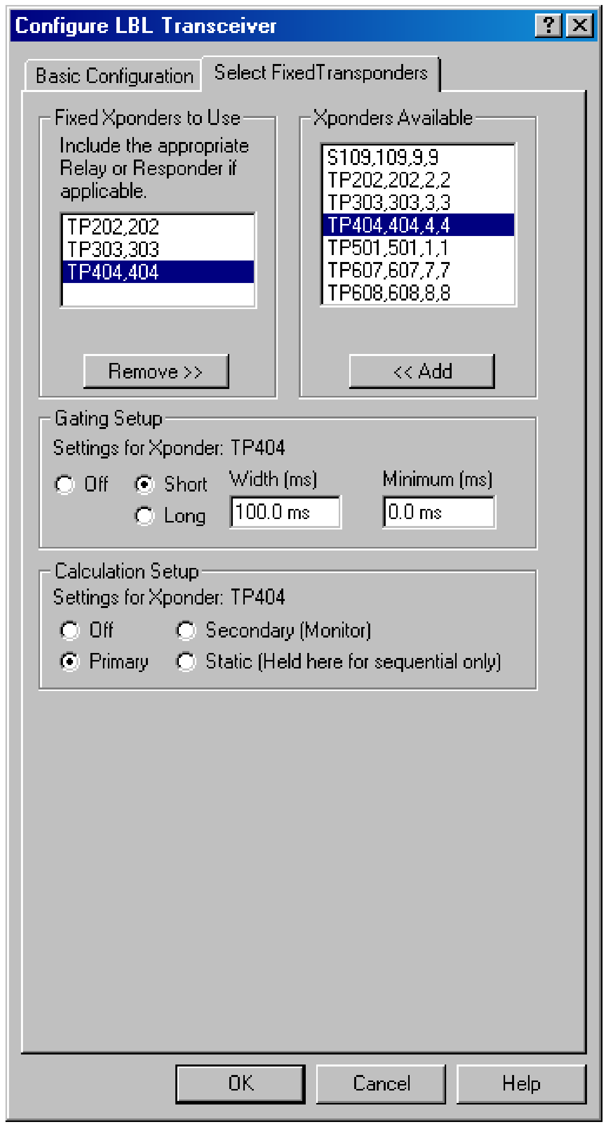
If the sequential option for collecting data to position the transceiver is required, select the II command from the Transmit Code drop down list. This is only available for Sonardyne PAN, ROVNAV MK 4 and MK 5 systems.

Select Fixed Transponders Tab

The transponders to be used for the associated positioning and calibration data collection are configured from this tab. The transponders are selected from the transponders in the **Working Xponder** file set to **Fixed**. In addition, the transponder gating and application in the position solution settings are configured here.

Note: the association of transponders for a given instance of the LBL TRANSCEIVER data item and their gating and application configuration are independent of the association of the same transponder for any other instance of a LBL TRANSCEIVER data item. For example, a given transponder can be used in one solution (complete with gating on) and monitored in another with no gating applied.

Note: the gating and calculation setup for a transponder can also be accessed from the **Calculations** window.



Fixed Xponders to Use

This is a list of those fixed transponders, selected by the operator from the Available list, to be used in conjunction with this transceiver.

To remove a transponder from the list, highlight it and click the **Remove>>** button.

To Add a transponder to the list, highlight it in the **Xponders Available** list and click the **<<Add** button or double-click the entry in the list.

Xponders Available

This is a list of all the fixed transponders in the **Working Xponder** file. Each one is identified by station name, address, reply code, and individual interrogation frequency (**IIF**). Those fixed transponders that do not have an address or IIF (i.e. the first one listed here) will not have anything between the first and second comma and will not have an IIF after the last comma.

To select a transponder required for use in conjunction with this vehicle. (i.e. for positioning or collecting ranges for calibration or for use with a relay/responder transponder) double-click the transponder in the list or highlight it and click the **<<Add** button. This will copy the transponder name to the **Fixed Xponders to Use** list. **Note:** the selected transponder still appears in the available list.

Gating Setup

These settings control the application of range Gating for the data for the transponder highlighted in the Fixed Xponders to Use list. Gating refers to comparing the new range against the expected range based upon a history for that range. If the new range lies within the gate (the expected range +/- the gate width) it is accepted, otherwise it is gated from the solution that is not used but still monitored.

Off	Gating is not applied to the range data for the transponder, all data will be used in the solution.
Short	Gating is applied using a short history, specifically the last 4 ranges, to determine the trend against which the new range is evaluated to determine if it is to be gated from the solution.
Long	Gating is applied using a long history, specifically the last 10 ranges, to determine the trend against which the new range is evaluated to determine if it is to be gated from the solution.
Width	If gating is on, this value is used as the criteria to accept or reject a range. If the range lies within the window created by this value and the trend determined by the **Long** or **Short** selection, it will be accepted. This value is in milliseconds.
Minimum	This is the minimum acceptable TWTT in milliseconds. If the associated TWTT is less than this entry, the range is not used in the solution. This test is independent of the gating and applied whether gating is on or off. It is grouped with the gating due to the similar nature of its use.

Note: if gating is on it requires two to four ranges before a trend can be established thus the first few sets of ranges will not result in a fix computation. This will be indicated in the **Calculations** window (see Monitoring the Standard LBL Operation).

Calculation Setup

These settings control how the range data for the transponder highlighted in the **Fixed Xponders to Use** list is used in the position calculations.

Off	The transponder's data are not used in the solution, nor is a residual calculated and displayed, i.e. the range is not monitored.
Primary	The transponder is used in the solution.
Secondary	The transponder is not used in the solution, but a residual is computed for the range, i.e. it is monitored.
Static	This mode applies to LBL systems that support WinFrog's sequential transponder interrogation. If selected, the last observed range will be used in subsequent position calculations and this transponder will not be interrogated again until the Static setting is changed.

8 Click **OK** to accept the settings and return to the **Configure Vehicle-Devices** dialog. At this point, the changes will take affect and any interrogations and calculations configured will commence.

9 Complete the configuration of the **Vehicle Position Calculations**, i.e. Kalman Filter control.

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

To Attach and Configure the XPONDER Data Item

The XPONDER data item associated with a given LBL device may be added more than once to the same vehicle or different vehicles. The subsequent configuration of each instance of the data item will differentiate the transponder to which it is associated from others. In this way, for example, multiple transponders that are attached to a single structure for the monitoring of its deployment and subsequent final positioning are associated with that vehicle in WinFrog.

1 Access the **Configure Vehicle-Devices** dialog for the appropriate vehicle.

2 Click the **Add** button.

3 Select the **LBL, *, XPONDER** data item 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.

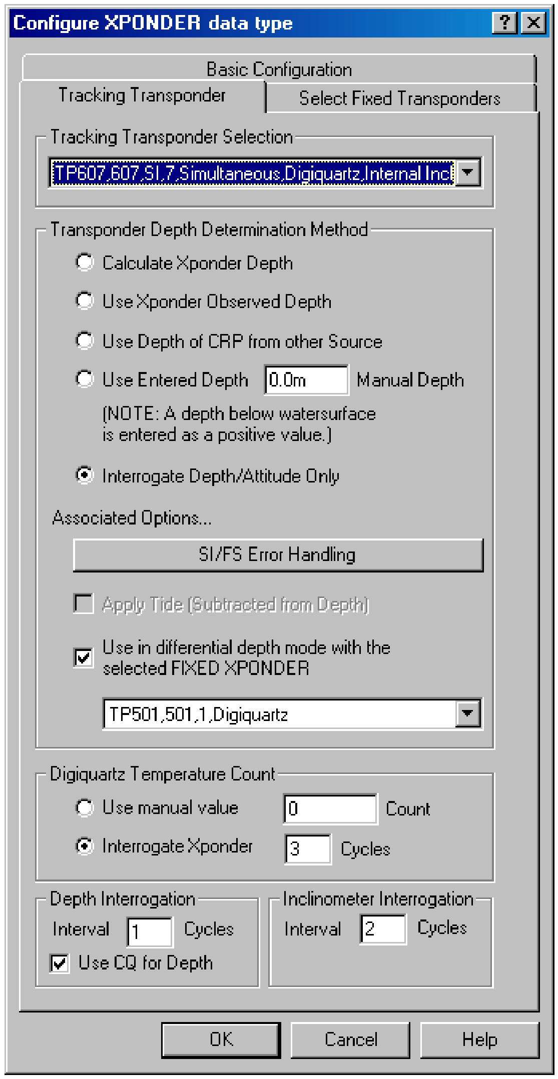
5 At the **Configure Vehicle-Devices** dialog, highlight the XPONDER data item.

6 Click **Edit**.

7 Configure the XPONDER data item as required.

Tracking Transponder Tab

This tab is used to select a non-fixed transponder from the **Working Xponder** file to be associated with this instance of the XPONDER data item and to configure the depth control.



Tracking Transponder Selection

This dropdown list box displays the transponders set to **Relay**, **Responder**, **Simultaneous, Sequential** or **Cyclic** in the **Working Xponder** file. If there are no transponders of these types in the transponder file then a vehicle cannot be positioned by this data item. Each transponder is described by its **Name**, **Address**, **Receive code**, **Transmit code**, **LBL transponder type** and **depth sensor type**. If the transponder does not use addresses then there will just be two commas between name and receive code.

Select the appropriate transponder or **None** to cancel a previous selection and stop interrogation.

The following are the available operating modes associated with the respective transponder type:

Responder Positioning Mode	Responder, the Responder must also be added to the Fixed Xponders to Use list.
Relay Positioning Mode	Relay transponder, the Relay transponder must also be added to the Fixed Xponders to Use list.
Simultaneous Positioning Mode	Simultaneous transponder
Cyclic Positioning Mode	Cyclic transponder
Sequential Positioning Mode – transponder	Sequential transponder

The selection of the transponder controls the available configuration options and must be done first.

Note that any option that refers to cycles, refers to the measurement cycle appropriate to the type of transponder selected. For example, a cycle for a Simultaneous transponder is a single measurement command and response cycle.

Transponder Depth Determination Method

This controls how the depth of the transponder will be determined.

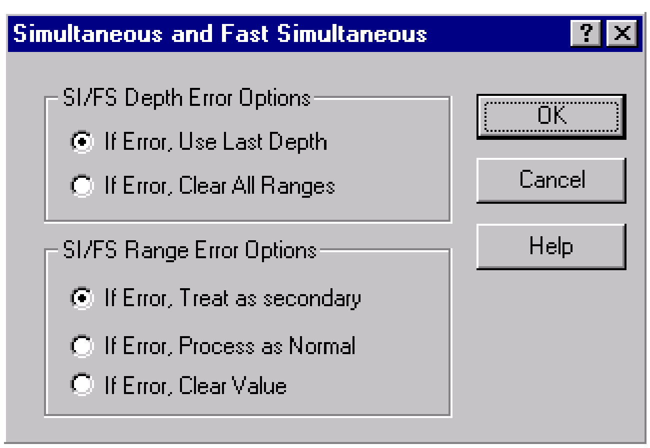
Calculate Xponder Depth	The depth will be calculated using the observed ranges (i.e. 3D solution).
Use Xponder Observed Depth	The depth observed directly from the transponder will be used as the depth in the solution (i.e. 2D solution, fixed depth). In come cases this is included with the data, in others it will require a specific interrogation to obtain it. If this method is selected and a specific interrogation is required for the transponder type, the **Depth Interrogation** edit box below becomes active and must be configured. In the case of a simultaneous transponder fitted with a Digiquartz, and you do not want to use the depth from the reply to the SI command, do not select this option. Instead select the **Use Depth from other Source** option. You may want to do this if a 9 second interrogation time is desired instead of the 1 second as part of the SI command.

Use Depth of CRP from other Source	The depth of the vehicle's CRP is determined using another sensor (device). This depth will be used in the solution (i.e. 2D solution, fixed depth). If the depth is to be determined by a simultaneous transponder using the CQ command, choose this option. Then select the Use CQ for Depth. You must also attach the ELEVATION data item for this device to this vehicle.
Use Entered Depth	The depth as entered here for the vehicle's CRP is used in the solution (i.e. 2D solution, fixed depth).
Interrogate Depth/Attitude only	If the transponder is to be used only for monitoring a structure and ranges are not required for a position determination, select this option. Then configure the Depth and Inclinometer interrogations appropriately. If the transponder is to be interrogated for depth, it must be equipped with a Digiquartz depth sensor. In addition, the associated ELEVATION data item must be attached to this vehicle. If the transponder is to be interrogated for inclination, the associated ATTITUDE data item must be attached to this vehicle and configured to use this transponder (select this transponder in the dropdown list in the configuration dialog).

Associated Options…

These are configuration options that enhance the application of the transponder data.

SI/FS Error Handling	If the selected transponder is a simultaneous transponder, this option is enabled. It accesses the following dialog allowing the configuration of action to take when errors are detected and reported by the LBL system.



SI/FS Depth Error Options

This controls how the detection of an error in the depth observation is handled.

If Error, Use Last Depth	If an error is reported for the depth observation, the last good depth observation is used in the solution.
If Error, Clear All Ranges	If an error is reported for the depth observation, all range data is cleared and no position is solved for.

SI/FS Range Error Options

This controls how the detection of an error in the range observation is handled.

If Error, Treat as Secondary	If an error is reported for a range observation, the respective range is not used in the solution but a residual is computed and displayed.
If Error, Process as Normal	If an error is reported for a range observation, it is ignored and the respective range is used in the solution.
If Error, Clear Value	If an error is reported for a range observation, the respective range is zeroed and treated as if it didn't exist.

Apply Tide

This option remains disabled unless the depth is observed from this transponder. In order to use this option, tide must be available to the vehicle, i.e. the TIDE data item must be attached to the vehicle. The tide is **subtracted** from the observed depth to obtain the depth below datum. When using this option, the fixed transponder's depths must be relative to this same datum.

Use in differential depth mode…

This option is available for the modes that utilize an observed depth value. The concept of a differential depth determination involves the monitoring of a static transponder's depth against the defined depth for that transponder. The difference observed between these values becomes a correction that can be applied to other depth observations to ensure they are relative to the static transponder's vertical datum, regardless of changes in tide and atmospheric pressures. If this option is checked, the **FIXED TRANSPONDER** that is to be used must be selected from the drop down list. Note that in order to use this option, a **FIXED XPONDER** data item must be attached to a vehicle, though not necessarily this vehicle, and configured (see To Attach and Configure the FIXED XPONDER Data Item).

Digiquartz Temperature Count

If the selected transponder is equipped with a digiquartz depth sensor, this controls how the associated temperature count data is obtained.

Use Manual Value	If this option is selected, WinFrog will use the value entered in the associated data entry window labeled **Count**.
Interrogate Xponder	If this option is selected, WinFrog will interrogate the transponder at the interval entered in the associated data entry window labeled **Cycle**.

Depth Interrogation

Case: Not a Simultaneous Transponder

If the **Use Xponder Observed** depth option is selected above and the selected transponder is not a Simultaneous transponder, this option is enabled. The interval between depth interrogations, if appropriate for the transponder type, is entered. This interval is in cycles and must be greater than 1.

Case: Simultaneous Transponder with a Digiquartz

If the Use Depth of CRP from other Source is selected, the Use CQ for Depth checkbox will become active. If checked, the Interval and the Digiquartz Temperature Count group box will become active. This allows you to use the long observation period of the CQ command (9 seconds) to obtain a more accurate reading than provided by the SI command (1 Second). If this box is checked, the ELEVATION data item of this device must be attached to this vehicle and configured.

Case: Interrogate Depth/Attitude Only

If this option is selected, the Use CQ for Depth checkbox will become active. If checked, the Interval and the Digiquartz Temperature Count group box will become active. If this box is checked, the ELEVATION data item of this device must be attached to this vehicle and configured.

Inclinometer Interrogation

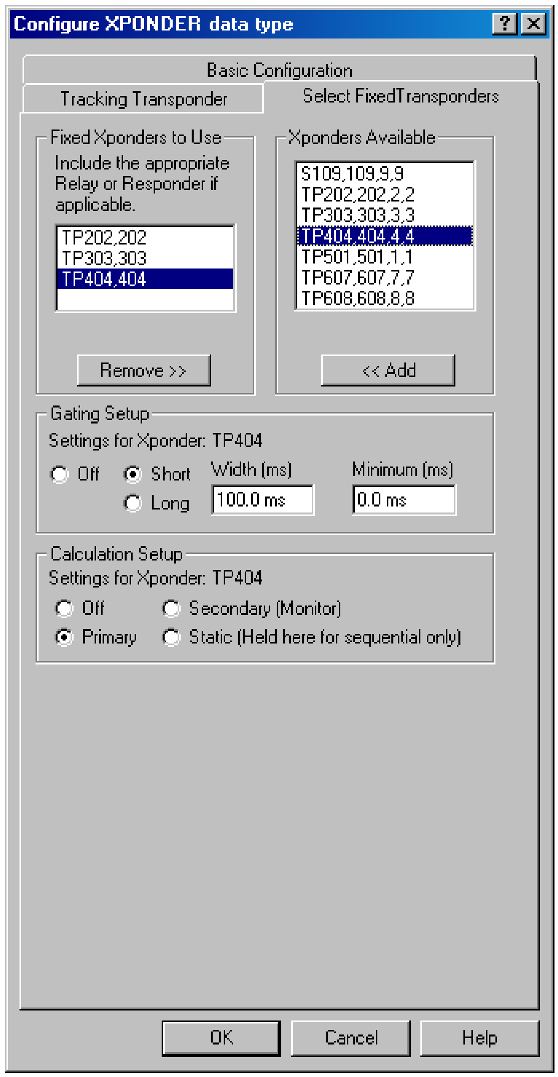
If the selected transponder is configured for an inclinometer, this option is enabled. The interval between inclinometer interrogations is entered. This interval is in cycles and must be greater than 1. The associated ATTITUDE data item must be attached to this vehicle and configured.

Select Fixed Transponders Tab

Use this tab to select the fixed transponders for use in the position solution or calibration data collection. The transponders are selected from the transponders in the **Working**

Xponder file set to **Fixed**, **Relay**, and/or **Responder**. In addition, the transponder gating and application in the position solution settings are configured here.

Note: the association of transponders for a given instance of the XPONDER data item and their gating and application configuration are independent of the association of the same transponder for any other instance of the XPONDER data items. For example, a given transponder can be used in one solution (complete with gating on) and monitored in another with no gating applied. This is important when multiple non-fixed transponders are attached to a structure and are interrogating the same fixed array. In this situation, a fixed transponder may provide a steady return to one non-fixed transponder while due to blockage or reflections of the signals, provide unreliable returns to one of the other non-fixed transponders, but yet can still be monitored.



Note: the gating and calculation setup for a transponder can also be accessed from the Calculations window.

Xponders Available

This is a list of all the fixed transponders and the non-fixed Relay and Responder transponders in the **Working Xponder** file. Each one is identified by station name, address, reply code, and individual interrogation frequency (IIF). Those fixed transponders that do not have an address or IIF (i.e. the first one listed here) will not have anything between the first and second comma and will not have an IIF after the last comma.

To select a transponder required for use in conjunction with this vehicle. (i.e. for positioning or for use as a relay/responder transponder) double click the transponder in the list or highlight it and click the **<<Add** button. This will copy the transponder name to the **Fixed Xponders to Use** list. Note that the selected transponder still appears in the available list.

Note: it is important that if operating in Relay or Responder positioning mode that the relay transponder or responder selected as the **Tracking Transponder** be added to the **Fixed Xponders to Use** list. Although this is not a fixed transponder, it is necessary to select it here.

Fixed Xponders to Use

This is a list of those fixed transponders, selected by the operator from the available list, to be used in conjunction with this transceiver.

Note: it is important that if operating in Relay or Responder positioning mode that the relay transponder or responder selected as the **Tracking Transponder** be added to the **Fixed Xponders to Use** list. Although this is not a fixed transponder, it is necessary to select it here. To remove a transponder from the list, highlight it and click the **Remove>>** button.

To add a transponder to the list, highlight it in the **Xponders Available** list and click the **<<Add** button or double-click the entry in the list.

Gating Setup

These settings control the application of range gating for the data for the transponder highlighted in the **Fixed Xponders to Use** list. Gating refers to comparing the new range against the expected range based upon a history for that range. If the new range lies within the gate (the expected range +/- the gate width) it is accepted, otherwise it is gated from the solution that is not used but still monitored.

Off	Gating is not applied to the range data for the transponder, all data will be used in the solution.
Short	Gating is applied using a short history, specifically the last 4 ranges, to determine the trend against which the new range is evaluated to determine if it is to be gated from the solution.
Long	Gating is applied using a long history, specifically the last 10 ranges, to determine the trend against which the new range is evaluated to determine if it is to be gated from the solution.

Width	If gating is on, this value is used as the criteria to accept or reject a range. If the range lies within the window created by this value and the trend determined by the **Long** or **Short** selection it will be accepted. This value is in milliseconds.
Minimum	This is the minimum acceptable TWTT in milliseconds. If the associated TWTT is less than this entry, the data is not used in the solution. This test is independent of the gating and applied whether gating is on or off. It is grouped with the gating due to the similar nature of its use. **Note:** if gating is on it requires two to four ranges before a trend can be established thus the first few sets of ranges will not result in a fix computation. This will be indicated in the **Calculations** window (see Monitoring the Standard LBL Operation).

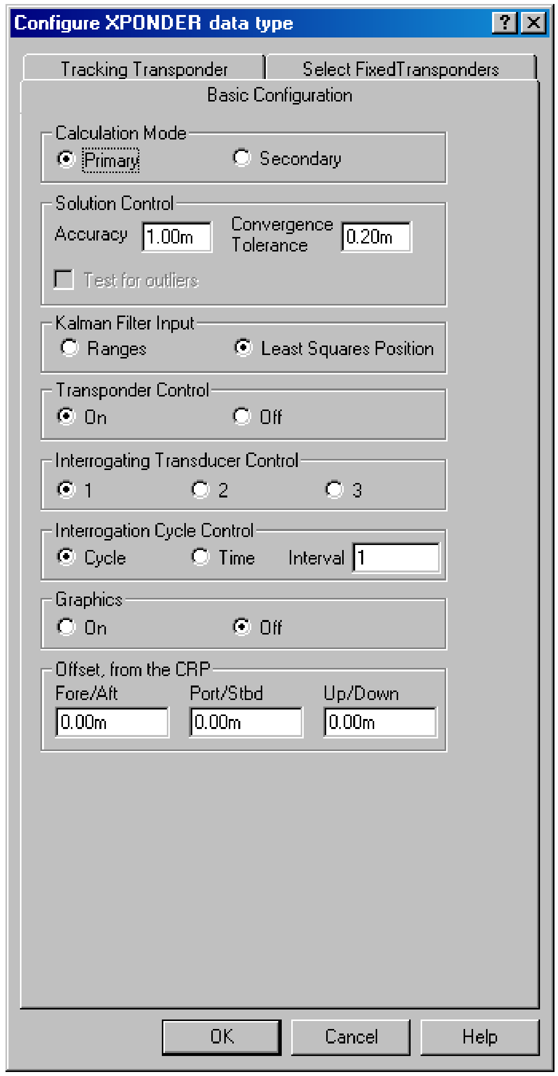
Calculation Setup

These settings control how the range data for the transponder highlighted in the **Fixed Xponders to Use** list will be used in the position calculations.

Off	The transponder's data are not used in the solution, nor is a residual calculated and displayed, i.e. the range is not monitored.
Primary	The transponder is used in the solution.
Secondary	The transponder is not used in the solution, but a residual is computed for the range, i.e. it is monitored.
Static	This mode applies to LBL systems that support WinFrog's sequential transponder interrogation. If selected, the last observed range will be used in subsequent position calculations and this transponder will not be interrogated again until this setting is changed.

Basic Configuration Tab

The basic transponder configuration is implemented from this tab.



Calculation

Primary The position determined for the transponder associated with the data item will be used in the Primary position calculation for this vehicle. Note that if the transponder is to be used for monitoring depth and inclination only, this setting is not applicable. In this case control of the use of the resultant data as primary or secondary is configured with the associated ELEVATION and ATTITUDE configurations.

Secondary The position determined for the transponder associated with the data item will be used as a Secondary position for monitoring this vehicle's primary position.

Solution Control

Accuracy The standard deviation to be used for each range

	used in the position solution for this transponder. This will depend upon frequency of the acoustics. The accuracy is entered in the default Distance units.
Convergence Tolerance	The position calculation is a least squares solution. The process is an iterative one where the least squares actually determines and applies a correction to a position estimate to arrive at the final position solution. Given reasonable data, this correction will become smaller every iteration, i.e. the solution will converge. The process is considered complete when the correction is less than a specified convergence tolerance. You can edit this tolerance to match the accuracy of the acoustics being used, e.g. the tolerance for EHF can be set to a small value to optimize the data, such as 1 cm. The tolerance is entered in the default Distance units.
Test for Outliers	This option pertains only to use with the Inverted LBL application and the Static Simultaneous transponder and is disabled here.

Kalman Filter Input

Ranges	Ranges are passed into the Kalman filter.
Least Squares Position	Computed positions (from the ranges) are passed into the Kalman filter.

Transponder Control

On	The transponder is active.
Off	The transponder is disabled within WinFrog, i.e. WinFrog will not communicate with it automatically as configured here.

Interrogation Transducer Control

1/2/3	This controls which transceiver connected to the control unit will be used to communicate with/interrogate the transponder.

Interrogation Cycle Control

You can control the primary interrogation cycle interval for this data item to provide improved control when multiple LBL operations are being performed, each with a different update requirement. Note that the depth and inclination interrogation intervals are based upon the primary interrogations, that is, they monitor the number of primary interrogations to determine when to interrogate for depth.

Cycle	Selecting this option dictates that the primary interrogation control interval will be based on complete cycles through all LBL interrogations, including all synchronized devices.
Time	Selecting this option dictates that the primary

interrogation control interval will be based on elapsed time between interrogations. Note that the interrogations will not necessarily occur precisely at the entered interval but at the first opportunity after the interval has elapsed.

Interval

This is the desired interval for the primary interrogations in either cycles or seconds, depending upon the above selection.

Graphics

On/Off

Turns the display of the raw transponder position **On** and **Off** in the **Graphics** window. Due to the relatively slow update rate of acoustics, this position may appear to lag behind the vehicle because it is only updated when new acoustic data are received and a position calculation is performed.

Offsets, from the CRP

Fore/Aft
Port/Starboard
Height

Enter the offsets from the CRP to the transponder. The vertical offset, Z, is positive up. Note that if the transponder is also being used as an ELEVATION data item, the actual depth sensor offsets must be entered in the configuration of that data item.

8 Click **OK** to accept the settings and return to the **Configure Vehicle-Devices** dialog. At this point, the changes will take affect and any interrogations and calculations configured will commence.

9 Complete the configuration of the **Vehicle Position Calculations**, i.e. Kalman Filter control.

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

To Attach and Configure the FIXED XPONDER Data Item

The FIXED XPONDER data item provides the capability for monitoring the real time depth observations of a static transponder (usually one of the fixed transponder array network) with respect to the depth assigned in the Working Xponder File. As a result of the monitoring, the entire fixed transponder array is continually updated with respect to their defined depths, or a correction accounting for variations in tide and atmospheric pressure is made available for application to the depth observations of dynamic transponders. This is referred to as differential depth determinations. Note that if a TRANSCEIVER data item requires the application of differential depth determination, the FIXED XPONDER would have to be configured to update the Working Xponder File.

The FIXED XPONDER data item associated with a given LBL device can be added only once to any vehicle though it can be added once to multiple vehicles. However, if multiple vehicles are to use the same transponder as a FIXED XPONDER, it is not necessary to add the data item to all the vehicles, but only one. Attaching it to more than one vehicle will result in unnecessary redundant interrogations that will slow the LBL interrogation cycle.

1 Access the **Configure Vehicle-Devices** dialog for the appropriate vehicle.

2 Click the **Add** button.

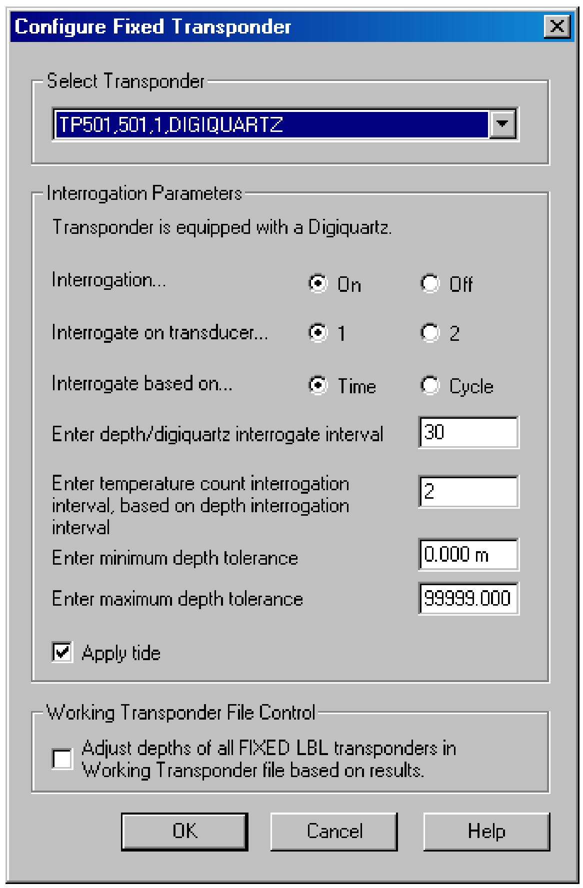
3 Select the **LBL, *, FIXED XPONDER** data item from the **Available Data Items** list, where the * is the operator assigned name for the device.

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

5 At the **Configure Vehicle-Devices** dialog, highlight the **FIXED XPONDER** data item.

6 Click **Edit**.

7 Configure the **FIXED XPONDER** data item as required.



Select Transponder

Select the transponder from the drop down list that is to be used as the **FIXED XPONDER**. Only those transponders in the **Working XPONDER File** set to **Fixed** are listed.

Interrogation Parameters

Transponder is equipped…	This line states the depth sensor type of the selected transponder.
Interrogation	Select On or Off to enable or disable the interrogation of this transponder for depth.
Interrogate on transducer	Select the transceiver to be used for transmitting the interrogation.
Interrogate based on	Select whether the interrogation interval is to be controlled by cycles or time. In the case of cycles, this refers to the complete LBL interrogation cycle, including all synchronized LBL devices. In the case of time, this refers to the elapsed time between interrogations. Note that in the case of a time interval, the interrogations are not necessarily executed as soon as the interval has elapsed but rather at the first opportunity, based on the cycle and transmission of other devices/commands, after the time interval has elapsed.
Enter depth/digiquatrz interrogate interval	Enter the interrogation interval. If the **Time** was selected above, this interval is in seconds.
Enter temperature count interrogation interval	If the depth sensor is a digiquartz, enter the interval between temperature count interrogations. This interval is based upon the depth interrogation cycle, i.e. every n depth interrogations.
Enter the minimum depth tolerance	This provides a basic filter of bad observations. Enter the minimum (shallowest) depth considered acceptable.
Enter the maximum depth tolerance	This provides a basic filter of bad observations. Enter the maximum (deepest) depth considered acceptable.
Apply tide	If tide is to be applied to the observations to relate the depths to a specific datum, select this checkbox. In order to use this option, tide must be available to the vehicle, i.e. the TIDE data item must be attached to the vehicle.

Working Transponder File Control

Select this checkbox if the depth observations are to be used to determine a correction to be applied to the depths of all **Fixed** transponders in the **Working Xponder File** in real-time.

To Attach and Configure the ELEVATION Data Item

The ELEVATION data item is required if, in the case of the **LBL TRANSCEIVER** data item, the **Depth Calculation Mode option is selected,** or in the case of the **XPONDER** data item, the **Transponder Depth Determination Method** is set to **Use Depth of CRP from other source** or **Interrogate Depth/Attitude Only**.

1 Access the **Configure Vehicle-Devices** dialog for the appropriate vehicle.

2 Click the **Add** button.

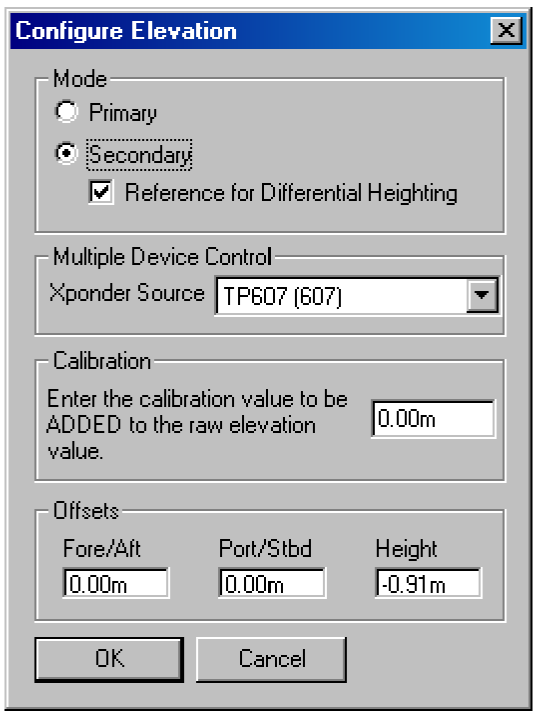
3 Select the **LBL, *, ELEVATION** data item from the **Available Data Items** list, where the * is the operator assigned name for the device.

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

5 At the **Configure Vehicle-Devices** dialog, highlight the **ELEVATION** data item.

6 Click **Edit**.

7 Configure the **ELEVATION** data item as required.



Mode

Primary — If the depth is to be used for the vehicle, select Primary.

Secondary — If the elevation is not to be used directly for the vehicle's depth, select Secondary.

NOTE: If the ELEVATION data item is associated with an XPONDER data item that has been configured to interrogate for depth and has been configured for Differential Depth mode, even though the depth is to be used for the vehicle, the mode is set to **Secondary**.

Reference for Differential Heighting

If the ELEVATION data item is associated with an XPONDER data item that has been configured to interrogate for depth and has been configured for Differential Depth mode this checkbox **must** be selected.

Multiple Device Control

Xponder Source

If the ELEVATION data item is associated with a TRANSCEIVER data item that has been configured to interrogate for depth, select **Transceiver** from the dropdown list.

If the ELEVATION data item is associated with an XPONDER data item that has been configured to interrogate for depth, select the transponder that is being interrogated for the depth (selected as the Tracking Transponder in the associated XPONDER data item configuration) from the dropdown list.

Calibration

If there is a known calibration value for the respective sensor, it is to be entered in the *Calibration* panel. Care must be taken with the sign convention. If the sensor is reading deeper than the actual depth, the entry is positive. If the sensor is reading shallower than the actual depth, the entry is negative. There are two important points to be aware of with respect to the calibration entry:

- When a transponder is selected, the depth sensor calibration value that was entered for the same transponder in the Xponder File is not automatically retrieved and used here. However, the same value and sign convention as used for that calibration value is used here even though it is stated here that the calibration is *added* and in the Xponder File dialog it is stated that the value is *subtracted*. This is because in the Xponder File dialog it is referring to a depth but in the ELEVATION data item dialog it is referring to a height.
- The calibration value is a depth term, not a pressure.

Offsets

Enter the offsets to relate the depth (pressure) sensor to the CRP of the vehicle. It is important to note that the offsets apply to the sensor, not the transducer. If an attitude sensor is available and set to on, the data from it will be used to reduce the offsets.

To Attach and Configure the ATTITUDE Data Item

The ATTITUDE data item is required if the attitude data from a transponder is to be used to orient the vehicle. Note this data item dialog is generic in nature and thus is the same for all attitude data items. Not all the settings available are applicable to LBL acoustics. See the individual device documents.

1 Access the **Configure Vehicle-Devices** dialog for the appropriate vehicle.

2 Click the **Add** button.

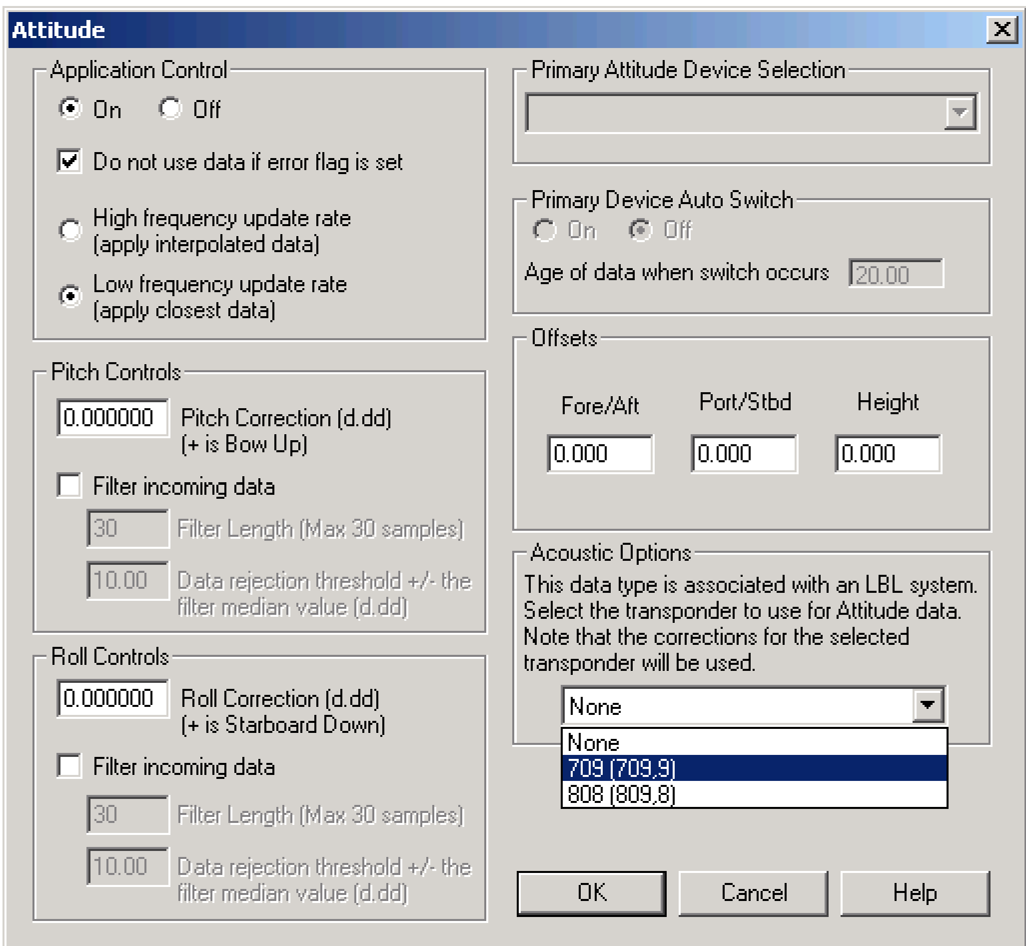
3 Select the **LBL, *, ATTITUDE** data item from the **Available Data Items** list, where the * is the operator assigned name for the device.

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

5 At the **Configure Vehicle-Devices** dialog, highlight the **ATTITUDE** data item.

6 Click **Edit**.

7 Configure the **ATTITUDE** data item as required.



Attitude

On If the attitude data is to be applied to orient the vehicle, select **On**.

Off If the attitude data is not to be applied to orient the vehicle, select **Off**.

Do not use data if error flag is set	Select this checkbox if the data is not to be used if the inclinometer reply error flag is anything but 0 (no errors).
High frequency update rate	Choosing this option allows WinFrog to interpolate/extrapolate a value to the desired epoch. However, this requires a high data rate (say 10hz) that is unlikely to be available from an underwater inclinometer. Thus this selection should not be made.
Low frequency update rate	Choosing this option allows WinFrog to use the value that's closest in time to the desired epoch. This is the selection that's most likely applicable to an inclinometer.
Pitch Correction	This value will be obtained from the transponder and assigned automatically when you select the transponder from the Acoustics option below. If the value is changed in the transponder file be sure to reselect the transponder in this dialog.
Roll Correction	This value will be obtained from the transponder and assigned automatically when you select the transponder from the Acoustics option below. If the value is changed in the transponder file be sure to reselect the transponder in this dialog.
Filtering	Filtering should only be used if there is a high rate of data available (say 10hz). Otherwise the sinusoidal shape of the data can become aliased. When this happens the filtering doesn't work and good data can be rejected and bad data accepted.
Auto switching	This feature allows you to set up automatic switching between attitude sources. However, due to interrogation issues only one acoustic attitude data item is allowed to be assigned to a vehicle at one time, from it the operator selects which transponder to interrogate (see below).
Offsets	These are not applicable to acoustic operations.

Acoustic Options

Select transponder that is to be used to provide the attitude data from the dropdown list. This ensures that the data from the correct transponder is used when the acoustic device is interrogating multiple transponders. The correction values are retrieved from the **Working Xponder File** for the selected transponder when it is selected (see **Inclinometer Calibration** in the **Working Files** chapter).

Differential Depth Operation

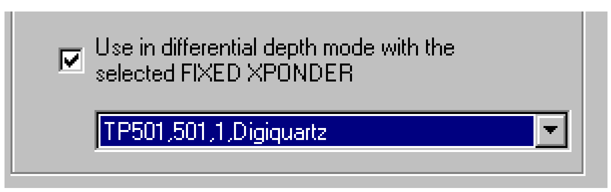
The Differential Depth option provides the means to use precise digiquartz depth sensors located in a fixed transponder (part of the network array) and a dynamic transponder(s) to monitor the depth of the dynamic transponder(s) and the associated vehicle(s) relative to the fixed transponders vertical datum regardless of changes in water levels (tides) and atmospheric pressures.

There are three basic methods of applying Differential Depth to address its application to standard positioning using simultaneous COMPATTs, positioning using another depth source, and monitoring depth/attitude only. It is important to note that these can be combined. For example, two transponders can be associated with the same vehicle. One transponder can be configured for **Interrogate Depth/Attitude Only** as per the steps below and the second for **Use Depth of CRP from other source** and then use the depth data from the former by configuring the **ELEVATION** data item for the former.

To Implement the Differential Depth for Standard Simultaneous Positioning Operations

The following details the configuration for standard Simultaneous transponder positioning using the differential depth feature.

1. Associate a **FIXED XPONDER** to a vehicle and configure it.
2. Associate an **XPONDER** data item to the respective vehicle.
3. Open the associated configuration dialog.
4. Select the Simultaneous transponder to use for positioning from the drop down list.
5. Select the **Use Xponder Observed Depth** option.
6. Select the **Use in differential…** checkbox and select the **FIXED XPONDER** to use as the reference from the dropdown list.



7. Enter the offsets to relate the transponder's transducer to the vehicle's CRP.
8. Complete the standard configuration of the **SI/FS Error Handling**, and the **Basic Configuration and Select Fixed Transponders** tabs.
9. Click **OK**.

To Implement the Differential Depth for CRP Depth from Other Source Positioning Operations

The following details the configuration for Simultaneous transponder positioning, interrogating the Simultaneous transponder's digiquartz directly to obtain a more accurate reading than that provided as part of the simultaneous interrogation.

1 Associate a **FIXED XPONDER** to a vehicle and configure it.

2 Associate an **XPONDER** data item to the vehicle to be positioned.

3 Open the associated configuration dialog.

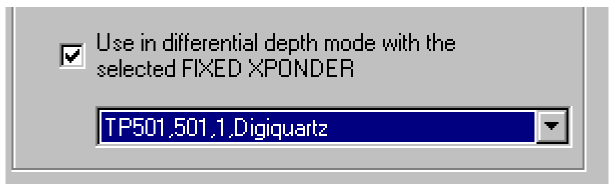
4 Select the Simultaneous transponder to use for positioning from the drop down list.

5 Select the **Use Depth of CRP from other source** option.

6 Check the **Use CQ for Depth** box and enter the interrogation interval cycle.

7 If interrogating the transponder for TQ, enter the respective interrogation interval cycle. If not, select the **Use manual value** option and enter the TQ value.

8 Select the **Use in differential…** checkbox and select the **FIXED XPONDER** to use as the reference from the dropdown list.



9 Enter the offsets to relate the transponder's transducer to the vehicle's CRP.

10 Complete the standard configuration of the **SI/FS Error Handling**, and the **Basic Configuration and Select Fixed Transponders** tabs.

11 Click **OK**.

12 Add the associated LBL **ELEVATION** data item to the vehicle to be positioned.

13 Open the **ELEVATION** data item configuration dialog. (The configuration is detailed below. For more information concerning the configuration of this data item see **To Attach and Configure the ELEVATION Data Item.**)

14 Select **Secondary** and check the **Reference for Differential Heighting** checkbox.

15 Select the same transponder that was selected as the Tracking Transponder in the associated **XPONDER** data item configuration, from the dropdown list.

16 If applicable, enter the calibration value for the depth source. Note that WinFrog does not automatically retrieve the calibration value for a selected transponder from the Working Xponder File – it must be re-entered here. If the sensor is reading deeper than actual, the calibration value is positive. Conversely, if the sensor is reading shallower than actual, the calibration value is negative.

17 Enter offsets to associate the depth sensor to the vehicle's CRP. Note that if a transponder is used, the offsets are from the depth sensor itself, not from the transducer.

18 Click **OK**.

To Implement the Differential Depth for Monitoring Depth/Attitude Operations

The following details the configuration for Simultaneous transponder monitoring only, interrogating the Simultaneous transponder's digiquartz directly.

1 Associate a **FIXED XPONDER** to a vehicle and configure it.

2 Associate an **XPONDER** data item to the vehicle to be positioned.

3 Open the associated configuration dialog.

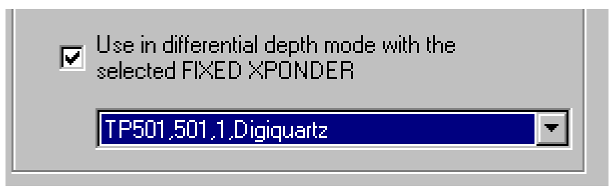
4 Select the Simultaneous transponder to monitor from the drop down list.

5 Select the **Interrogate Depth/Attitude Only** option.

6 Check the **Use CQ for Depth** box and enter the interrogation interval cycle.

7 If interrogating the transponder for TQ, enter the respective interrogation interval cycle. If not, select the **Use manual value** option and enter the TQ value.

8 Select the **Use in differential…** checkbox and select the **FIXED XPONDER** to use as the reference from the drop down list.



9 Enter the offsets to relate the transponder's transducer to the vehicle's CRP.

10 Click **OK**.

11 Add the associated LBL **ELEVATION** data item to the vehicle to be positioned.

12 Open the **ELEVATION** data item configuration dialog.

13 Select **Secondary** and check the **Reference for Differential Heighting** checkbox.

14 Select the same transponder that was selected as the Tracking Transponder in the associated **XPONDER** data item configuration, from the dropdown list.

15 If applicable, enter the calibration value for the depth source. Note that WinFrog does not automatically retrieve the calibration value for a selected transponder from the Working Xponder File. If the sensor is reading deeper than actual the calibration value is positive. Conversely, if the sensor is reading shallower than actual, the calibration value is negative.

16 Enter offsets to associate the depth sensor to the vehicle's CRP. Note that if a transponder is used, the offsets are from the depth sensor itself, not from the transducer.

17 Click **OK**.

Monitoring the Standard LBL and Differential Depth Operations

LBL operations can be monitored from the **I/O Devices** window, where the actual telegrams being sent to the LBL device and the data sent to WinFrog can be monitored, the **Calculations** window and the **Acoustics** window. The following details the use of the Calculations window.

Details for the Acoustic window are given in the chapter Operator Display Windows. The Acoustic window provides more comprehensive monitoring options and also includes the following.

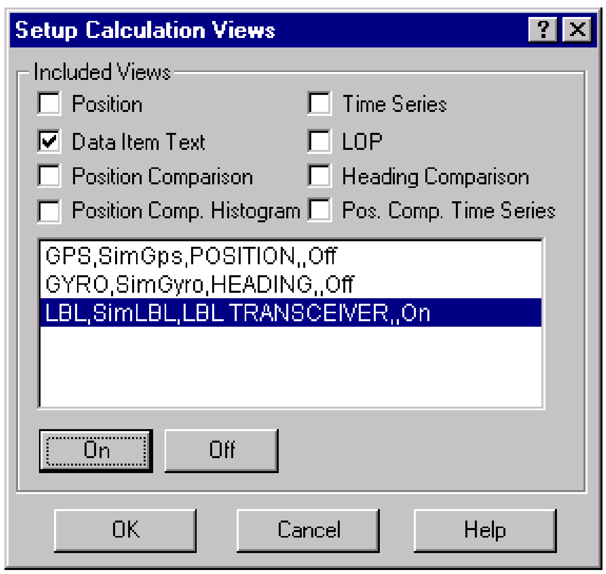
To Monitor LBL Operations in the Calculation Window

The **Calculations** window is used in the same way for both the LBL TRANSCEIVER and XPONDER data items. The data presentation is almost identical and is discussed as one here.

1 Open a **Calculations** window. (**View > Calculations**)

2 From the dropdown list, select the appropriate vehicle.

3 Click the **Setup** button.



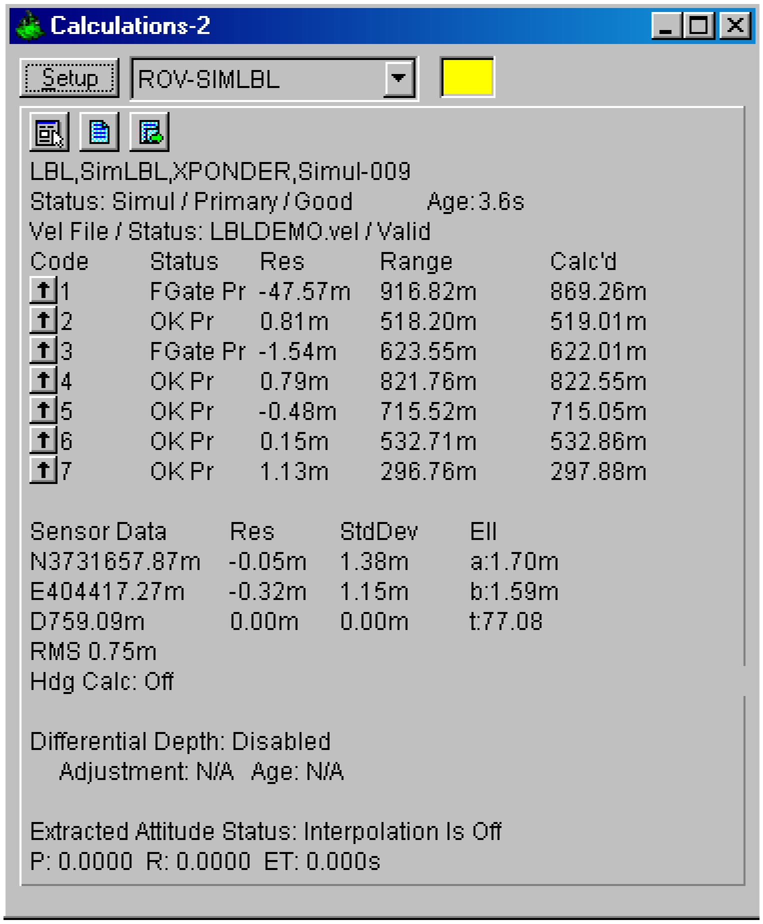
4 In the **Setup Calculation Views** dialog, check **Data Item Text**.

5 Highlight the LBL data item associated with this vehicle and click **On** (or double-click the desired item).

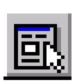
Using the LBL Data Items Calculation Window for XPONDER and LBL TRANSCEIVER

The information in the **Calculations** window (Data Items option) for an LBL data item provides you with the means to monitor the performance of the acoustics in detail.

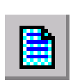
The window essentially presents the information in four sections if the data item is XPONDER, three if it is LBL TRANSCEIVER. Section one contains three lines of general status information. Section two contains a header line followed by a data/status line for each transponder assigned to the data item solution. The third section (only displayed for the XPONDER data item) displays the Differential Depth status and data. The third or fourth section, depending upon the data type, contains the solution results. In addition, there are four buttons used to access configuration dialogs or alter the data presented.



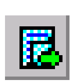
The Top Buttons



Accesses the configuration for the data item, either the LBL TRANSCEIVER or XPONDER.



N/A



Toggles the display of the last two columns for the transponder data. The data can be displayed as the following:

- Observed and calculated range in the default distance units
- Observed and calculated TWTT in milliseconds
- Sound velocity value used to reduce the raw data to distance and the transponder address (if applicable).

Section 1

Line 1

Device name and data item. If the data item is LBL TRANSCEIVER, the transducer number is also displayed. If the data item is an XPONDER, the respective transponder name is displayed.

Line 2

Status

Either Primary or Secondary as set by the operator for positioning with this device. This is followed by a slash then by either **Good** or **Bad**. Good displays if the fix was calculated with no errors and Bad if it was not. The Bad state may be caused by insufficient ranges or too many ranges that are invalid and gating is off.

Note: if the data item is an XPONDER, the status starts with the type of transponder associated with it.

Age

The time, in seconds, since the last fix was computed.

Line 3

The name of the current **Working Velocity** file and the status of the file's data with respect to the solution. If there is no **Working Velocity** file, this line is red and flashes "No VEL File".

The status messages are as follows:

Insufficient

The solution's depth or that of one of the fixed transponders lies outside of the scope of the data contained within the Velocity file, i.e. above the shallowest velocity entry or below the deepest velocity entry.

Valid

The velocity file data covers the depths of the transponders and transceivers involved in the solution and a velocity was successfully determined for all ranges.

Section 2

Header

The header **Code Status Res Range Calc'd, Code Status Res TWTT Calc'd,** or **Code Status Res Vel Add** is displayed depending upon the state of the toggle button (third from right in the top button area).

Column 1 - Code

The transponder **transmit** frequency/channel. If this is a relay transponder, the command or frequency used to interrogate it is displayed. In addition, there is an **up arrow** button that accesses a configuration dialog specifically associated with the transponder for which the line corresponds.

Column 2 - Status

The Status is a combination of two abbreviations.

The first abbreviation possibilities are as follows:

OK	The transponder was used in the position calculation.
No	The transponder was not used in the position calculation, possibly due to a zero range.
FGate	The transponder was not used in the position calculation. Its range lay outside the gating parameters set by the operator.
MGate	The transponder was not used in the position calculation. Its range was less than the minimum set by the operator.
HLD	The transponder range is currently being **Held Fixed** as configured via the **up arrow** button in Column 1.
MAN	The transponder range is currently being **Held Fixed** to the manually entered range as configured via the **up arrow** button in Column 1.
	The second abbreviation possibilities are as follows:
Pr	This transponder is set to Primary and was used in the calculation.
Sd	This transponder is set to Secondary and was not used in the calculation. The residual is displayed for monitoring.
	Alternatively, the status may be one of the following terms:
Off	The operator has set this transponder to Off and the range was not used in the solution.
Static	The operator has set to this transponder to Static and the last range observed when the setting was made is being used for each position calculation.
Err Sd	There was a range error detected by the LBL system.
Err	There was a general error detected in the response from the LBL system.

Column 3 - Res The range residual in milliseconds or distance units, depending upon the state of the toggle button (third from the right in the top button area).

Column 4 - Range Depending upon the state of the toggle button (third from the right in the top button area):

Range	Reduced one-way range in the distance units
TWTT	Observed TWTT in milliseconds
Velocity	The calculated velocity of sound used to reduce the travel time to distance.

Column 5 - Calc'd Depending upon the state of the toggle button (third from the right in the top button area):

Calc'd	The calculated reduced one-way range in distance units or calculated TWTT in

milliseconds to correspond with the aforementioned Range or TWTT in Column 4

Add The address of the transponder, if applicable.

Section 3

Header The header **Sensor Data Res StdDev Ell** refers to the data found in columns 1 through 4 of this section.

Sensor Data The unfiltered sensor (transceiver or transponder) position in map projection Northing and Easting coordinates, Depth, and the Root Mean Square (RMS) of the residuals of the used ranges.

Res The difference between the unfiltered CRP position derived directly from the unfiltered sensor position and the vehicle’s Primary CRP position for Northing, Easting, and Depth respectively. Note the sign convention is consistent with Primary CRP - unfiltered CRP.

StdDev The standard deviations of the Northing and Easting coordinates (and Depth if a 3D solution) respectively, extracted from the Least squares solution covariance matrix.

Ell The 2D error ellipse at 95% confidence for the solution, semi-major axis a, semi-minor axis b, and the orientation of the a axis, respectively.

Section 4

Differential Depth When monitoring the XPONDER data item, this presents the status of the Differential Depth mode. If enabled, the selected transponder would be displayed with the associated adjustment and the time since the fixed transponder’s last depth observation.

Section 5

Extracted Attitude Status This presents the status of the attitude data extracted for use reducing the sensor position to the CRP. If enabled, and successful, the pitch and roll data used is displayed along with the age of the data.

 **Button** There is an “up arrow” button associated with each transponder displayed in section 2. Click any of these buttons to allow you access to the configuration for that specific transponder. This configuration is displayed and edited in the **LBL Range** dialog. See Editing an LBL LOP at the end of this chapter.

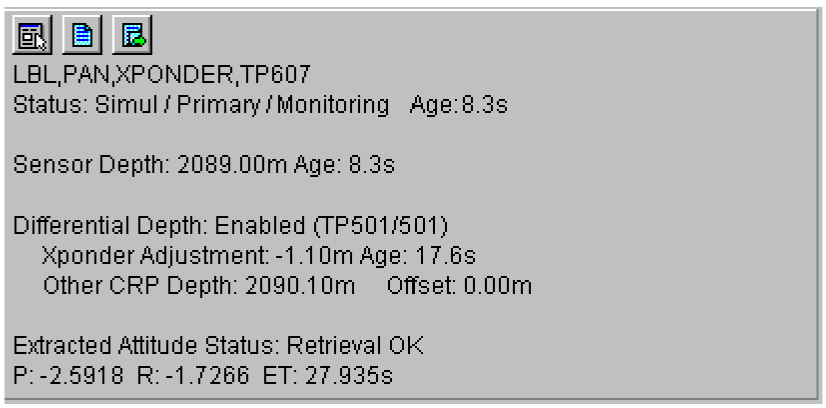
Using the LBL Data Items Calculation Window for XPONDER, Depth and Attitude Only

The information in the **Calculations** window (Data Items option) for an LBL data item provides you with the means to monitor the performance of the acoustics in detail.

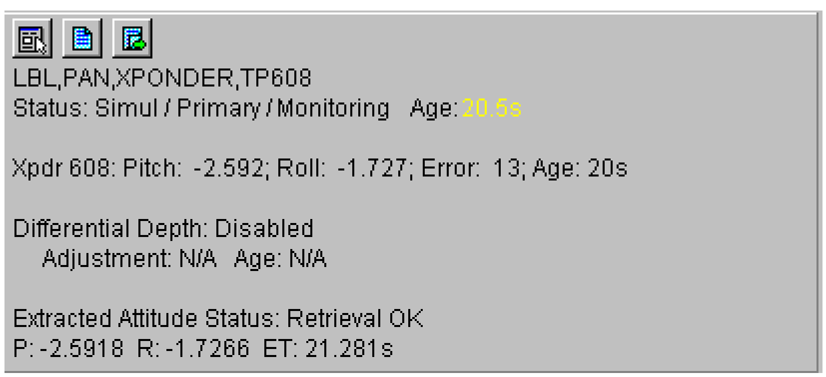
The window presents the information in four sections. Section one contains two lines of general status information. Section two contains the depth or attitude data depending upon the configuration for this transponder. The third section displays the Differential Depth status and data. If the respective transponder is set to interrogate for attitude data, this section indicates that this mode is disabled and the data is not available. Section four displays the attitude data extracted for use in reducing the depth data from the sensor to the CRP. In addition, there are four buttons used to access configuration dialogs or alter the data presented.

It is important to note that all the data for you to manually work through the Differential Depth process and confirm the results is provided in the respective view. Supporting information is provided in the Calculation Data Item view for the FIXED XPONDER (see below).

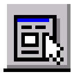
Monitoring Depth Interrogations



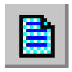
Monitoring Attitude Interrogations



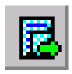
The Top Buttons



Accesses the configuration for the data item.



N/A



N/A

Section 1

Line 1 — Device name and data item, including the name of the associated transponder.

Line 2

- **Status** — The status line starts with the type of transponder associated with this data item, then either Primary or Secondary as set by the operator for positioning with this device. This is followed by a slash and the term Monitoring.
- **Age** — The time, in seconds, since the last respective data was received.

Section 2

Monitoring Depth Data — The transponder's transducer reduced depth and the age since the last interrogation. If the data has not yet been received, N/A is displayed. If the option to apply Differential Depth corrections was enabled, this depth is adjusted for the differential depth correction.

Monitoring Attitude Data — The attitude sensor observation, error flag and the age since the last interrogation. If the data has not yet been received, N/A is displayed. Note that the associated ATTITUDE data item must be also associated with this vehicle in order for the attitude data to be used (and displayed here).

Section 3

Differential Depth — This presents the status of the Differential Depth mode. If enabled, the selected transponder would be displayed with the associated adjustment, the time since the fixed transponder's last depth observation, the CRP depth for the fixed transponder and the vertical component of this transponder's (not the fixed transponder) offsets, corrected for attitude, applied to the CRP depth to derive the sensor depth.

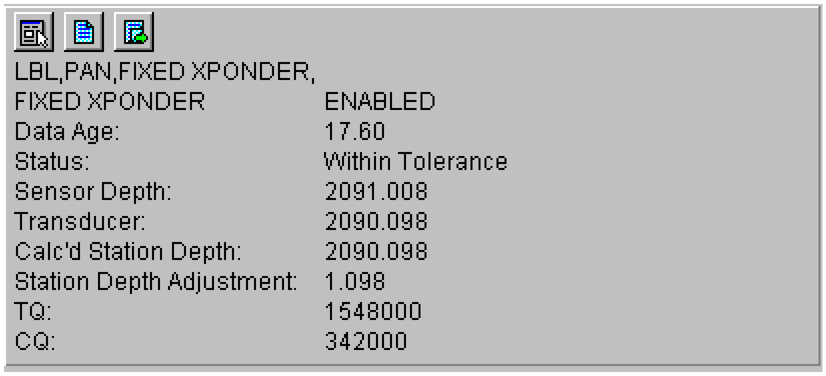
Extracted Attitude Status This presents the status of the attitude data extracted for use reducing the fixed transponder's CRP to the sensor position. If enabled, and successful, the pitch and roll data used is displayed along with the age of the data.

To manually check the differential depth calculations, follow these steps:

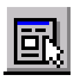
1. From the IO Device window, note the depth for the respective transponder's depth sensor. This will be given along with the raw CQ and TQ values.
2. In the Calculation window displaying the data item text for the respective ELEVATION data item, confirm that the reduced value is equal to the IO window depth value multiplied by –1 (to represent the depth as an elevation) plus the ELEVATION calibration value.
3. In the Calculation window displaying the data item text for the XPONDER data item:
    a. The Other CRP Depth term is the CRP depth from the associated ELEVATION data item, i.e. the aforementioned reduced value, corrected for the ELEVATION data item's offsets to the CRP.
    b. The Xponder Adjustment term is from the associated FIXED XPONDER data item and is the reverse sign of the Station Depth Adjustment value displayed for that data item in the Calculation window. The reverse sign is due to the fact that the adjustment to the array to correct the entire fixed transponder array for the change in water column depth is the opposite to the adjustment applied to a dynamic transponder to correct it to the fixed transponder array. This term is added to Other CRP Depth to produce the differential depth CRP depth. This is the depth that is passed to the vehicle and used as the CRP elevation/ROV depth.
    c. The Offset term is the vertical offset from the CRP to the transponder's transducer. Subtracting this from the adjusted CRP depth value gives the depth of the transponder's transducer. This depth is used in the Least Squares solution for the transponder's position if the XPONDER is configured for positioning.

Using the LBL Data Items Calculation Window for FIXED XPONDER

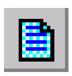
The information in the **Calculations** window (Data Items option) for an LBL data item provides you with the means to monitor the performance of the acoustics in detail.



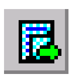
The Top Buttons



Accesses the configuration for the data item.



N/A



N/A

Line 1	Device name and data item.
FIXED XPONDER	Operation status, either ENABLED or DISABLED.
Line Data Age	Time in seconds since the last observation update.
Status	Observation status with respect to the minimum and maximum tolerances.
Sensor Depth	Calculated depth of the transponder’s depth sensor.
Transducer Depth	Calculated depth of the transponder’s transducer.
Calc’d Station Depth	Calculated depth of the respective transponder station.
Station Depth Adjustment	The calculated depth adjustment, the known station depth (from the Working Xponder File) minus the calculated station depth.
TQ	The raw temperature count.
CQ	The raw digiquartz sensor count.

Inverted LBL Application

Overview

The Inverted LBL application is specifically designed for Sonardyne hardware (PAN or ROVNAV MkIV). The application is for precisely positioning a moving structure relative to a target. In this application the transceivers and Simultaneous transponders are fixed at known locations and transponders are attached to a vehicle and are dynamic. The positions of the transducers of these transponders are to be precisely surveyed so that the offsets of each transponder's transducer with respect to the vehicle's CRP in a local reference coordinate frame are known. The device that supports the interface to the LBL unit for this application is actually the same as the PAN driver, but modifications have been made to make it appear as a new device to minimize possible confusion.

The associated data items are INVERTED TRANSCEIVER and INVERTED XPONDER. These are attached to the vehicle that is to be tracked. They are then associated with Static Transceiver and/or Static Simultaneous (xponders) from the Working Xponder file. The subsequent configuration includes setting the Dynamic Array transponders that are to be tracked. These transponders will be those that are physically attached to the vehicle that is being tracked. In addition, you have the option to use the positions determined for the transponders to determine the heading and attitude of the tracked vehicle.

The positioning process involves sequentially commanding the transceivers and simultaneous transponders to range to the dynamic transponders. At each data update for a given INVERTED data item, the data for the other INVERTED data items attached to the same vehicle are accessed and combined in a 3 dimensional least squares adjustment. This least squares adjustment also makes use of the fact that the offsets of each dynamic transponder are precisely known and therefore baselines between each transponder pair are known and can be constrained in the adjustment.

Once the positions of each transponder's transducer are determined, these positions can be used to determine the CRP position, heading and attitude of the vehicle in another least squares adjustment.

In order to use these data items, there are minimum requirements with respect to the number of fixed and dynamic units. In order to solve for the positions of the dynamic transponders (those attached to the vehicle) the number of ranges observed from all the fixed transceivers and/or simultaneous transponders to all the dynamic transponders must be equal to or greater than the number of dynamic transponders multiplied by 3. Therefore, there must be a minimum of 3 fixed units. This will support the determination of any number of dynamic transponders. In order to solve for the CRP position, heading, pitch and roll there must be a minimum of 3 transponders on the vehicle.

Adding the INVERTED LBL Device

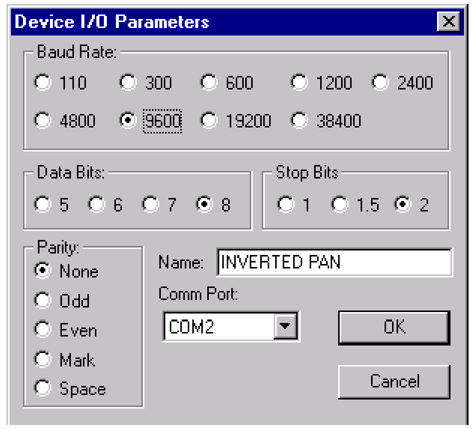
1 Connect the Sonardyne PAN or ROVNAV MkIV LBL system to a WinFrog com or Digiboard™ port.

2 From the Main Menu, select **Configure > I/O Devices… > Add,** or from within the **I/O Devices** window, right-click and choose **Add Device** from the pop-up menu.

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

4 Select the INVERTED PAN device.

5 Click **OK**.



6 Enter an appropriate name for the device in the **Name** field.

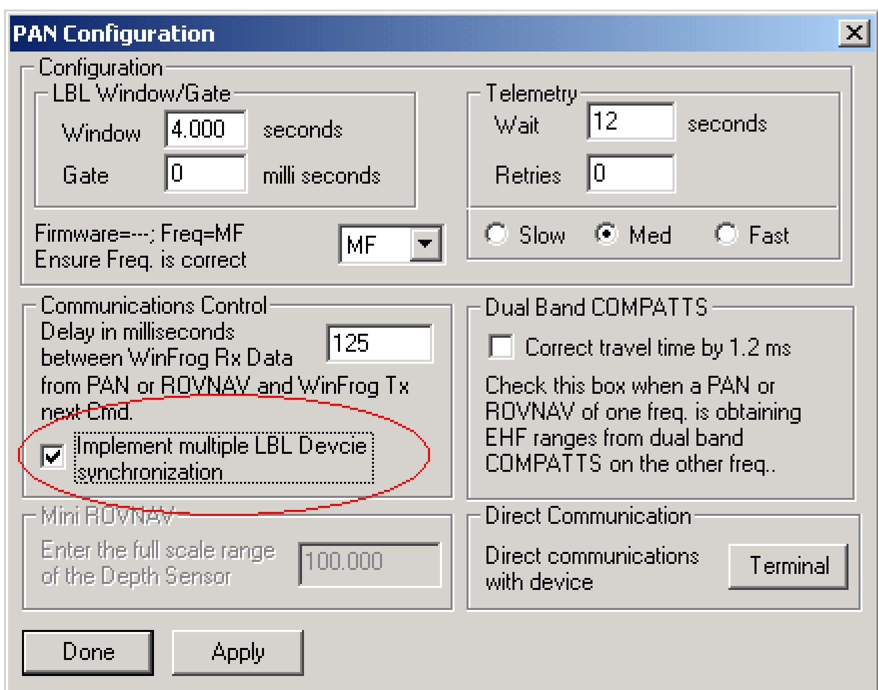
7 Set all of the communication parameters to match those of the LBL device.

8 Click **OK**.

At this point the LBL device has been added to WinFrog. WinFrog will start transmitting the initialization telegrams to the device based upon default parameters. These can be monitored in the **I/O Devices** window.

The data received from the LBL system will be displayed in the **I/O Devices** window.

It is very important that if there are to be multiple INVERTED PAN devices added to WinFrog, the **Implement multiple LBL Device synchronization** option is checked.



Attaching Data items to the Vehicle

The INVERTED TRANSCEIVER and INVERTED XPONDER data items are attached to the vehicle being tracked.

When an INVERTED data item is attached to a vehicle, WinFrog tries to determine if another INVERTED data item has already been attached to this vehicle. If an existing one is found, the configuration settings pertaining to its application are copied to the newly attached data item. In addition, if these same configuration settings for any INVERTED data item attached to a given vehicle are changed, the respective settings for all other INVERTED data items attached to the same vehicle are also changed. This enables the adjustment control parameters to be kept synchronized between the INVERTED data items. The configurations settings that are kept in synchronization are indicated in the following sections with an * and are as follows:

Configure Inverted LBL Transceiver/Xponder Settings Tab

- Solution Control
- Attitude Calculations Tab
- Use
- Solution Criteria

The configuration for the **INVERTED TRANSCEIVER** and **INVERTED XPONDER** are very similar and dealt with together in the following. The specific data item the configuration is associated with is given in brackets.

1 Access the **Configure Vehicle - Devices** dialog for the appropriate vehicle.

2 Click the **Add** button.

3 Select the **LBL, *, INVERTED TRANSCEIVER or LBL, *, INVERTED XPONDER** data item 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.

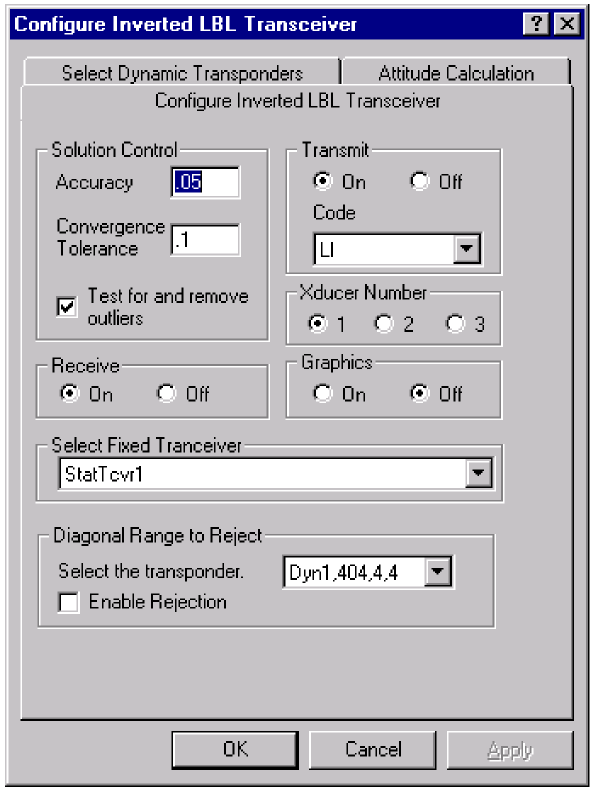
5 At the **Configure Vehicle - Devices** dialog, highlight the **LBL, *, INVERTED TRANSCEIVER** or **LBL, *, INVERTED XPONDER** data item.

6 Click **Edit**.

7 Configure the data item as required. The configuration of the INVERTED data items are very similar and addressed together here.

Configure Inverted LBL Transceiver Tab (INVERTED TRANSCEIVER only)

The configuration of how the transceiver is to operate as attached to this vehicle is edited in this tab.



Solution Control*

Accuracy* The standard deviation of the ranges observed directly by the transceiver. This will depend upon frequency of the acoustics. Note that the accuracy is entered in the default distance units, not milliseconds.

Convergence Tolerance* The position calculation is a least squares solution. The process is an iterative one where the least squares actually determines and applies a correction to a position estimate to arrive at the final position solution. Given reasonable data, this correction will become smaller every iteration, i.e. the solution will converge. The process is considered complete when the correction is less than a specified **convergence tolerance**. You can edit this tolerance to match the accuracy of the acoustics being used, e.g. the tolerance for EHF can be set to a small value to optimize the data, such as 5 cm. The tolerance is entered in the default distance units.

Test for and remove outliers* After the Dynamic Transponder position adjustment is performed, the residuals are tested to determine observation outliers. If found, the worst is removed from the solution and the solution is re-adjusted. This is repeated until removing anymore would result in a solution not being possible.

Receive

For future development.

Select Fixed Transceiver

This drop down list box accesses the Working Xponder file and lists all those xponders configured as Static Transceivers. Select the one associated with this instance of the data item.

Transmit

On	This must be selected when the transceiver is used for any operations.
Off	The transceiver is disabled for all uses.
Code	This is the command or code required by the device to initiate range observations. The drop down list lists all the possible selections for this option. It is recommended that the LI command be used.

Xducer Number

The Sonardyne PAN and ROVNAV support 2 transceivers. Select the one that is associated with this instance of the data item.

Graphics

Controls the display in the Graphics window of the solved for positions of the associated Dynamic Array transponders on the vehicle. Due to the relatively slow update rate of acoustics, this position may appear to lag behind the vehicle because it is only updated when new acoustic data is received and a position calculation is done.

Diagonal Ranges to Reject

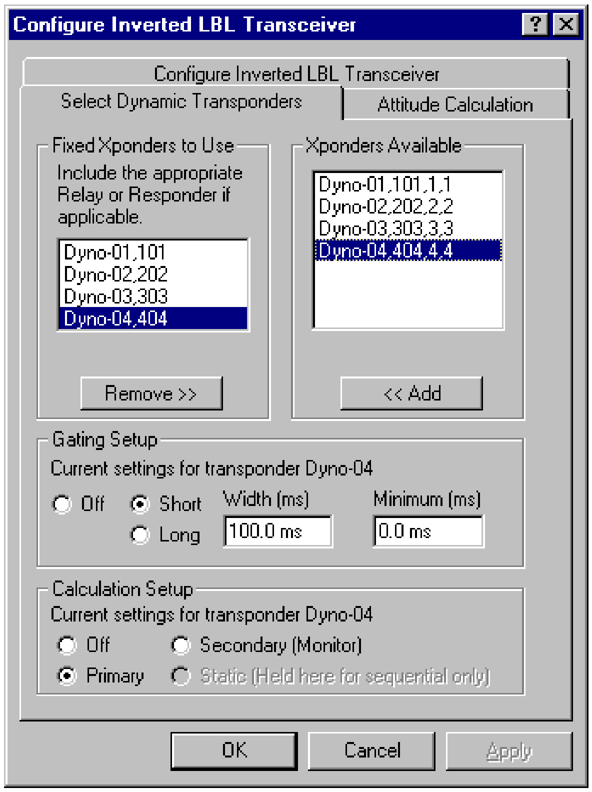
Allows you to disable the use of a selected range associated with this data item, specifically the diagonal range that in applications of the INVERTED LBL operation could be heavily influenced by the signal path. This includes the possibility of the signal actually traveling through the structure. Note that this rejection is specifically associated with only this INVERTED TRANSCEIVER data item and is not applied to any other INVERTED data items.

Select the transponder	From the dropdown list of all Dynamic Array transponders in the Working Xponder file, select the one whose range is to be disabled. Select None if all are to be used.
Enable Rejection	Check this box to implement the rejection of the selected Dynamic Array transponder from the solution.

Select Dynamic Transponders Tab
(same for INVERTED TRANSCEIVER and INVERTED XPONDER)

The selection of the dynamic transponders for use in the position solution is done from this tab. The transponders are selected from the transponders in the Working Xponder file set to Dynamic Array. In addition, the transponder gating and application in the position solution settings are configured here.

Note: The Gating and Calculation Setup for a transponder can also be accessed from the Calculations Window (see **Reading the INVERTED LBL Data Items Calculation Window**).



Xponders Available

This is a list of all the Dynamic Array transponders in the Working Xponder file. Each one is identified by station name, address, reply code and individual interrogation frequency (**IIF**). Those fixed transponders that do not have an address or IIF (i.e. the first one listed here) will not have anything between the first and second comma and will not have an IIF after the last comma.

To select a transponder required for use in conjunction with this vehicle double click the transponder in the list or highlight it and click the **<<Add** button. This will copy the transponder name to the **Fixed Xponders to Use** list. Note that the selected transponder still appears in the available list.

Fixed Xponders to Use

In this application, this is a list of those Dynamic Array transponders, selected by the operator from the **Available** list, to be used in conjunction with this transceiver.

To Remove a transponder from the list, highlight it and click the **Remove>>** button.

To Add a transponder to the list, highlight it in the Xponders Available list and click the **<<Add** button or double click the entry in the list.

Gating Setup

These settings control the application of range **Gating** for the data for the transponder highlighted in the **Fixed Xponders to Use** list.

Off	Gating is not applied to the range data for the transponder, all data will be used in the solution.
Short	Gating is applied using a short history, specifically the last 4 ranges, to determine the trend against which the new range is evaluated to determine if it is to be gated from the solution.
Long	Gating is applied using a long history, specifically the last 10 ranges, to determine the trend against which the new range is evaluated to determine if it is to be gated from the solution.
Width	If gating is on, this value is used as the criteria to accept or reject a range. If the range lies within the window created by this value and the trend determined by the Long or Short selection it will be accepted. This value is in milliseconds.
Minimum	This is the minimum acceptable TWTT in milliseconds. If the associated TWTT is less than this entry, the data is not used in the solution. This test is independent of the gating and applied whether gating is on or off. It is grouped with the gating due to the similar nature of its use.

Note: If gating is on it requires two to four ranges before a trend can be established thus the first few sets of ranges will not result in a fix computation. This will be indicated in the calculations window (see **Reading the INVERTED LBL Data Items Calculation Window**).

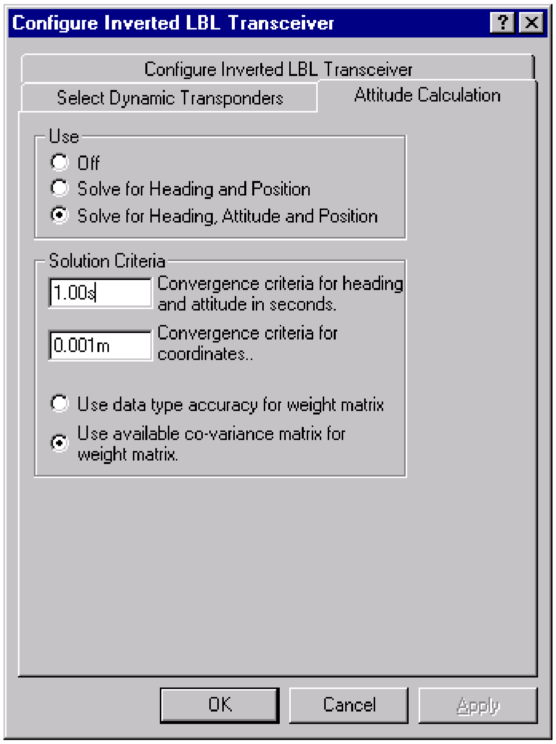
Calculation Setup

These settings control how the range data for the transponder highlighted in the **Fixed Xponders to Use** list will be used in the position calculations.

Off	The transponder's data is not used in the solution, nor is a residual calculated and displayed, i.e. the range is not monitored.
Primary	The transponder is used in the solution.
Secondary	The transponder is not used in the solution, but a residual is computed for the range, i.e. it is monitored.
Static	This option is not applicable for INVERTED LBL application.

Configure Attitude Calculation Tab

The configuration of how the positions of the Dynamic Array transponders attached to the vehicle are to be used to determine the vehicle heading and attitude is controlled from this tab.



Use*

Off*

The vehicle's heading and attitude are obtained from other sources/sensors. This data is used to compute a CRP position.

Solve for Heading and Position*

The Dynamic Array transponder position data is used to solve for the vehicle heading and CRP position. The positions for the transponders that form the longest horizontal baseline are used to determine a heading. This heading is then used with the transponder offsets to determine a mean CRP position. Attitude is not solved for nor obtained from another source but is assumed to be 0 pitch and 0 roll.

Solve for Heading, Attitude and Position*

The Dynamic Array transponder position data is used in a least squares adjustment to solve for the vehicle's heading, attitude and CRP position.

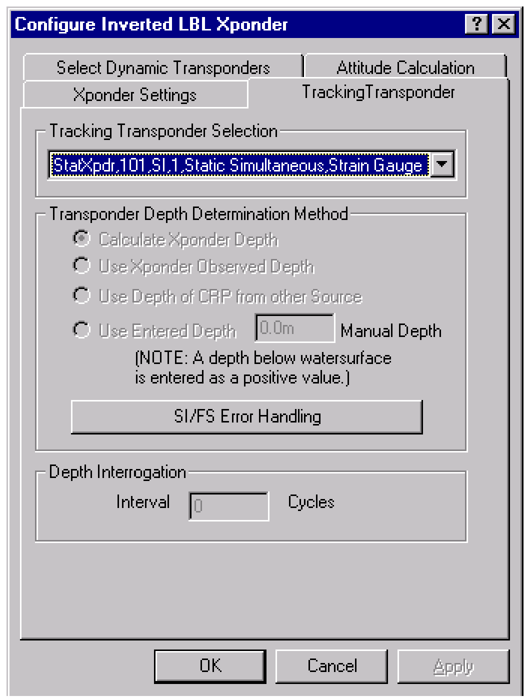
Solution Criteria*

The unknowns in the least squares adjustment are heading, pitch, roll and CRP Northing, Easting and depth. You can enter the convergence criteria for the angular and position components here. The default is 1” and 0.05m. The criteria for the position components are entered in the default distance units.

You can also select whether to use an arbitrary weight matrix where all observations used in the adjustment are equally weighted based on a standard deviation of 0.01m. Or the covariance matrix from the least squares adjustment for the Dynamic Array transponders (the observations for this adjustment) is used for the creation of the weight matrix. The latter provides a more realistic statistical analysis of the final CRP position results.

Configure Tracking Transponder Tab (INVERTED XPONDER data item only)

The selection of Static Simultaneous (transponder) from the Working Xponder file to be associated with this instance of the INVERTED XPONDER data item is done in this tab.



Tracking Transponder Selection

This drop down list box displays the transponders set to Static Simultaneous in the Working Xponder file. If there are no transponders of these types in the transponder file then a vehicle cannot be positioned with this data item. Each transponder is described by its Name, Address, Receive code, Transmit code, LBL transponder type and depth sensor type.

Select the appropriate transponder or **None** to cancel a previous selection and stop interrogation.

Transponder Depth Determination Method

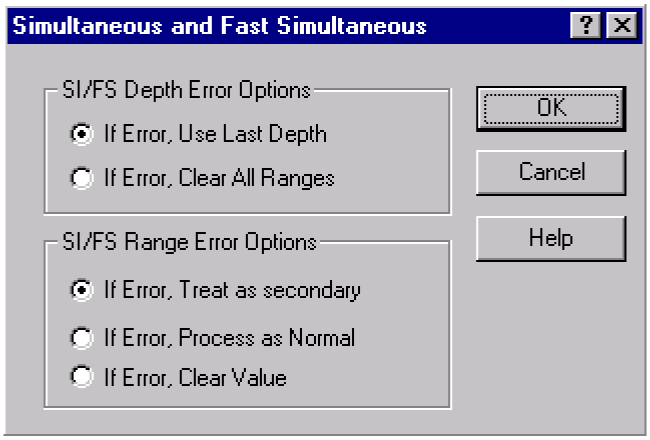
Not applicable for this data item.

Depth Interrogation

Not applicable for this data item.

SI/FS Error Handling

This accesses the following dialog allowing the configuration of action to take when errors are detected and reported by the LBL system.



SI/FS Depth Error Options

This controls how the detection of an error in the depth observation is handled.

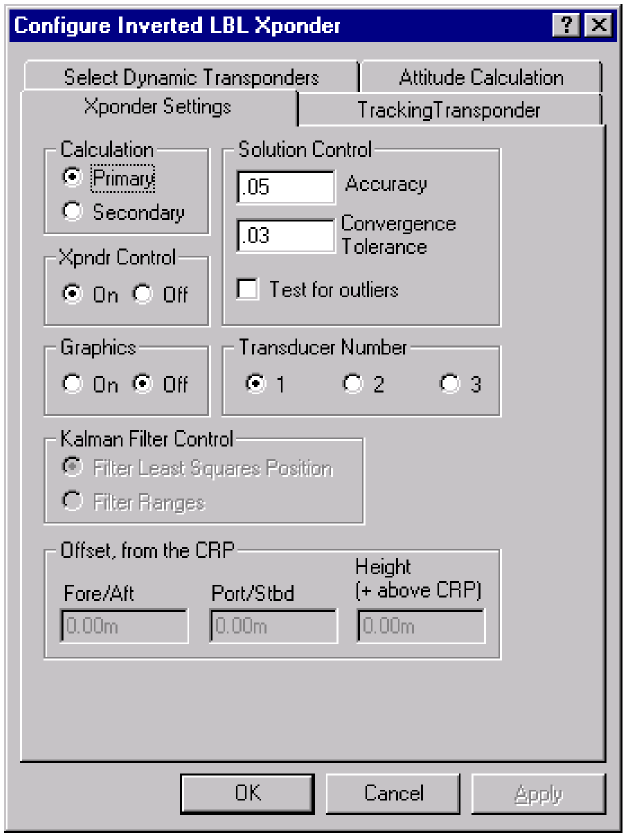
If Error, Use Last Depth	If an error is reported for the depth observation, the last good depth observation is used in the solution.
If Error, Clear All Ranges	If an error is reported for the depth observation, all range data is cleared and no position is solved for.

SI/FS Range Error Options

This controls how the detection of an error in the range observation is handled.

If Error, Treat as Secondary	If an error is reported for a range observation, the respective range is not used in the solution but a residual is computed and displayed.
If Error, Process as Normal	If an error is reported for a range observation, it is ignored and the respective range is used in the solution.
If Error, Clear Value	If an error is reported for a range observation, the respective range is zeroed and treated as if it didn't exist.

Xponder Settings Tab (INVERTED XPONDER data item only)



Calculation

Primary	The position determined for the vehicle the associated Dynamic Array transponders are attached to will be used in the Primary position calculation for this vehicle.
Secondary	The position determined for the vehicle the associated Dynamic Array transponders are attached to will be used as a Secondary position for monitoring this vehicle's primary position.

Solution Control*

Accuracy*	The standard deviation to be used for each range used in the position solution for this Static Simultaneous transponder. This will depend upon frequency of the acoustics. This is entered using the default distance units.
Convergence Tolerance*	The position calculation is a least squares solution. The process is an iterative one where the least squares actually determines and applies a correction to a position estimate to arrive at the final position solution. Given reasonable data, this correction will become smaller every

iteration, i.e. the solution will converge. The process is considered complete when the correction is less than a specified **convergence tolerance**. You can edit this tolerance to match the accuracy of the acoustics being used, e.g. the tolerance for EHF can be set to a small value to optimize the data, such as 5 cm. This is entered using the default distance units.

Test for outliers* If checked, after the Dynamic Transponder position adjustment is performed, the residuals are tested to determine observation outliers. If found, the worst is removed from the solution and the solution is re-adjusted. This is repeated until removing anymore would result in a solution not being possible.

Xponder Control

On The transponder is active.

Off The transponder is disabled **within** WinFrog, i.e. WinFrog will not communicate with it automatically as configured here.

Xducer Number

This controls which transceiver connected to the control unit will be used to communicate/interrogate the transponder.

Graphics

Turns the display of the raw transponder position **On** and **Off** in the Graphics window. Due to the relatively slow update rate of acoustics, this position may appear to lag behind the vehicle because it is only updated when new acoustic data is received and a position calculation is done.

Kalman Filter Control

Not applicable for this data item.

Offsets

Not applicable for this data item.

8 Click **OK** to accept the settings and return to the **Configure Vehicle-Devices** dialog. At this point, the changes will take affect and any interrogations and calculations configured will commence.

9 Complete the configuration of the **Vehicle Position Calculations**, i.e. Kalman Filter control.

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

To Monitor INVERTED LBL Operations in the Calculation Window

The **Calculations** window is used in the same way for both the INVERTED TRANSCEIVER and INVERTED XPONDER data items. The data presentation is almost identical and is discussed as one here.

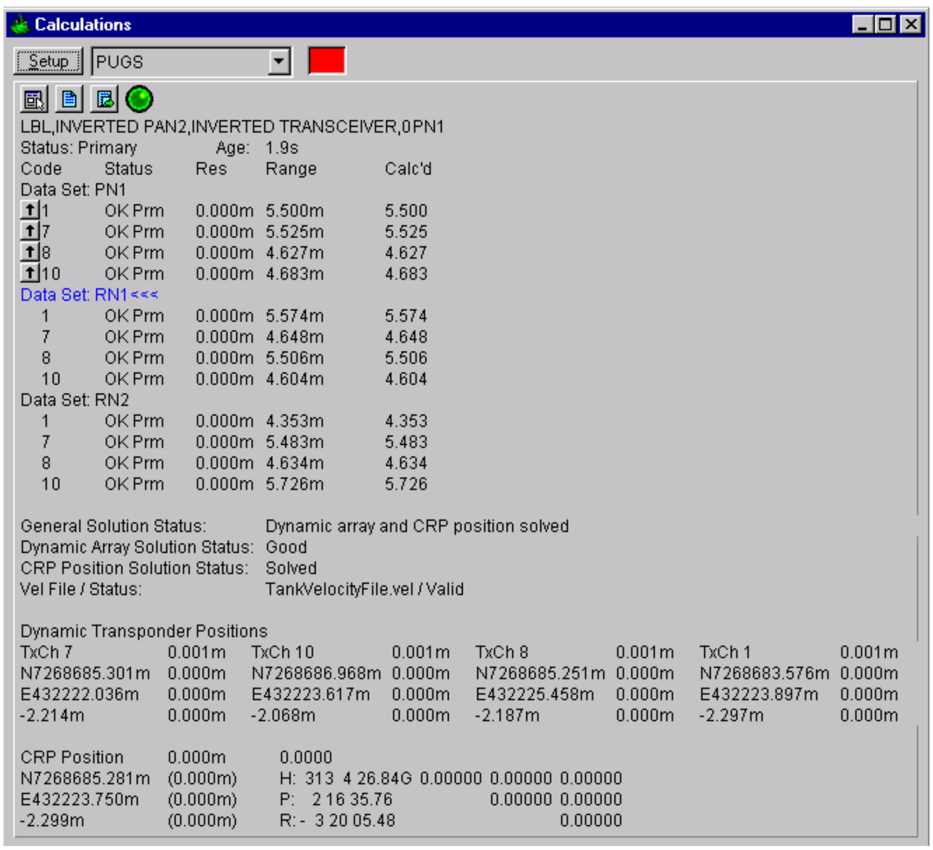
1 Open a **Calculations** window. From the main menu, click on **Views** and then **Calculations**.

2 From the drop down list, select the appropriate vehicle.

3 Click the **Setup** button.

4 In the **Setup Calculation Views** dialog, check **Data Item Text**.

5 Highlight the INVERTED LBL data item associated with this vehicle and click **On**. This will provide a display of the available ranges with their status and residuals as shown here.



Understanding and Using the INVERTED LBL Data Items Calculation Window

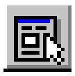
The information in the **Calculations** window (Data Items option) for an INVERTED LBL data item provides you with the means to monitor the performance of the acoustics in detail.

The window essentially presents the information in five sections. Section one contains two lines of general application information and a status LED. Section two contains a header line followed by a data/status line for each transponder assigned to the data item solution. The third section presents status for specific solution phases. The fourth section contains the Dynamic

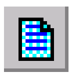
Array transponder position solution results. The last section presents the results of the CRP position determination and any heading and attitude results that are applicable. In addition, there are four buttons used to access configuration dialogs or alter the data being presented.

It is important to note that this display is updated by other INVERTED data items other than the one configured for display. This allows all the data and solutions to be monitored from a single Calculations window rather than having one window open for each INVERTED data item. There is a limitation to this window in that only those LOPs associated directly with the data item selected for the Calculations window can be accessed via the shortcut buttons.

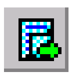
The Top Buttons



Accesses the configuration for the data item, either the INVERTED TRANSCEIVER or INVERTED XPONDER.



N/A



Toggles the display of the last two columns for the transponder data. The data can be displayed as the following:

- Observed and calculated range in the default distance units
- Observed and calculated TWTT in milliseconds
- Sound velocity value used to reduce the raw data to distance and the transponder address (if applicable).

LED reflects general status of the solution represented in this window. If the solution of the Dynamic Array transponders failed or the status is unknown, the LED is red. If the solution for the Dynamic Array transponders was successful, the LED is yellow. If the latter was successful and also the solution of the CRP position, the LED is green.

Section 1

Line 1

Device base type and operator assigned name, data item, and if INVERTED TRANSCEIVER, transducer number and associated Static Transceiver name or if INVERTED XPONDER, associated Static Simultaneous name.

Line 2

Mode — Either Primary or Secondary as set by the operator for positioning with this device.

Note: If the data item is an INVERTED XPONDER, the status starts with the type of transponder associated with it.

Age — The time in seconds since the last fix based upon new data for the INVERTED data item directly associated with this window was computed.

Section 2

This section displays all the observations used in the Dynamic Array transponder adjustment, including those accessed from other INVERTED data items.

Header

The header **Code Status Res Range Calc'd** or **Code Status Res TWTT Calc'd** or **Code Status Res Vel Add** is displayed depending upon the state of the toggle.

Data Set

The name of the Static Transceiver or Xponder associated with the following observation set. The data set that has just received new data and is therefore responsible for a new update is displayed in blue and indicated with <<<.

Column 1

The transponder Transmit frequency/channel. In addition there is an up arrow button that accesses a configuration dialog specifically associated with the transponder for which the line corresponds. See **Button**.

Column 2

The **Status** will either be a combination of two abbreviations or a single word.

In the case of the display of two abbreviations, the first abbreviation possibilities are as follows:

OK The transponder was used in the position calculation.

NODATA The transponder was not used in the position calculation, no data available for it.

XPDR Though there was data available for this transponder, a match in the Working Xponder File to a Dynamic Array transponder that was turned on was not found.

FILT The transponder range was failed the gating filter and was de-weighted from the solution.

MIN The transponder range was less than the minimum acceptable range setting and was de-weighted from the solution.

NEG The transponder range when reduced was a negative value and de-weighted from the solution. Probably due to an incorrectly entered TAT for this transponder.

MAN The transponder range was entered manually and is currently being held static at this value (see **Button**).

HLD The transponder range has been selected from the range observation history and is currently being held static at this value (see Button).

D Rej — The transponder range has been selected to be rejected by the operator using the Diagonal Ranges to Reject option.

w-IN — The transponder range has been detected as an outlier using the w-test, but due to solution failing if this range is de-weighted due to insufficient ranges, it has been flagged but still used in the solution.

w-OUT — The transponder range has been detected as an outlier using the w-test and de-weighted from the solution.

In the case of the display of two abbreviations, the second abbreviation possibilities are as follows:

Prm — This transponder is set to **Primary** and was used in the calculation.

Sd — This transponder is set to **Secondary** and was not used in the calculation. The residual is displayed for monitoring.

In the case of the display of a single word, the possible displays are as follows:

Off — The operator has set this transponder to **Off** and the range was not used in the solution.

Column 3 — The range residual in milliseconds or distance units, depending upon the state of the toggle.

Column 4 — Depending upon the state of the toggle:

Range — Observed one-way range in the distance units; or

TWTT — Observed TWTT in milliseconds; or

Velocity — The calculated velocity of sound used to reduce the travel time to distance.

Column 5 — Depending upon the state of the toggle:

Calc'd — The calculated one-way range in distance units or calculated TWTT in milliseconds to correspond with the aforementioned Range or TWTT in column 4; or

Add — The address of the transponder if applicable.

Section 3

Line 1		The Status for the overall solution including the determination of the Dynamic Array transponder positions and the CRP and associated parameters. The status messages are as follows:
	Failed	The solution failed completely.
	Dynamic Array Solved	The positions of the Dynamic Array transponders were successfully determined.
	Dynamic Array and CRP Position Solved	The positions of Dynamic Array transponders and the CRP position and associated parameters were successfully solved.
	Unknown	An unknown solution status has been detected.
Line 2		The Status specifically for the determination of the Dynamic Array transponder positions and the CRP and associated parameters. The status messages are as follows:
	Good	The positions of the Dynamic Array transponders were successfully determined.
	No Xponder File	No Working Xponder file was detected.
	No Dynamic Xponders	The Working Xponder file does not contain any Dynamic Array Xponders.
	Initializing	The adjustment is initializing, insufficient data has set be collected to perform the first solution.
	Bad Unknown	The solution failed for undetermined reasons.
	Insufficient usable observations	Insufficient acceptable ranges from this and associated Static Transceivers/Xponders are available to perform an adjustment.
	Poor/singular Geometry, unable to inverse N	The solution failed due to the geometry of the adjustment or insufficient independent observations and as result the Normal matrix could not be inversed.
	Bad Observations, solution did not converge	The adjustment did not converge and failed. This is due to the combination of observation quality, accuracy and convergence tolerance settings. As observation quality deteriorates, the convergence tolerance must be increased if a solution is desired.
	Unknown	The solution status flag is of unknown setting.

Line 3		The Status for the CRP and associated parameters solution. The status messages are as follows:
	Not Solved Yet	The adjustment has not yet been solved due to the lack of Dynamic Array transponder position data being available.
	Initializing	The adjustment is initializing using the available observation sets.
	Initialized	The adjustment has initialized and will proceed with the computations.
	Failed: Unable to Initialize	The adjustment was unable to initialize due to poor observations.
	Failed: Unable to inverse Covariance Matrix	The use of the covariance matrix from the Dynamic Array adjustment failed due to being unable to perform an inversion of it.
	Failed: Insufficient Observations	The adjustment failed due to insufficient observations.
	Failed: Unable to inverse Normal Matrix	The adjustment failed due to poor geometry of the adjustment or insufficient independent observations. (The least squares was unable to inverse the Normal matrix).
	Failed: Unable to Converge	The adjustment did not converge, probably due to bad data.
	Solved	The adjustment of the unknown parameters was successfully performed.
	Unknown	An unknown solution status has been detected.
Line 4		The name of the current Working Velocity file and the status of the file's data with respect to the solution. If there is no Working Velocity file, this line is red and flashes "No VEL File". The status messages are as follows:
	Insufficient	The solution's depth or one of the fixed transponders lies outside of the scope of the data contained within the Velocity file, i.e. above the shallowest velocity entry or below the deepest velocity entry.
	Valid	The velocity file data covers the depths of the transponders and transceivers involved in the solution and a velocity was successfully determined for all ranges.

Section 4

This section displays the results of the adjustment for the individual Dynamic Array transponders. This information is presented in up to 2 rows, each with up to 5 transponders for a total possible of 10. The data presented for each transponder is presented in 2 columns.

Column 1

Name	Name assigned in the Working Xponder file.
Northing	Adjusted Northing for the transponder's transducer.
Easting	Adjusted Easting for the transponder's transducer.
Depth	Adjusted Depth for the transponder's transducer.

Column 2

RMS	RMS for this transponder from the adjustment for the individual Dynamic Array transponder positions.
Northing Residual	The residual in Northing associated with this transponder in the heading, attitude and CRP solution.
Easting Residual	The residual in Easting associated with this transponder in the heading, attitude and CRP solution.
Depth Residual	The residual in Depth associated with this transponder in the heading, attitude and CRP solution.

Section 5

This section displays the results of the adjustment for the individual CRP position and the associated unknown parameters solved for.

Column 1

Title	
Northing	Adjusted Northing for the CRP.
Easting	Adjusted Easting for the CRP.
Depth	Adjusted Depth for the CRP.

Column 2

Status/RMS	Displays the status of the adjustment if the adjustment has not been solved or if it is not to be solved (Attitude Calculation setting is not set to solve for Heading, Attitude and CRP Position) in which case it displays "Not Solved" or "N/A". Otherwise the RMS for adjustment is displayed.

Northing Residual The difference of the solved CRP Northing and the vehicle Northing.

Easting Residual The difference of the solved CRP Easting and the vehicle Easting.

Depth Residual The difference of the solved CRP Depth and the vehicle Depth.

Column 3

Status/A Posteriori Displays the status of the adjustment if the adjustment has not been solved or if it is not to be solved (Attitude Calculation setting is not set to solve for Heading, Attitude and CRP Position) in which case it displays “Not Solved” or “N/A”. Otherwise the A Posteriori variance factor for adjustment is displayed.

Heading Displays Not Solved if the heading is not to be solved for, otherwise displays the solved Grid heading.

Pitch Displays Not Solved if the attitude is not to be solved for, otherwise displays the adjusted pitch.

Roll Displays Not Solved if the attitude is not to be solved for, otherwise displays the adjusted roll.

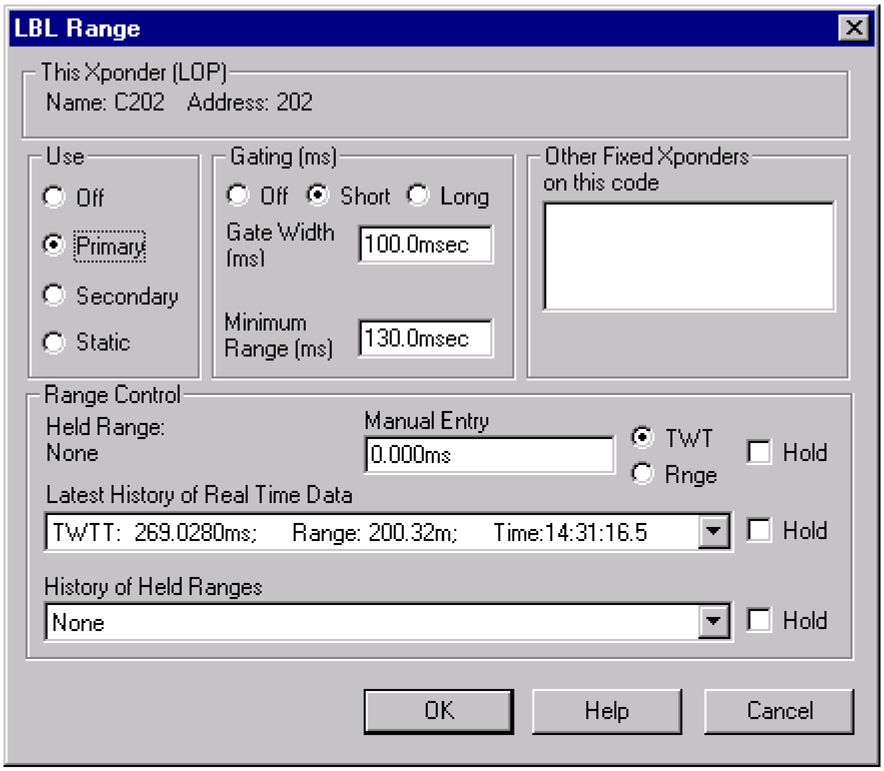
Columns 4-6

Covariance Matrix Displays the upper triangle of the resulting covariance matrix. If not solved for, asterisks are displayed.

 **Button** There is an “up arrow” button associated with each transponder displayed in section 2 of this window that is specifically associated with the INVERTED TRANSCEIVER or XPONDER selected for the Data Item text option. Clicking on this button enables an operator to access the configuration for that specific transponder. This configuration is displayed and edited in the LBL Range dialog. See Editing an LBL LOP.

Editing an LBL LOP

When viewing an LBL or INVERTED LBL data item in the Calculations window, there is an up arrow located to the left of each line displaying range data. Clicking this button accesses the LBL Range dialog enabling you to configure the use of the range within the associated solution.



Edit LBL Range

This Xponder (LOP)

The relevant transponder is identified by the name and the address assigned to it in the **Working Xponder** file.

Use

Set the **use** of this transponder in the solution (see **Select Fixed Transponder Tab**).

Gating

Set the gating control for this transponder in the solution (see **Select Fixed Transponder Tab**).

Other Fixed Xponders

Any other transponders in the **Working Xponder** file with either the same transmit frequency or channel as that assigned to this transponder are listed.

Range Control

This option allows you to configure the range for this transponder to be held static in the solution. In the **Calculations** window, the associated line is displayed in magenta with the status of either **HLD** or **MAN** as is appropriate. Checking one of the **Hold** checkboxes will set the associated data to static. This range is then held static until a new one is selected or the **Hold** box is unchecked. The current status is displayed in the top left of this panel. The options are as follows.

- Manually enter the TWTT in milliseconds or the raw slant range in the default distance units.
- Select a range to hold static from the history of the last 20 observed ranges (the list shows the TWTT in milliseconds, the raw slant range in meters and the epoch).
- Select a range to hold static from the history of the last 10 ranges that have been held static (the list shows the TWTT in milliseconds, the raw slant range in meters and the epoch or manual).