Chapter 17: Special Applications

Speed Log and Inertial Devices

The use of a USBL beacon, gyro, and **Doppler Speed Log** or **Inertial Unit** attached to a vehicle to obtain precise positioning requires careful configuration. The following sections detail this case.

Note that for simplification in the following section, the term INS is used for both Speed Log and Inertial devices and respective data item, unless a variation in the application requires differentiating. The primary difference between these two as far as the use in WinFrog is concerned is that SPEED LOG devices generally provide velocities determined with Doppler observations and are only usable if these observations are based on bottom lock, i.e. are observed speed over ground and not speed through the water, whereas the Inertial units provide velocities determined from accelerometers and are not dependent upon the bottom.

WinFrog is able to utilize the data from the INS in the position **Kalman Filter** to enhance the results, specifically for positioning an ROV with USBL. It is critical that it be setup correctly and monitored in order to ensure correct application.

WinFrog also provides a simple calibration feature to determine the alignment correction for the INS. This value can then be entered and applied to the data before it is used by WinFrog.

The following documents the application, monitoring and calibration of the INS. It is important to note that the values and limits stated here for any of the configurations discussed are guidelines. You must evaluate the actual performance and make adjustments accordingly.

General Kalman Filtering

The **Kalman Filtering** performed by WinFrog allows the direct input to the filter of position and velocity data. The application of this data within the filter is a balance between the accuracy attributed to each individual data type and the **Kalman Filter** setting itself. The former is the accuracy entered by the operator for each data type when configuring its use as attached to a vehicle. The latter refers to the **Kalman Filter** setting controlled with the slider bar in the **Configure Vehicle-Devices** dialog box.

It is important to realize that the correct application of the **Kalman Filter** requires careful consideration of the actual accuracy of each data type and the relative accuracy between each data type. If the accuracy relationship is unbalanced, the **Kalman Filter** will be biased towards that data type with the overly optimistic accuracy setting.

The **Kalman Filter** setting controls how reactive the filter will be to new data. The default setting of 0.1 is applicable for most situations. The impact that the new data has in the filter is also affected by the accuracy setting for that data type.

Gyro Requirements

An INS unit provides WinFrog with fore/aft and port/starboard (and in some cases, up/down) velocities. For use in the **Kalman Filter**, these are converted to Northing and Easting velocity vectors. Therefore, it is necessary to have a reasonably accurate and calibrated vehicle heading source to enable the transformation of the velocities from a vehicle-based X/Y reference frame to an absolute North/East reference. The heading data used are those that are configured for the vehicle, including any offsets applied in the associated HEADING data type configuration.

At present, the vertical velocities are not utilized within WinFrog.

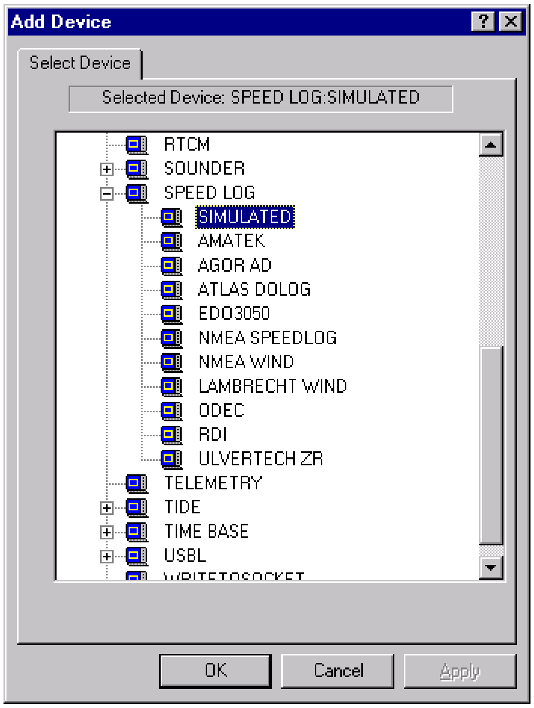
Adding the INS to WinFrog and the Vehicle

The device is added in the same way that any device is added. Note that due to the multifunctional aspect of many sensors, a device that supports the SPEED LOG or INERTIAL data type may be listed under the SPEED LOG, INS or GYRO device groups.

To Add the INS Device

1 From the **Devices** window, right-click to display available device types.

2 Scroll down to **SPEED LOG** or **INS** and expand the list.



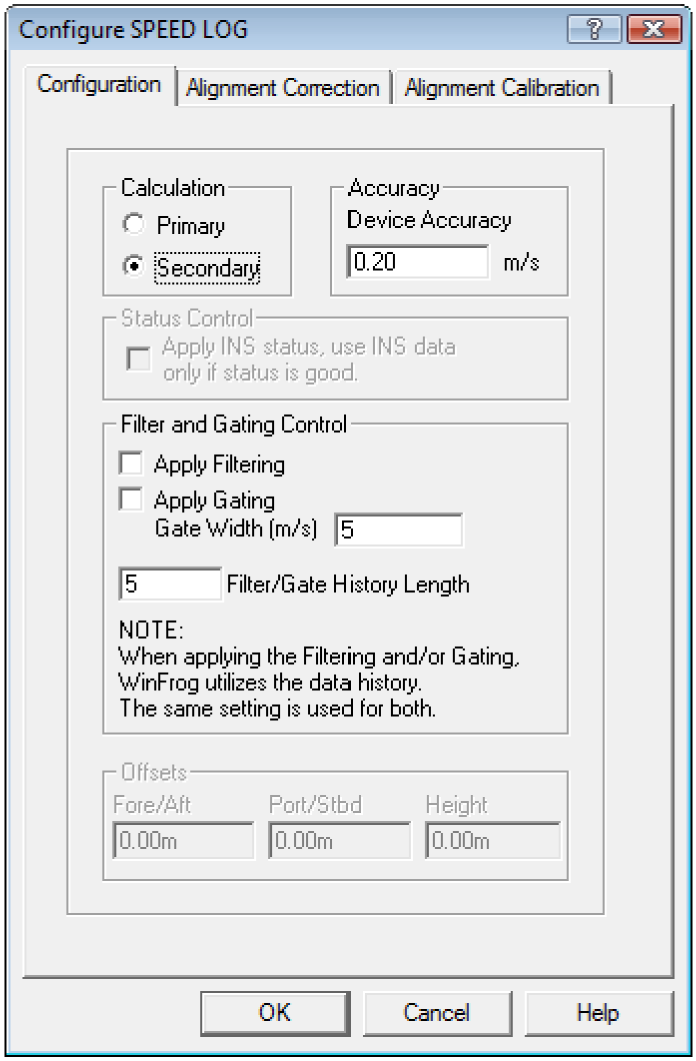
3 Select the appropriate doppler speed log or INS system.

This device will provide either the SPEED LOG or INERTIAL data item.

4 Add this to the appropriate vehicle.

Configuring the INS Data Type

The basic configuration options for the **INS** data type are shown in the next figure and detailed here. Note that the calibration feature and application of the associated results are discussed later in this section.



Calculation

Primary — Doppler data are used to assist the position of the vehicle.

Secondary — Doppler data are not used to assist the position of the vehicle.

Accuracy

Device Accuracy — Accuracy of the doppler speed log in m/s. The default is 0.2.

Status Control

This option is available only for the INERTIAL data item.

If the respective device is providing data status (valid or not valid) for the INERTIAL data, selecting this option will result in WinFrog monitoring the data status and if it is set to not valid, the data will not be used. This includes not inputting it to the filter and thus potentially skewing the filter performance.

If this option is not selected, the data is used regardless of the data status.

Filter and Gating Control

Apply Filtering	Controls the filtering of the raw doppler data prior to its use in the **Kalman Filter**. If selected, a central tendency filter is applied to the data using the number of samples defined in the **Filter/Gate History Length** below, the result of which is used for input to the **Kalman Filter**.
Apply Gating	Controls the gating of the raw data prior to its use in the **Kalman Filter**. If selected, the new data is tested against the data history based upon the number of samples defined in the **Filter/Gate History Length** below. If it exceeds the gate limits, the data is rejected.
Gate Width	Defines the gating limits in m/s. The value must be determined by monitoring the data.
Filter/Gate History Length	Defines the number of samples (minimum 3, maximum 30) to be used for both the central tendency filtering and the gating. This setting must reflect the application, environment and the INS performance. It depends upon balancing the need to smooth the data and the required responsiveness to real changes in the data. The longer the filter, the smoother the result, but less responsive to the actual dynamics of the vehicle. The shorter the filter, the less smooth the results, but more responsive to the actual dynamics of the vehicle.

Offsets

This setting is not used.

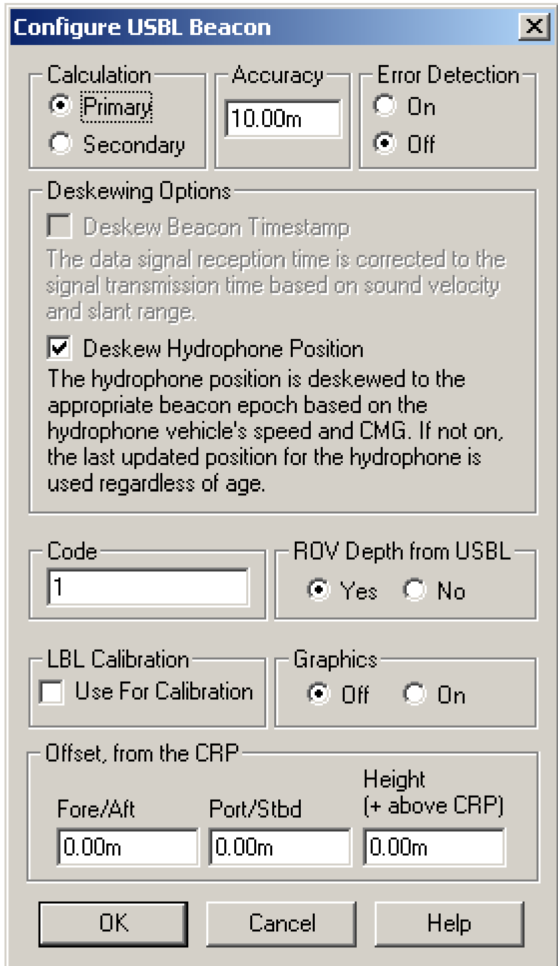
Note: if the **Apply Filtering** option is selected, but not the **Apply Gating** option, for the purpose of utilizing the filtering function, a default gating value of 10m/s is used.

Associated Configurations

The correct use of the INS data type is dependent upon the correct use of associated data types and the configuration of the associated vehicle Position Calculations. In a typical situation, the doppler speed log is mounted on an ROV being positioned with USBL, so this is the setup that will be examined here.

USBL BEACON Data Type Configuration

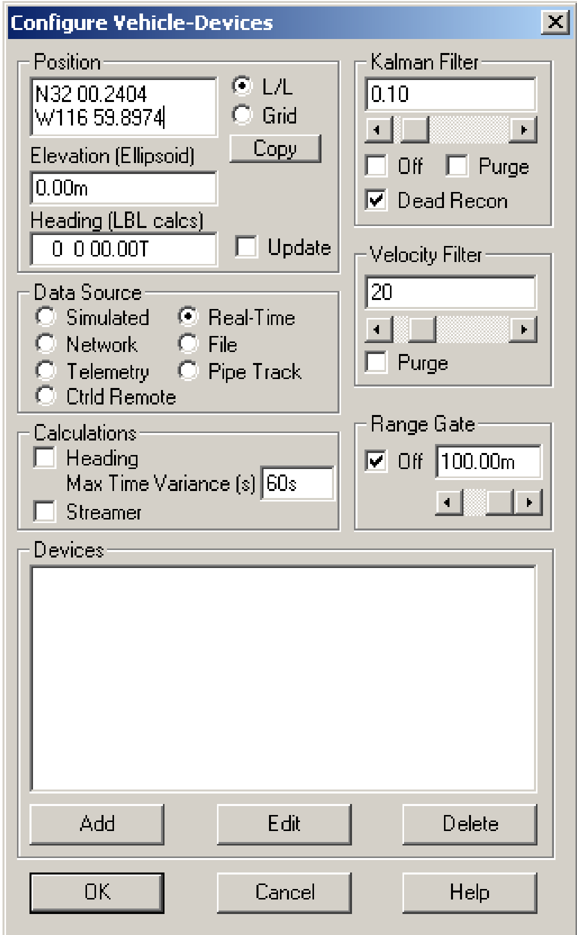
The ROV is positioned using a USBL BEACON data type. The next figure shows a suitable configuration.



The **Accuracy** is a critical setting. It is generally between 7-15 meters, depending upon the performance of the USBL system. The lower the value, the greater the influence of the USBL data in the Kalman Filter. The higher the value, the less the influence of the USBL data in the Kalman Filter.

Configure Vehicle-Devices Dialog

The **Configure Vehicle Devices** dialog box, shown below, enables you to configure the **Kalman Filter** and the **Position Gating**.



Kalman Filter

In order to utilize the **INS** data in the determination of the vehicle position in conjunction with other devices, the Kalman Filter should be **on** (i.e. **not** checked **off**).

The responsiveness of the filter to new data is controlled with the untitled numerical entry in the Kalman Filter panel. This value can be entered directly in this box, or controlled with the slider. The smaller the number, the less responsive to new data the filter is. The default is 0.10 and this is appropriate for the majority of applications. In noisy environments on a vehicle with a low dynamics, this can be reduced. Similarly, with good data on a vehicle with high dynamics, this can be increased. However, changes to this value should be made and monitored carefully to ensure that an inappropriate filter is not used. In general, this value will not be less than 0.05, or greater than 0.4. For ROV operations, a range of 0.10 to 0.30 is reasonable.

Note: If the Kalman Filter is not used, the INS velocity vectors are used to set the respective vehicle's velocity and a new position based on these velocities and the last calculated position is generated. The Velocity Filter setting does not impact the use of the INS velocities directly. It is also to be noted that if the Kalman Filter is not used and other devices are also associated with the vehicle, the resulting positioning may be erratic.

Range Gate

The **Range Gate** setting (see the previous figure) is used not just for gating ranges, but position data also. It is an invaluable tool when positioning with USBL. This should be set to a value in keeping with the performance of the USBL system. The default of 100m is much too large to be of any use with the USBL. A value of 20m is a reasonable initial setting to use.

Monitoring the Application of the INS

The monitoring of the speed log device falls into 3 categories:

1 Input of data.

2 Filtering and gating of the INS data, prior to use in the Kalman Filter.

3 Affect of the INS data on the position.

The **I/O Devices** window should be reviewed regularly to confirm that data are being received.

To Monitor Use of the INS Data Type as Attached to the Vehicle

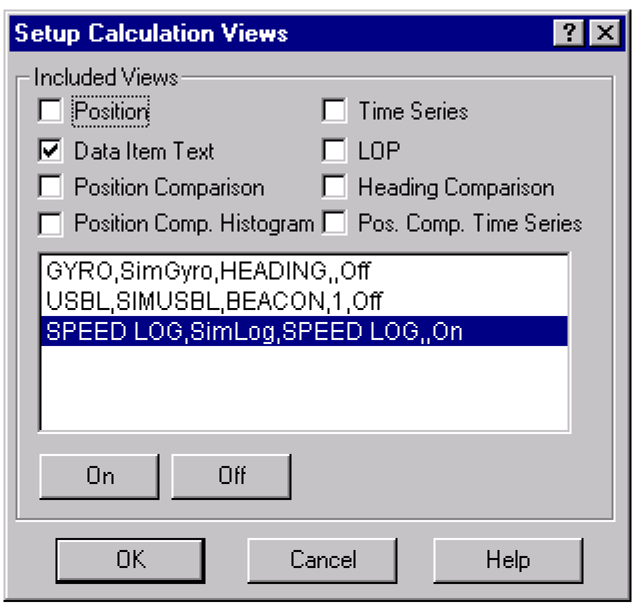
1 Open a **Calculations** window. (**View** > **Calculations**)

2 Select the appropriate vehicle from the dropdown list.

3 Click the **Setup** button to access the **Setup Calculation Views** dialog box.

4 Check the **Data Item Text** box.

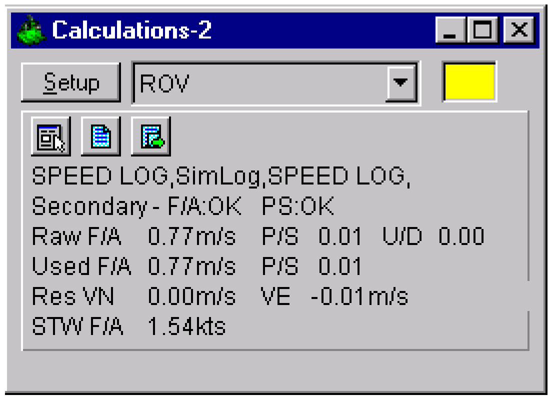
5 Highlight the **INS** item.



6 Click the **On** button.

7 Click **OK** to exit.

The speed log data can then be monitored in this **Calculations** window, as shown in the next figure.



The lines of data provided in the **Calculations** window are detailed below:

- Data Type and Device Name
- Calculation setting (Primary/Secondary) and the status of the F/A and P/S velocity data. The status can be OK, Gate or Bad. OK indicates that the data is valid and used. Gate indicates that the data has been gated and is not used. Bad indicates that the data as received from the speed log was either invalid, or in the case of the SPEED LOG, not an Over Ground Speed.
- The raw F/A, P/S, and Up/Down Over Ground velocities in m/s.
- The F/A and P/S velocities used in the Kalman Filter. If the INS data filtering is turned on, these will be the results of the filter. If not, these will be the raw data repeated.
- The Northing and Easting velocity vector residuals in m/s. The residuals are the Kalman Filter results minus the used data.
- The Speed Through Water, if the device also provides (or only provides) this value

This window provides you with the means to observe the results of the gating and filtering. If excessive gating occurs, or the filtered data does not reasonably represent the raw data, changes to the INS data type configuration are required.

It should also be noted that a time series plot of the used velocities (and **Speed Through Water** if available) can be displayed by checking the **Time Series** box in the **Configure Vehicle-Devices** window.

To Monitor the Impact of the INS Data Type

The monitoring of the impact of the INS data type on the positioning of the vehicle requires the setting up of **ghost** vehicles. To minimize the distraction of the ghost vehicles on actual navigation and tracking, you may wish to do the following. From the **Vehicle Presentation** configuration option for the ghost vehicles, select **Vehicle Window Data: Off** to prevent the display of the vehicle data in the **Vehicle** window(s). You may also wish to limit the vehicle shape to a simple cross in a different color to make graphical comparison easier.

The following details the ghost vehicle setup.

1 Add an INS data only ghost vehicle.

- Add a vehicle to WinFrog.
- Add the appropriate HEADING and INS data types.

Make sure to configure the vehicle's positioning parameters (i.e. **Kalman Filter** and **Range Gating**) and the data types exactly as configured on the actual ROV Vehicle. When running with only an INS data type as a source of positioning data, the vehicle must be given a starting positioning. Do this by copying the current ROV vehicle's position into the appropriate edit box in the **Configure Vehicle Calculations** dialog box and check the **Update** box.

2 Add a USBLBEACON data only ghost vehicle.

- Add a vehicle to WinFrog.
- Add the appropriate HEADING and USBLBEACON data types.

Make sure to configure the vehicle's positioning parameters (i.e. **Kalman Filter** and **Range Gating**) and the data types exactly as configured on the actual ROV Vehicle.

3 Monitor the difference in positioning between these vehicles and the actual vehicle will illustrate the affect the use of the INS data is having in the Kalman Filter.

To Reset the Vehicle's Position

Based upon the monitoring of the aforementioned ghost vehicles, you will be able to determine if the actual ROV position has been overly and incorrectly biased by either the INS or the USBL to the point where it requires correction. This can be accomplished in several ways.

Option 1 - Purging the Kalman Filter

From the **Configure Vehicle-Devices** dialog box, check the **Purge** checkbox in the **Kalman Filter** area and click **OK** to exit this dialog.

This will reset the **Kalman Filter** and purge the history. The positioning will start afresh with the input of new data of any type currently configured to Primary for that vehicle.

Option 2 - Updating the Vehicle Position

Enter or copy a new initial position in the **Configure Vehicle-Devices** dialog box and check the **Update** checkbox.

This will force the vehicle to this position and the Kalman Filter will take over.

Option 3 - Disabling a Data Source

Either the INS or USBL BEACON data type can be removed from the solution by setting them to Secondary. The affect of the data will remain for a short period due to the fact that the Kalman Filter uses history to predict the future.

Note: though any of the aforementioned options can be used separately, it generally requires some combination to affect a proper vehicle position reset.

Calibrating the INS Data Type

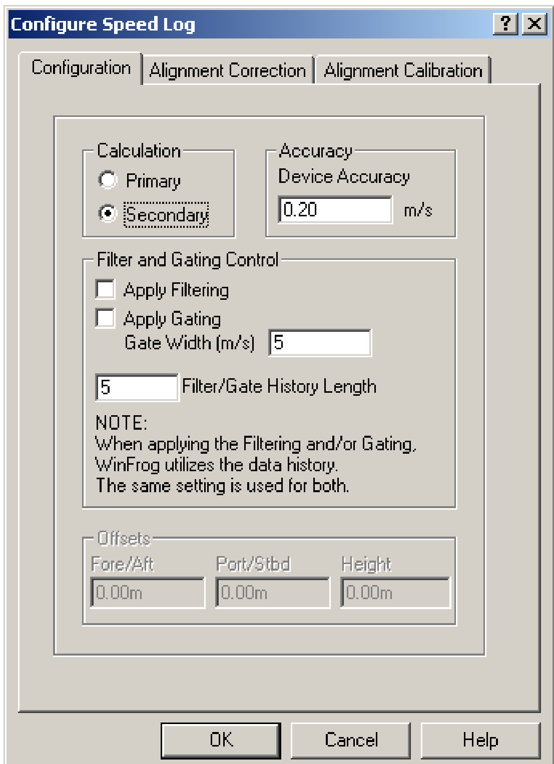
The calibration of the INS feature provides a simple method to determine an alignment correction and apply this to the INS data for real-time application.

1 Select a route of known azimuth that the ROV can track during the calibration. A pipeline is a good option.

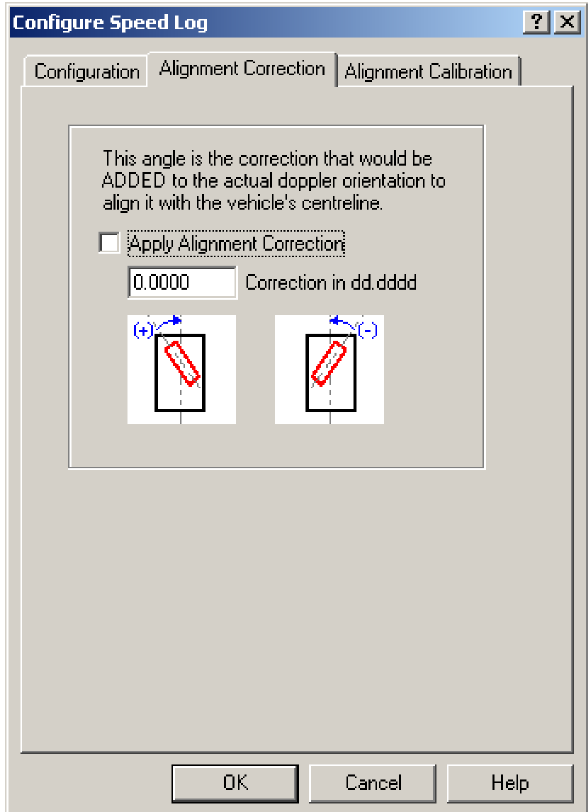
2 Position the ROV on the selected route and prepare to travel along the route, including aligning with the route and setting down to allow the positioning of the ROV to stabilize.

3 Access the **Configure Speed Log** dialog via the **Configure Vehicle-Devices** dialog.

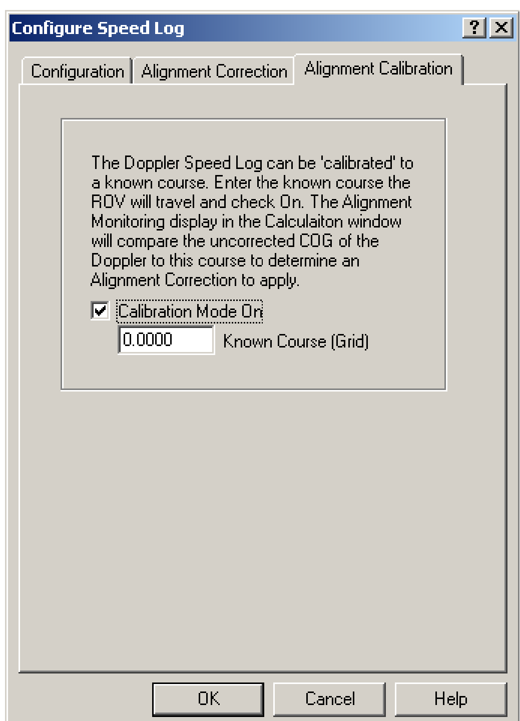
4 On the **Configuration** tab, set the INS to **Secondary**. Use of the Filtering and Gating is optional, but be aware that if applied, it is the result that is monitored during the calibration itself.



5 Go to the **Alignment Correction** tab and ensure that the **Apply Alignment Correction** checkbox is not checked.



6 Go to the **Alignment Calibration** tab. Enter the **Known Course (Grid)** azimuth and select the **Calibration Mode On** checkbox.



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

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

9 Open a **Calculations Window** and configure this to view the Data Item Text and turn the INS data type on.

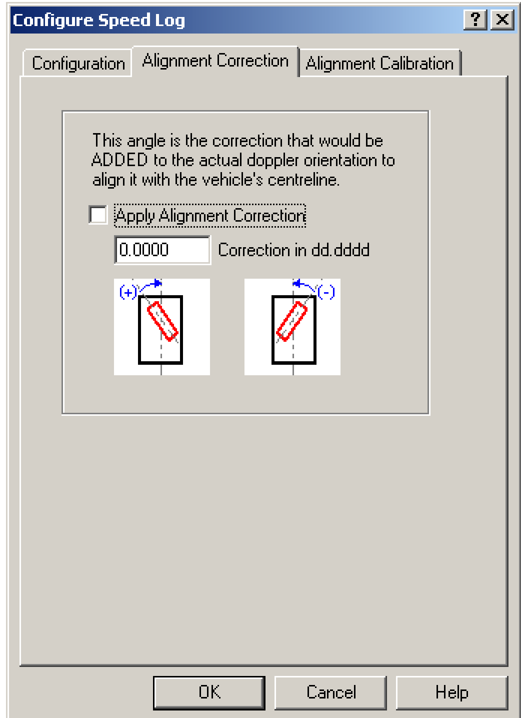
The information displayed is as follows:

Uncorr'd Log COG	the resultant grid velocity vector derived from applying the raw fore/aft and port/starboard velocities to the ROV heading
Cal Alignment	the grid azimuth of the selected route
Calc'd Correction	the INS calibration correction derived from a central tendency filter based on a sample size of 10. This sample and the result is updated with every valid INS data input. The correction based on the current epoch is given in brackets.
Corr'd Log HDG	the resultant grid velocity vector with the calibration corrections applied. Note that this value will be the same as the uncorrected during calibration if the Apply Calibration Correction checkbox was unchecked (see step 2). The ROV's Course Over Ground (COG) is displayed in brackets.

10 Monitor the Calc'd Correction value to determine the calibration correction to apply. Note that at this time, this data is not logged nor can it be printed.

11 When the ROV has completed the course and a calibration value has been determined, access the **Alignment Calibration** tab in the **Configure Speed Log** dialog and uncheck the **Calibration Mode** checkbox.

12 In the same dialog, go to the **Alignment Correction** tab and enter the value determined for the calibration correction in the **Correction in dd.dddd** field. Then check the **Apply Alignment Correction** checkbox.



13 In the same dialog, go to the **Configuration** tab and re-configure the INS for use, specifically setting it to **Primary**.

14 The performance can be monitored in the Calculation Window in the same way the calibration was monitored. The only difference is that Alignment Calibration has changed to state Alignment Monitoring and the Cal Alignment value now shows the vehicle's COG.

Pipe Bundle Tow Monitoring

WinFrog supports the tracking of a pipe bundle tow through an interface to a third party Bundle Tow software package. This allows you to view the pipe bundle in the Graphics and Profile windows to monitor its position while under tow.

The interface also supports output from WinFrog to the third party package.

This output includes the position and KP data for up to three vessels.

The pipe bundle is handled as a WinFrog Vehicle. The positioning of the bundle is based upon the application of the depth and gyro (true heading) data received from transponders located at specified intervals along the bundle in a three dimensional, open-ended traverse calculation. The starting position for the traverse is derived from position sources located at specified locations on the bundle. The position sources supported are GPS, USBL and LBL. It is expected that the most commonly applied source will be the USBL. The transponder and position source positions are defined by the distance they are from the head of the pipe bundle.

The implementation of the pipe bundle tow monitor option has been done in such a way that most of the standard WinFrog Vehicle functionality is available to the pipe bundle vehicle. The methodology implemented for associating the position sources with the bundle enable multiple sources to be used. WinFrog automatically matches the data to the correct point on the bundle.

In addition, it also supports the passing of the base position data for the pipe bundle into the WinFrog Kalman Filter resulting in a smoothed position for the starting point of the traverse.

The standard WinFrog Vehicle capabilities supported include a variation on the Line Tracking. If a Survey Line is selected for the respective vehicle, the line track information is calculated for each point on the bundle that a position is derived for. This information is then available for display in the Numerics window and for alarming in the Alarms windows.

The Pipe Bundle Traverse

The primary legs of the traverse are defined by the following points:

- The head and tail of the pipe bundle; and
- The midpoints between those transponders providing heading data. Based on these transponders, the heading provided by a given transponder is applied to that portion of the pipe bundle starting midway between the preceding transponder and this transponder continuing to the midpoint between this transponder and the following one. In the case of the first transponder from the head, the leg starts at the head of the bundle. In the case of the last transponder from the head, the leg ends at the tail.

Secondary traverse points are located on the aforementioned primary legs at the transponders themselves.

The primary legs and secondary points are dependent upon the available heading and depth data at each data update, i.e., if a transponder that is set to provide a heading does not provide a valid value, the primary legs are determined as if this transponder did not exist as a heading transponder. It will still exist as a secondary point for the purpose of displaying the transponder position graphically. Similarly, if a depth transponder does not provide a depth, a depth is interpolated for it.

The bundle vehicle also has a Common Reference Point (CRP) defined by a distance from the head of the bundle.

When depth data is updated from the pipe bundle package, depths are applied to the respective depth transponder points. Depths for all other points as defined above are then interpolated or extrapolated from these.

When a position data source is updated, WinFrog matches this with the respective point on the pipe bundle, that is, a point at a known distance from the head of the bundle. This position is then traversed to the CRP. If the vehicle is configured to use the Kalman Filter, this position is passed into the filter and the resulting filtered position is then used for the subsequent traverse calculations. If the Kalman Filter is not to be used, this CRP position is used as is. The CRP position is then used to traverse ahead and back to determine the horizontal positions of the start and end points of the primary legs and of the secondary points.

The heading associated with the Bundle Vehicle is the mean of all the transponders' heading values.

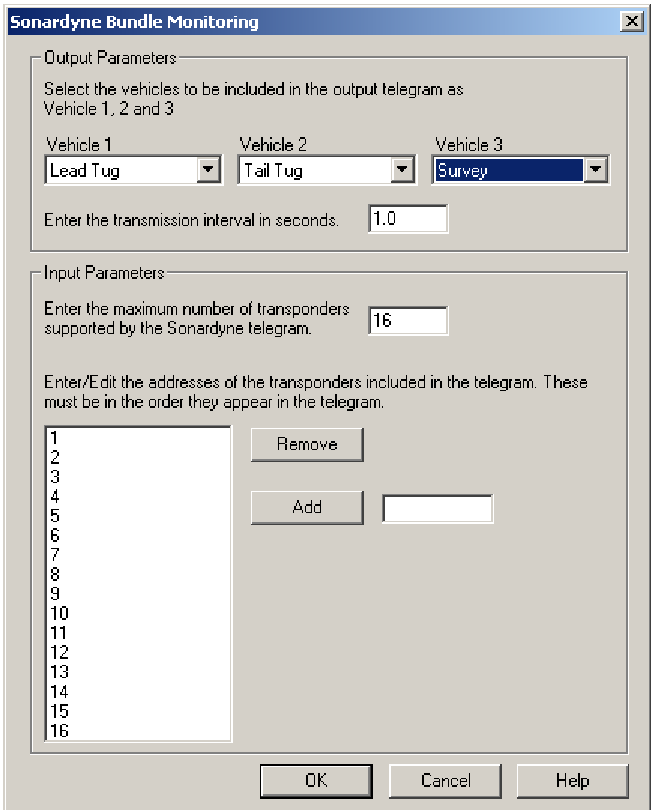
Adding and Configuring the Device

1 From the I/O Device window, right-click and select **Add Device.**

2 Go to the **COMPASS** devices and select the **Sonardyne Bundle Monitor** device and click **OK**.

3 Configure the serial port parameters appropriately and click **OK**.

4 In the I/O Device window, select the Bundle Monitor device, right-click and select **Configure Device**. The **Sonardyne Bundle Monitoring** dialog box appears**.**



5 The top panel allows you to select those vehicles to be included in the output telegram. Note that only those already added to WinFrog are listed.

- Select the desired vehicles.
- Enter the output interval in seconds that the output telegram is to be transmitted.

Note: The DATA OUTPUT data item associated with this device must be assigned to the respective vehicles.

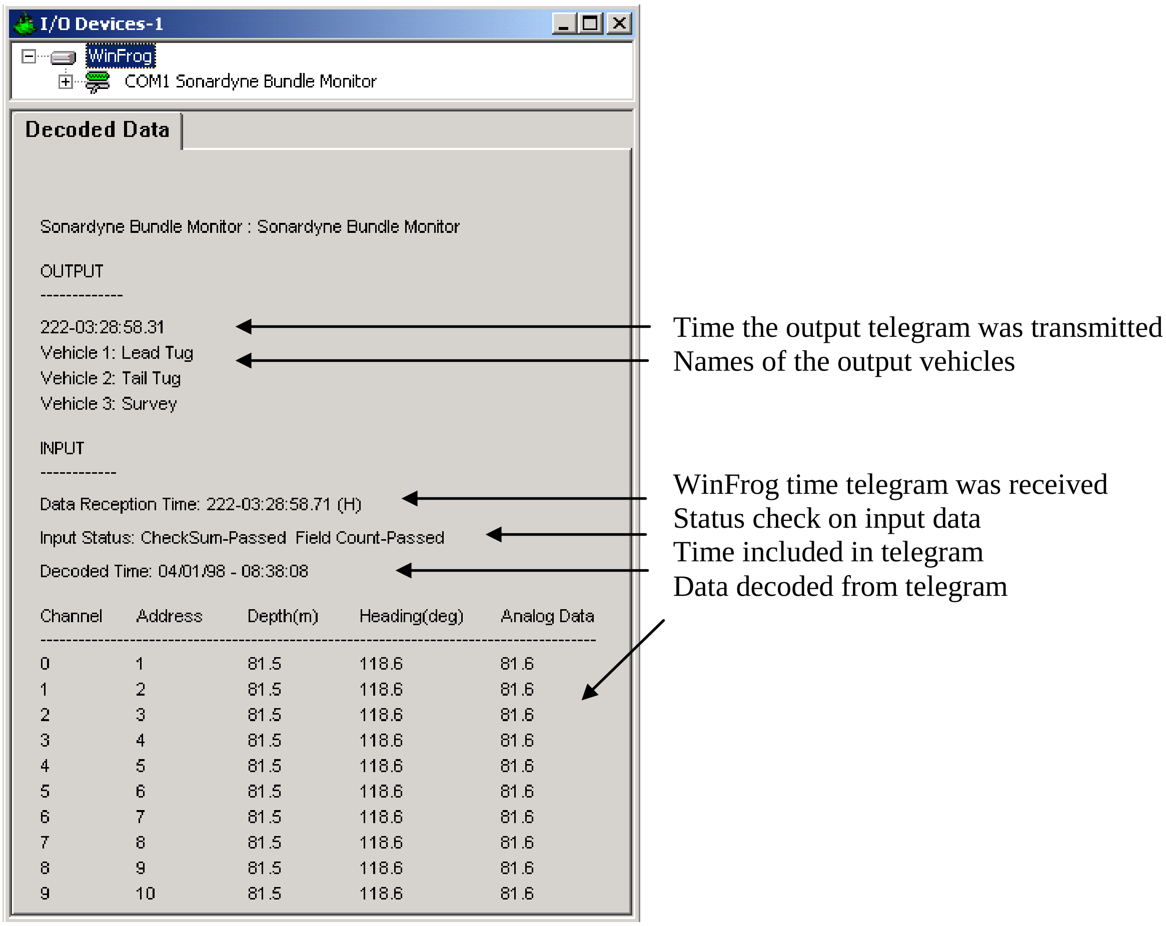
6 The lower panel allows you to define the data being received from the pipe bundle software package.

- Enter the maximum number of transponders included in the telegram.
- Enter the channel identifier for the transponders included in the telegram. These must be in the order they will occur in the telegram. The identifier must be the USBL beacon ID associated with the transponder if USBL interrogations of the

transponders will be executed. If the transponders will be interrogated with LBL, the transponder address is to be added. Enter the identifier in the field to the right of the **Add** button and click the **Add** button. If an identifier is to be removed, highlight the transponder identifier to be removed and click the **Remove** button.

7 Click **OK**.

The device can be monitored in the device window.



Configuring the Pipe Bundle Vehicle

The configuration of the Pipe Bundle vehicle is essentially the same as any other vehicle. It is important to note that not all vehicle options/features are available. The most notable is the inability to use the Vehicle Offset option.

1 Add a vehicle.

2 Configure the vehicle shape such that no shape is associated with this vehicle:

- Select **Ship** mode
- Enter 0 for the **Width Of** and **Origin To** items
- Make sure the **Moonpool Used** checkbox is **not** checked.

3 If using USBL to position the Pipe Bundle:

- Add a BEACON data item from the respective USBL system for each beacon that may be used.
- Configure each BEACON data item:
  - Set the Calculation mode to Secondary
  - Enter the appropriate Code
  - Make sure all offsets are 0
  - Select Graphics On.

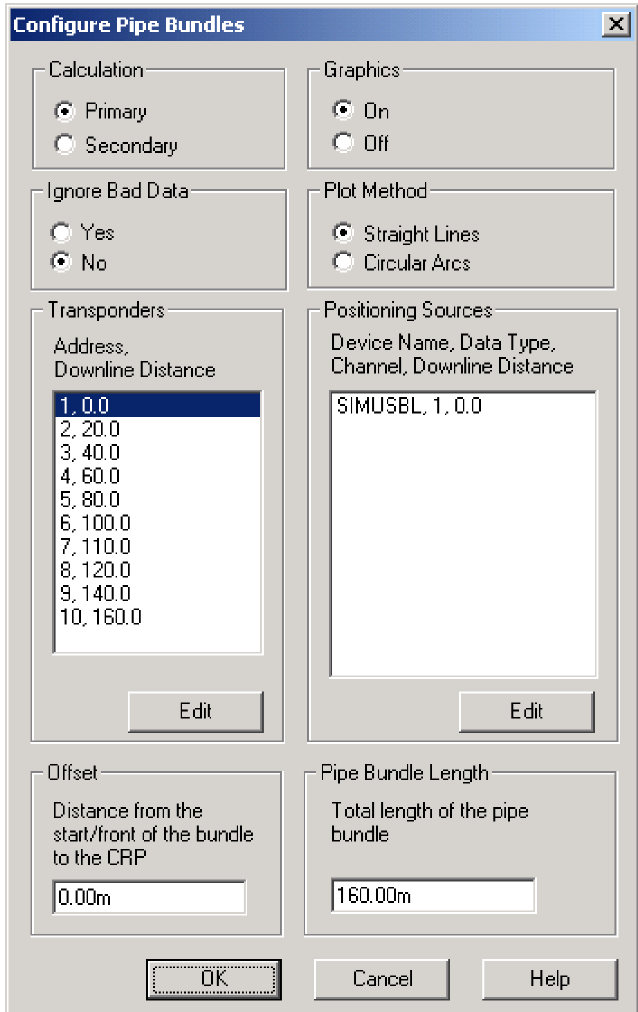
OR

If using LBL to position the Pipe Bundle

- Add a XPONDER data item from the respective LBL system for each transponder that may be used.
- Configure each XPONDER data item for normal operation (see **Chapter 17: LBL Acoustics**), ensuring the following settings are implemented:
  - Set the Calculation mode to Secondary
  - Make sure all offsets are 0
  - Select Graphics On.

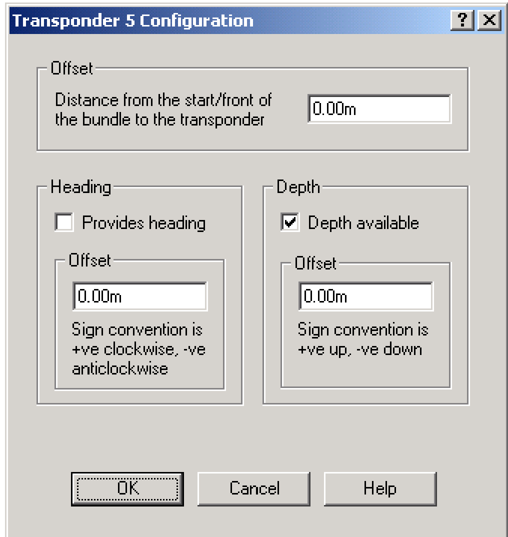
4 Add the **BUNDLE** data item to the vehicle.

5 Click the **Edit** button to access the **BUNDLE** configuration dialog.



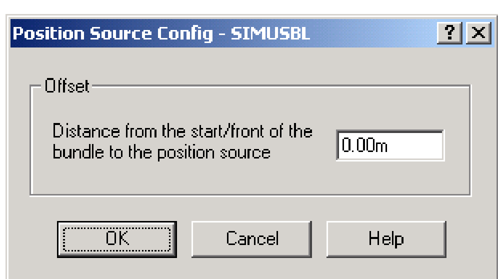
6 Configure the data item:

- Set Calculation Mode to **Primary**.
- Set Graphics **On** to display the transponder identifiers in the Graphics window.
- Set the Ignore Bad Data. If data flagged as bad or invalid is received, you have the option to use it anyway (No) or not (Yes).
- Set the Plot Method. You can choose between straight lines, or lines joined by circular curves.
- In the Transponders panel, all the transponders added to the device configuration are displayed. Each must be configured. Highlight the transponder in the list and click the **Edit** button or double-click the transponder in the list. A **Transponder Configuration** dialog box appears.



- Enter the distance from the head of the pipe bundle to this transponder.
- In the **Heading** panel…
  - If the transponder is providing heading data, check the **Provides heading** checkbox.
  - Enter any heading correction to be added to the raw heading value.
- In the **Depth** panel…
  - If the transponder is providing depth data, check the **Depth available** checkbox.
  - Enter any correction and/or offset to be added to the raw depth value. This includes offsets to that point of the pipe bundle to be positioned, e.g. to the center the bundle, and calibration values.
- Click **OK**.

- In the **Positioning Sources** panel on the **Configure Pipe Bundles** dialog, any positioning data items associated with this vehicle are listed. Each of these must be configured. Highlight the source in the list and click the **Edit** button or double-click the source in the list. A **Position Source Config** dialog box appears.



- Enter the distance from the head of the pipe bundle for this positioning source and click **OK**.

- In the **Offset** panel on the **Configure Pipe Bundles** dialog, enter the distance from the head of the pipe bundle to that point assigned as the CRP.

  Note: There are two main issues to address when selecting the CRP:

  - If one positioning source will be the primary source used, e.g. a specific transponder, this should be used as the CRP.
  - Alternatively, if it is desired that a towline be displayed from the lead tow vessel to the pipe bundle, the CRP should be the head of the bundle. This allows you to set up dynamic tracking between the tow vessel and the bundle vehicle utilizing the option to draw a line between the respective vehicle points.

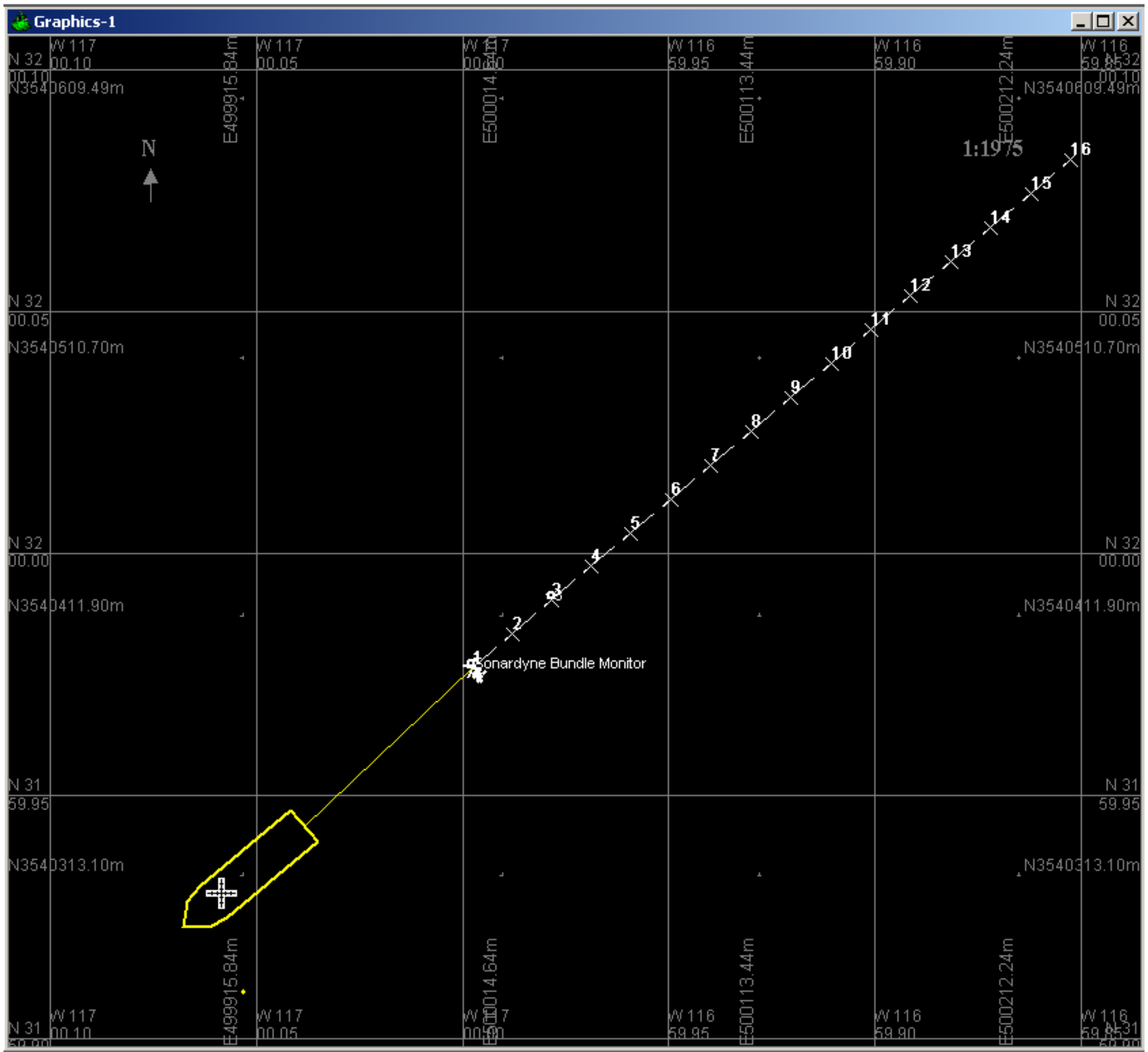
- In the **Pipe Bundle Length** panel, enter the total length of the pipe bundle.
- Click **OK**.

7 Complete the configuration of the vehicle (see **Chapter 6: Vehicles**):

- Configure the vehicle to use the Kalman Filter and Range Gate as desired.
- Configure vehicle trail and color.
- Configure if vehicle is to be displayed in the Graphics window and/or the Profile window.

Viewing the Pipe Bundle Vehicle

The pipe bundle vehicle can be viewed in both the **Graphics** and **Profile** windows. The configuration of these windows can be found in **Chapter 8: Operator Display Windows**.



In addition, the data associated with each of the traverse points can be viewed in the Numerics window and used for alarming in the Alarms windows. For more information on the use of these windows, refer to **Chapter 8: Operator Display Windows**. In addition, the following must be noted when using these windows:

Numerics Window

- the names used for the items for the Numerics window must be based upon a name that does not change, therefore the term used is Node *n* where *n* is the number of the node from 1 to 64
- the names associated with each traverse point are N*n* where *n* is the node number counting from the head of the bundle to the tail; in the case that a transponder is located at the traverse point, the transponder address is appended in brackets, e.g. N3(103)

- therefore the component *n* in the aforementioned Numerics and traverse point names are correlated
- the maximum possible number of traverse points must be added to the Numerics window for display; if one is dropped due to no heading data or depth data, the last node(s) displayed change to display *N/A*

Alarms Window

- the naming method for the Alarms windows is the same as that used for the Numerics window so the same rules apply to the configuration
- in the case of the Alarms window, it cannot determine when a traverse point has been dropped and as a result will display all selected nodes despite the possibility that they are no longer valid
- it is best then, to have the Numerics and Alarms windows located and sized such that the correlation between the selected items to display and monitor can easily be determined and therefore ignore those alarms that are invalid