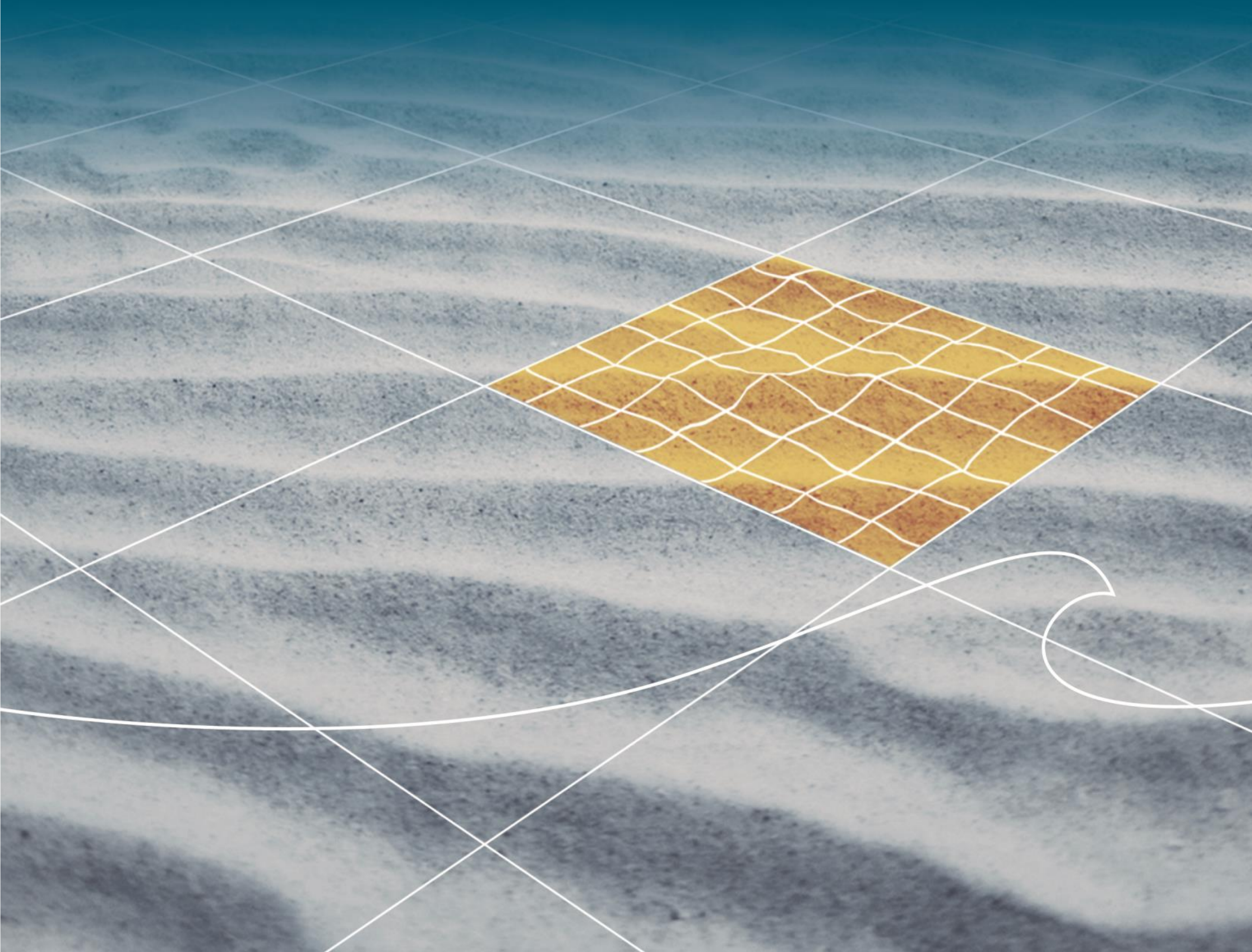
NAVIPAC 4.2

NAVIPAC ONLINE



Contents

1 Reading guide

This manual describes the user interface of the NaviPac 4.0 for NaviSuite Kida Online program. It provides you with an overview of how to get around in the program as well as a description of the many dialogue boxes. The NaviPac Setup program is **not** described in this document; please refer to the NaviPac Setup dedicated manual.

The NaviPac Online program is a Microsoft 32-bit program running on one or more Windows workstations. You must be familiar with the Windows environment to be able to operate the NaviPac software correctly.

The NaviPac Online manual is structured according to the main functions of the Online program:

Chapter 2: Presents an overview of the main windows, functions, and how to start/stop the program.

Chapter 3: Describes all the menu functions in NaviPac Online one by one.

Chapter 4: Contains general information about:

- Alarm handling in NaviPac
- Navigation modes/states
- Navigation scenarios
- Filtering components
- Dead reckoning
- Simulation
- Quality factors

Chapter 5: Lists definitions used in NaviPac user documentation. If you do not know the meaning of a word, try this list for an explanation.

Chapter 6: Lists all tables and figures in this manual.

2 Program overview

This chapter outlines an overview of the NaviPac Online program (eg the Online main window) and briefly describes all menu functions.

The NaviPac Online process allows the navigator to perform all phases of surface, subsea and remote navigation, to view all sensor data, to perform changes in navigation principles and components, to perform various calculations etc. Beside the GUI-related parts, the navigation system includes a kernel program for data calculation, a data I/O function for data acquisition and time stamping, a data communication part for exchange of data or commands with other components and a data simulator for simulation of sensor data.

At start, the user may choose which Lines of Position (LOPs) to use (ie which surface navigation systems and stations to use in the navigation process).

The program reads all basic information from the Setup database, which presents all available stations and lets the navigator specify the stations wanted. All the information is stored in the Online database file, which can be maintained by one or more Online programs.

Any changes performed during operations (eg selection or de-selection of LOPs, changes in C-O, weight or sigma) are also stored in the Online database, which ensures that a fast restart after a stop can be performed without any user interaction.

If needed, the system administrator may keep more copies of Setup database / Online database, which allows to store files (on tape etc.) for various jobs, functions etc. The name/location of the Online DB is $EIVAHOME/DB/onlsetup.DB.

However, if a major change has been performed in the Setup database, there is a risk that the change will not be useful later, and a manual start must be performed to re-initialise all basic settings (estimated position, selected LOPs, selected dynamic positions etc).

2.1 Online main window

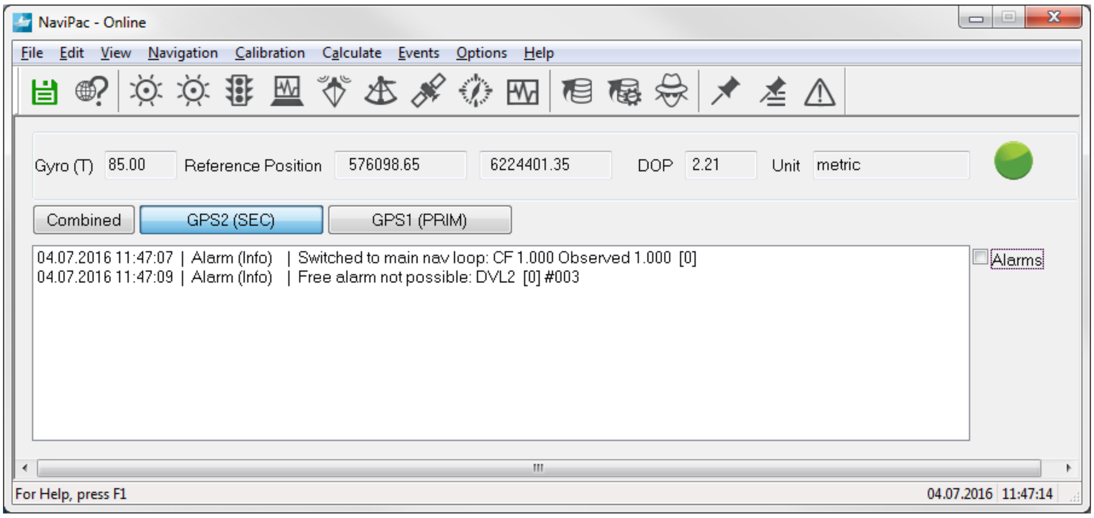


Figure 1 NaviPac Online main window

As illustrated above, NaviPac Online is built as a standard Windows program, for which the primary purpose is to let the navigator operate and view the navigation system. The main window consists of a menu bar, a toolbar and a scrolled list where different information concerning changes to the Online system and alarms registered by the Kernel will be shown. The messages in this window can also be logged in a log file if the administrator has enabled it ([online] section in navipac.INI).

2.1.1 Toolbar

The toolbar can be disabled or moved to another place. It holds the following functions:

Figure 2 Toolbar

- Save settings
- Estimated Position
- Helmsman's Display
- Online 3D
- Input Monitor
- Raw data
- Position Monitor
- Object Monitor
- GPS Status

- Attitudes (Roll, Pitch, Gyro)
- Data Monitor
- Data Logging (one instance only)
- Data Logging - Custom (multiple instances)
- Instrument Spy
- Manual Event
- Manual Event (Note)
- Alarm Monitor

The following items are dynamically updated in the online main window:

2.1.2 Date & Time

Shows current date and time. Controlled by either GPS or internal clock. Presented in lower right corner (status bar). Format depends on your regional settings.

2.1.3 Gyro

Shows current heading (true – that is, not corrected for meridian convergence) of the ship. In range 0.00 - 359.99 degrees.

2.1.4 Reference Position

Shows ship reference position in geographical or grid coordinates

Easting field: Displayed as X (EEEEEEEE.EE), Longitude (DD◦MM’SS.ss” or DD◦MM.mmmm’)

Northing field: Displayed as Y (NNNNNNNN.NN) or Latitude (DD◦MM’SS.ss” or DD◦MM.mmmm’).

2.1.5 DOP

Shows standard deviation of the reference position. Unit: decimal number. The following combinations exist:

- **One GPS system**
  Shows horizontal dilution of precision (HDOP) from GPS.
- **2 or fewer LOPs**
  Shows -1 as no over-determination is possible.
- **More than 2 LOPs**
  Shows ordinary standard deviation based on least square fit of the LOPs.

2.1.6 Unit

Display name of selected unit. For example:

- **Metric**
  Positions are shown in metres.
- **US Survey Feet**
  Positions are shown in US Survey Feet.

2.1.7 Status

Indicate the status of navigation computations. Possible colours are green, yellow, and red:

- **Green**: All is OK
- **Yellow**: Watch out
- **Red**: Something is non-functioning

2.1.8 Alarms/messages

When alarms occur they will be shown in the lower part of this window. Also, when the user makes changes to the setup (online.DB) the changes will be displayed in this window.

Note: The messages are also logged to a file, which can be displayed from **Alarm & Message File** in the **View** menu.

Alarm/Messages have a check box. When alarms occur, the button is checked and the text turns red. When checked off (by user) text turns green.

2.1.9 Navigation

The navigation buttons are as follows:

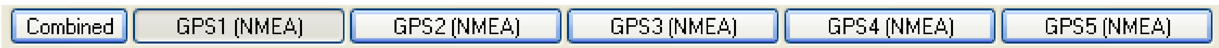


Figure 3 Navigation buttons

These buttons show which source NaviPac uses for primary navigation input. It contains one button called **Combined** and one button for each navigation group.

In the above figure, the current selection (GPS1 (NMEA)) is marked as if it were clicked.

2.2 Menu function overview

The Online program has 7 drop-down menus: **File**, **Edit, View, Navigation, Calibration, Calculate, Events, Options** and **Help,** which will be briefly described below.

2.2.1 File

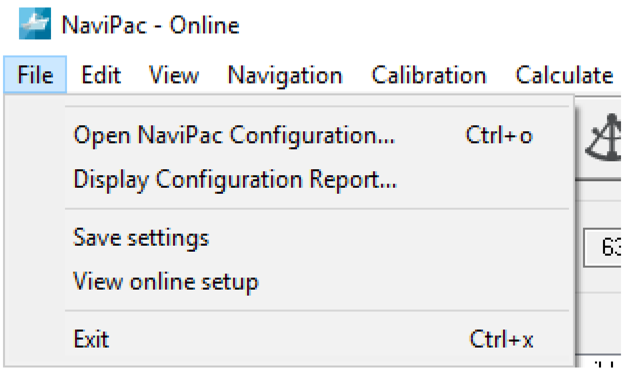


Figure 4 File menu

This menu contains file-oriented menu entries.

- **Open NaviPac Configuration**
  Starts the NaviPac definition program NaviPac Configuration.
- **Display Configuration report**
  Show ASCII report on the configuration
- **Save settings**
  Saves the current window size and position of the NaviPac Online program.
- **View online setup**
  Show NaviPac Online setup (selected LOPs, gyros, speed logs, motion sensors and dynamic objects) as ASCII listing.
- **Exit**
  Stops NaviPac Online. Exiting NaviPac Online does not stop data collection from sensors and calculation of reference position; only the GUI part is stopped. A new Online program can be started from Setup, Navigation, and Online Display.

2.2.2 Edit

This menu contains entries for performing changes in the online navigation setup.

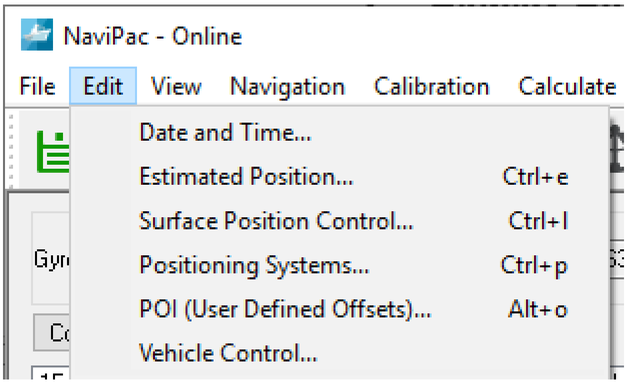


Figure 5 Edit menu

- **Date and Time**
  Opens a new dialogue box for changing date/time control and setting the system clock.
- **Estimated Position**
  Opens a new dialogue box for inputting the new estimated position. This function may be needed to ensure that calculations don't get out of range.
- **Surface Position Control**
  Opens a new dialogue box for manually specifying the weight, sigma (tolerance limit) and C-O (Calculated - Observed) of each position observation in the navigation computation algorithm.
- **Positioning Systems**
  Opens a new dialogue box for changing the setup of surface and dynamic navigation systems.
- **(POI) User Defined Offsets**
  Opens a new dialogue box for changing fixed offsets (XYZ, name, and on/off).
- **Vehicle Control**
  Opens a new dialogue box for check and control of gyro and motion sensor. Here, you can select which unit to use as the primary source for position calculation.

2.2.3 View

The menu contains entries for opening new windows with detailed navigation information.

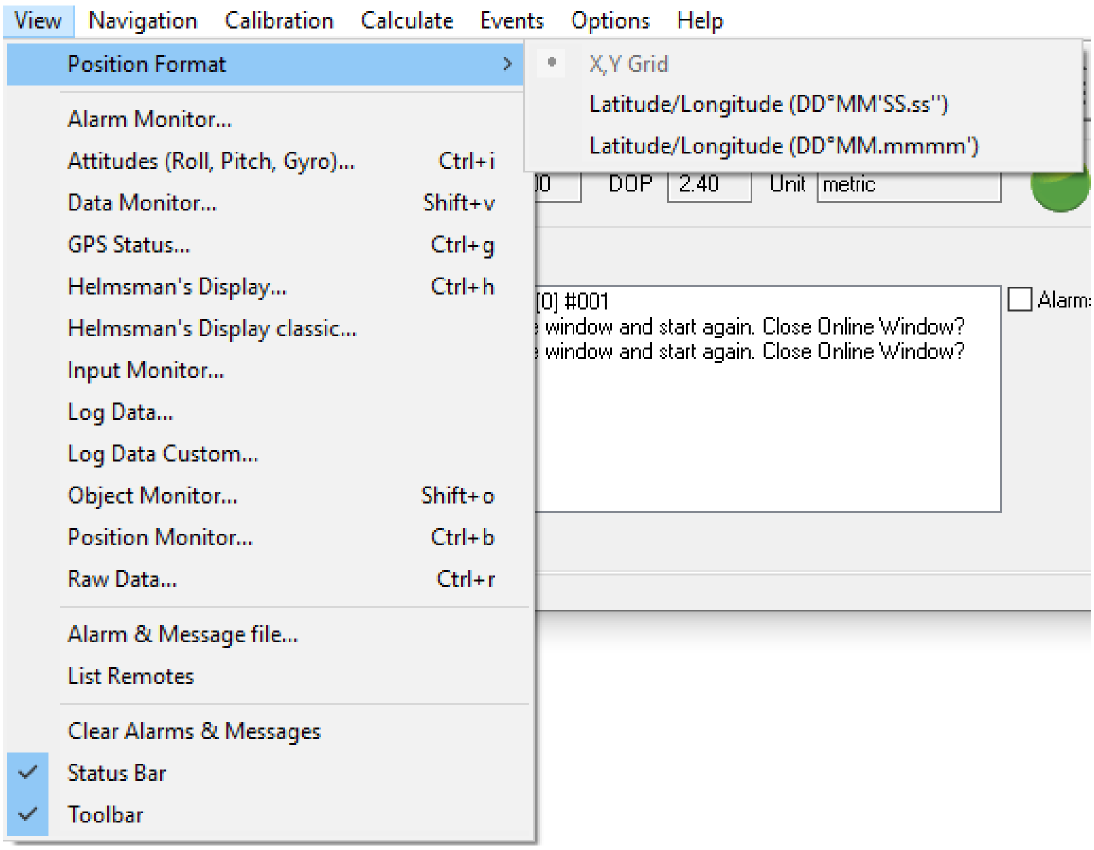


Figure 6 View menu

- **Position Format**
  A cascading button allowing the operator to select a format of the positioning display. The system supports:
  - **X,Y Grid** as easting/northing
  - **Latitude/Longitude (DD°MM ‘SS.ss”)**
  - **Latitude/Longitude (DD°MM.mmmm”)**
- **Alarm Monitor**
  Ordered alarm display and control of user-defined alarms.
- **Attitudes (Roll, Pitch, Gyro)**
  Open a new window with detailed attitude and speed information, where a gyro, motion and speed log system can be selected and data displayed. If, for example, 2 systems should be compared, the user may open 2 windows.

- **Data Monitor**
  Open a new window with functions for selection of attitude, echo sounder channels and Z-offsets that can be displayed in text views as well as graphical views. Display can be time series plots or along kilometre points (KPs).
- **GPS Status**
  Open a new window with status information for up to 5 selected GPS systems.
- **Helmsman's Display**
  Opens the Helmsman's Display for line-planning, steering control and vessel tracking.
- **Helmsman's Display classic**
  Opens the version 3 Helmsman's Display for line-planning, steering control and vessel tracking.
- **Input Monitor**
  Open a dedicated input monitor window, which shows statistics on the incoming data.
- **Log Data**
  Open a new window with logging functions.
- **Log Data Custom**
  Open a new window with custom logging functions.
- **Object Monitor**
  Open a new window for monitoring of the object positions, including fixed offsets, remote positions and dynamic positions.
- **Position Monitor**
  Open a new window for display with detailed information of the position observations included in the navigation calculation.
- **Raw Data**
  Open a new window with port data display/selection functions.
- **Alarm & Message file**
  Open a window with logged alarms and Online user actions.
- **List remotes**
  List number of connected remote displays (shown as message list).
- **Clear Alarms & Messages**
  Empty the message list in the Online window.
- **Status Bar**
  Toggle the status bar on and off.
- **Toolbar**
  Toggle the toolbar on and off.

2.2.4 Navigation

This entry contains menu items with various functions for changing navigation options.

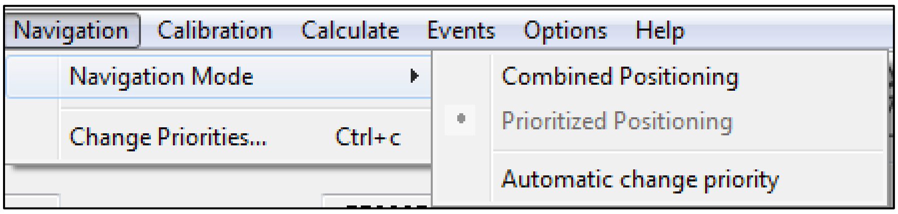


Figure 7 Navigation tool

- **Navigation Mode**
  Points to the two navigation mode radio buttons: **Combined Positioning** and **Prioritized Positioning**. The current selected mode will be dimmed.
- **Change Priorities**
  Only available for **Auto Prioritised Positioning** mode. This menu entry results in opening of a new dialogue box, which allows the user to manipulate the LOP grouping (ie to define which stations/systems should be part of which priority group).
  Note: This can also be reached via buttons on the front page.
- **Automatic change priority**
  Only available for **Auto Prioritised Positioning** mode. NaviPac automatically switches to navigation group 2 if the primary navigation drops out (in other words, if the primary is in red state). If selected, NaviPac switches navigation group if there has been a red state for more than 3 seconds.
  Note: NaviPac will not automatically switch back to the former priority– the user must decide themselves when it is stable enough.

2.2.5 Calibration

This menu contains menu entries with various functions for calibration.

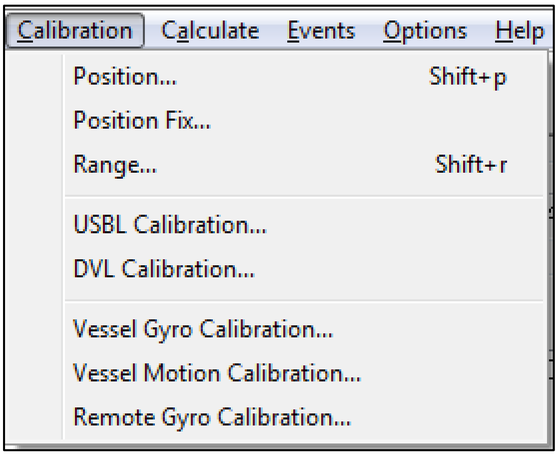


Figure 8 NaviPac calibration tool

- **Position**
  Opens a new window for specification and performance of position calibration.
- **Range**
  Opens a new window for specification and performance of range calibration.
- **Position Fix**
  Starts a special XYZCal calibration function.
- **USBL Calibration**
  Starts the USBL Calibration tool (USBL Fix).
- **Vessel Gyro Calibration**
  Starts dedicated program to perform quay-based gyro calibration.
- **Vessel Motion Calibration**
  Starts dedicated program to perform quay based roll/pitch calibration. (For further details, see dedicated manual.)
- **Remote Gyro Calibration**
  Starts dedicated program to perform dynamic gyro calibration. (For further details, see dedicated manual.)

2.2.6 Calculate

This menu contains menu entries with various helpful calculation utilities.

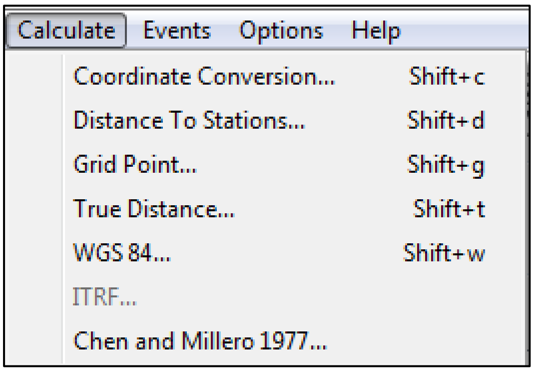


Figure 9 NaviPac built-in calculators

- **Coordinate Conversion**
  Open a calculator dialogue box for converting positions between X, Y grid and geographical coordinates.
- **Distance To Stations**
  Open a small calculator dialogue box for calculation of the distance to all stations in use.
- **Grid Point**
  Open a calculator dialogue box for calculating grid points based on range/bearing.
- **True Distance**
  Open a calculator dialogue box for calculation of true distance between two points.
- **WGS 84**
  Open a calculator dialogue box for conversion between user datum and WGS84.
- **ITRF**
  Test additional ITRF shift parameters (if enabled in NaviPac Configuration)
- **Chen and Millero 1977**
  Calculate sound velocity based on temperature, pressure and salinity.

2.2.7 Events

This menu contains entries with various helpful events utilities.

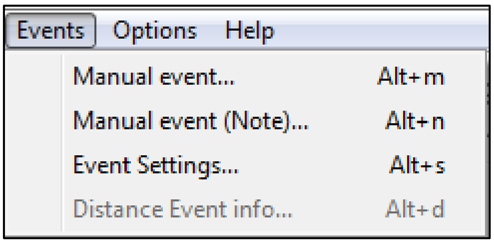


Figure 10 NaviPac eventing

2.2.8 Options

This menu contains entries with various system options.

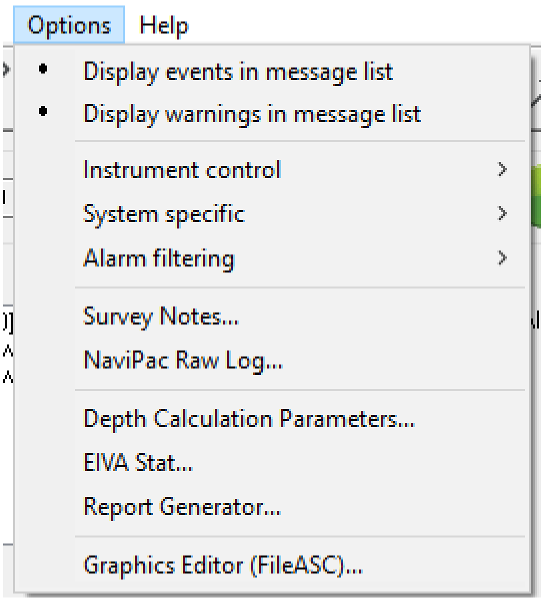


Figure 11 NaviPac options tools

- **Display events in message list**
  Decides whether or not generated events will be displayed in the online message list.
- **Display warning in message list**
  Decide whether generated warnings will be displayed in the online message list.
- **Instrument control**
  Lists commands and views closely related to instrument controls:
  - **Instrument monitor and control**
    Opens dedicated function to display incoming or outgoing data, including

option for data capture. In addition, allows the sending of commands to connected inputs.

    - **Show Digicourse status**
      Opens dedicated status window for Digicourse bird monitor. For 2D seismic.
    - **Geodimeter Control**
      Opens dedicated status and control window for Geodimeter ATS 600.
    - **Topcon Total Station Control**
      Opens dedicated status and control window for Topcon Total Station.
    - **Satel Modem Control**
      Opens small utility module to control SATEL modems.
    - **Telemetry watch-dog Monitor**
      Opens small tool for monitoring and fixing telemetry multiplexer communication failures.
- **System specific**
  Includes special functionality for limited use, typically specialised for a single client for special operation.
    - **NaviPac to UKOOA P2/94**
      Translator from NaviPac survey format to UKOOA P2/94
    - **Subsea7 - Dive number**
      Online control of diving number – related to ‘SCS ROV LOG2’ data output
- **Alarm filtering**
  Includes menus to filter out irrelevant alarms:
    - **Objects**
      Deselect alarms for objects (eg when ROVs are on deck)
    - **Instruments**
      Deselect alarms for dedicated instrument
    - **Reset on Warmstart**
      Decide whether NaviPac reset the filter definition on restart of the navigation process
- **Survey Notes**
  Activates the EIVA common survey log application.
- **NaviPac raw log**
  Opens dedicated module for raw data logging (prepared for playback).
- **Depth calculation parameters**
  Enables dialogue box to specify parameters relevant for depth calculation.
- **EIVA Stat**
  Opens recording and statistics module for EOL reporting.
  Note: This requires .NET 2.0 on the computer.
- **Report Generator**
  Opens special reporting and documentation application.
  Note: This requires .NET 2.0 on the computer.
- **Graphics editor**
  Opens the small graphic file format viewer tool

- **EIVATide**
  Link to the EIVA tidal file reader. Common in NaviPac and NaviScan

2.2.9 Help

This menu contains information and online help for Online.

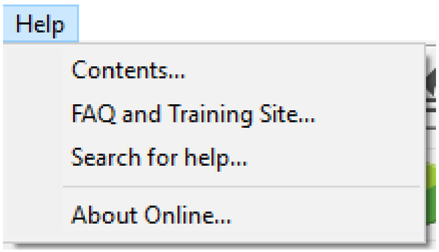


Figure 12 NaviPac Help and About

- **Contents**
  Shows this manual in HTML
- **FAQ and training site**
  Provides access to EIVA documentation site
- **Search for help**
  Search the EIVA web pages for help on entered topic
- **About online**
  Opens dialogue with information about program

2.3 Start program

The Online program will normally be started as part of the navigation process (from NaviPac Configuration or from the Windows start menu).

The program can also be started via the Windows start menu, but this will require that the navigation cycle is running actively.

3 Detailed function description

This chapter will describe the different menu functions in NaviPac Online in detail. A dialogue box that appears when the user selects a function will be outlined by a figure and an explanation of the different fields and buttons.

Note: The most menu functions can be reached through keyboard accelerator keys (eg **Quality control** can be started by pressing Ctrl + q.

3.1 File menu

3.1.1 Open NaviPac Config

Starts the NaviPac definition program NaviPac Configuration.

3.1.2 Exit

Stops the NaviPac Online program. It does not stop the collection of data from sensors or the calculation of reference positions; only the GUI part is stopped.

Before exiting, the operator is prompted to confirm:

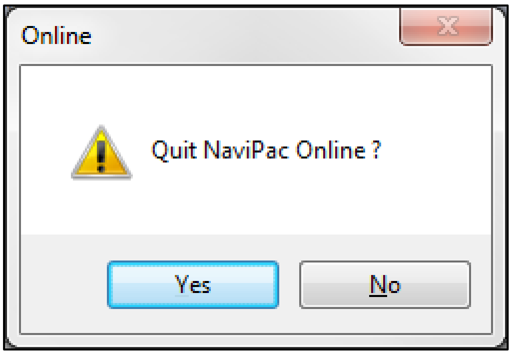


Figure 13 Quit NaviPac Online dialogue box

Click **Yes** to exit the program. Click **No** to leave Online on the screen.

3.2 Edit menu

3.2.1 Date & Time

Opens a new dialogue box for changing date/time control and setting the system clock if desired.

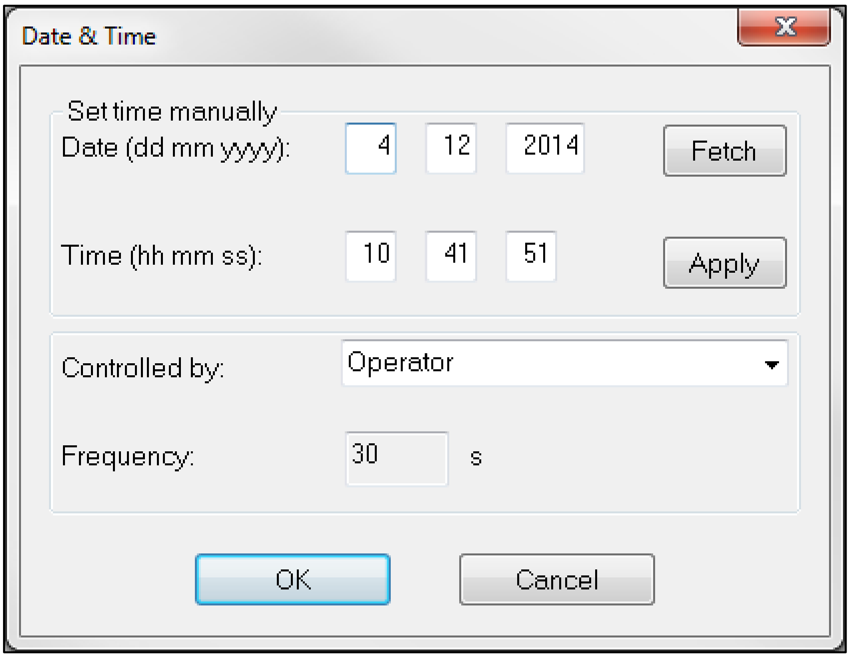


Figure 14 Date & Time dialogue box

Normally date and time must be controlled by the GPS system (typically by the use of dedicated ZDA/UTC input). Using the above dialogue box, the user can choose to control date/time by the operator and if needed change the internal clock.

3.2.1.1 Controlled by

In the selection list, the operator can toggle between controlling date by the available GPS systems, the input from a special GPS Time source UTC/NMEA ZDA or controlling date by the computer clock (Operator).

Default is: Operator.

3.2.1.2 Frequency

If controlled by a GPS, the operator must specify how often the clock should be adjusted.

3.2.1.3 Date

Format: dd mm yyyy.

As default the fields show the current date. If the above **Controlled by** is set to **Operator**, the operator may here specify a new date.

Note: Will not be updated unless you click **Fetch**.

3.2.1.4 Time

Format: hh mm ss (00:00:00 to 23:59:59). As default the fields show the current time. If the above **Controlled by** is set to **Operator**, the operator may here specify a new time of day.

Note: Will not be updated unless you click **Fetch**.

3.2.1.5 Apply

If the clock is operator-controlled, you may enter a new date/time and click **Apply**. The clock will then be set and information about changes are written in the online list.

If the action results in a message box with the following text:

Could not set system time - have no SE_SYSTEMTIME_NAME privilege

Then, you do not have sufficient Windows rights to control the clock.

3.2.1.6 Fetch

To update the displayed time/date with current computer clock, just click **Fetch** and the new values are shown. It will overwrite potential changes.

3.2.1.7 OK

If any changes have been performed, they must be acknowledged by clicking **OK**. This closes the dialogue box and makes the changes active.

3.2.1.8 Cancel

Close the current dialogue box without applying the specified changes to the system.

3.2.2 Estimated Position

The menu entry opens a new dialogue box for inputting new estimated position. This function may be needed to ensure that calculations do not get out of range.

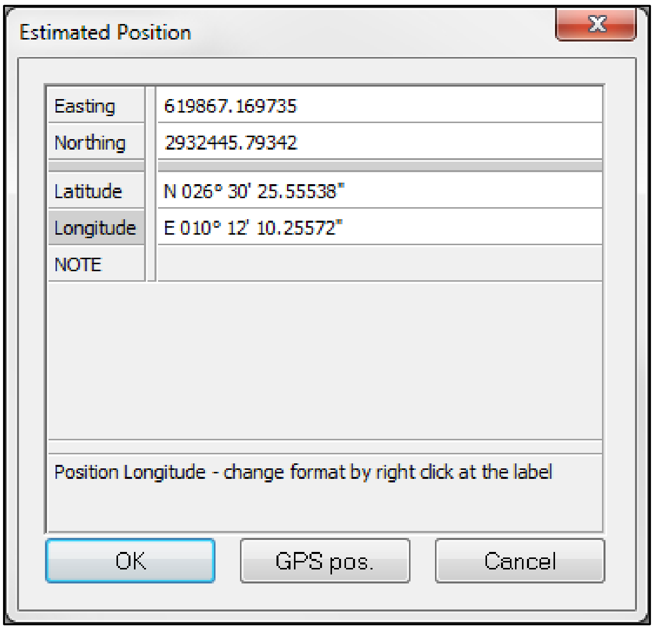


Figure 15 Estimated Position dialogue box

To keep the navigation cycle algorithm on track, the operator might be forced to specify an estimated position. For an example, see the following scenario:

Let us assume that the surface navigation is a Range-Range system with 3 LOPs only. To start the position calculation the program needs an estimated position. Depending on the geometry of the shore stations, the estimated position accuracy must be within ± 500 m to ± 50 km.

When the program is navigating, it sometimes happens that 2 or all LOPs drops out. This is possible if the vessel loses line of sight with the shore stations. This will cause the Kalman position to take over. If the vessel is turning while using the Kalman position the program might not accept the ranges again when they come back as they fall outside the acceptance window of the predicted position.

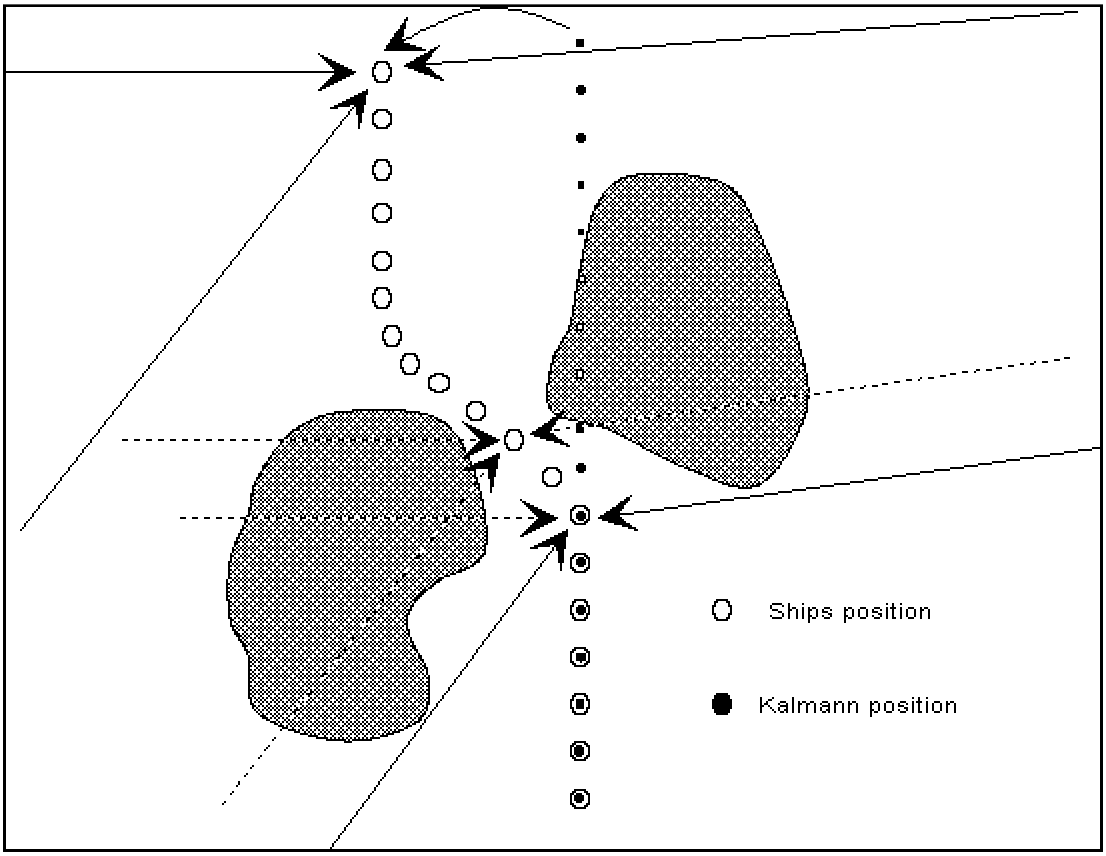


Figure 16 Kalman position

To have the program accept the data again the user must activate **Estimated Position** and accept the settings (to accept, click **OK**). The position displayed when pressing **Estimated Position** will be accurate enough for the program to calculate the correct position. The operator does not have to input new coordinates. However, if the correct position is very far away and the geometry of the shore stations is very narrow, it can be necessary to input an accurate position.

3.2.2.1 Position

You may enter the position as either grid coordinates (easting/northing) or geographical coordinates (latitude/longitude). If you enter one, then the other is calculated automatically.

The latitude/longitude format may be changed by right-clicking the field label.

3.2.2.2 GPS pos:

Fetch the estimated position from the last GPS update. The selected position will be shown in the position fields.

3.2.2.3 OK

Close the **Estimated Position** dialogue box and apply the specified estimated position to the navigation cycle.

3.2.2.4 Cancel

Closes the **Estimated Position** dialogue box without applying the specified estimated position to the navigation.

3.2.3 Surface Position Control

Open a dialogue box for manually specifying the weight, sigma (tolerance limit) and C-O (Calculated - Observed) of each navigation observation in the navigation computation algorithm.

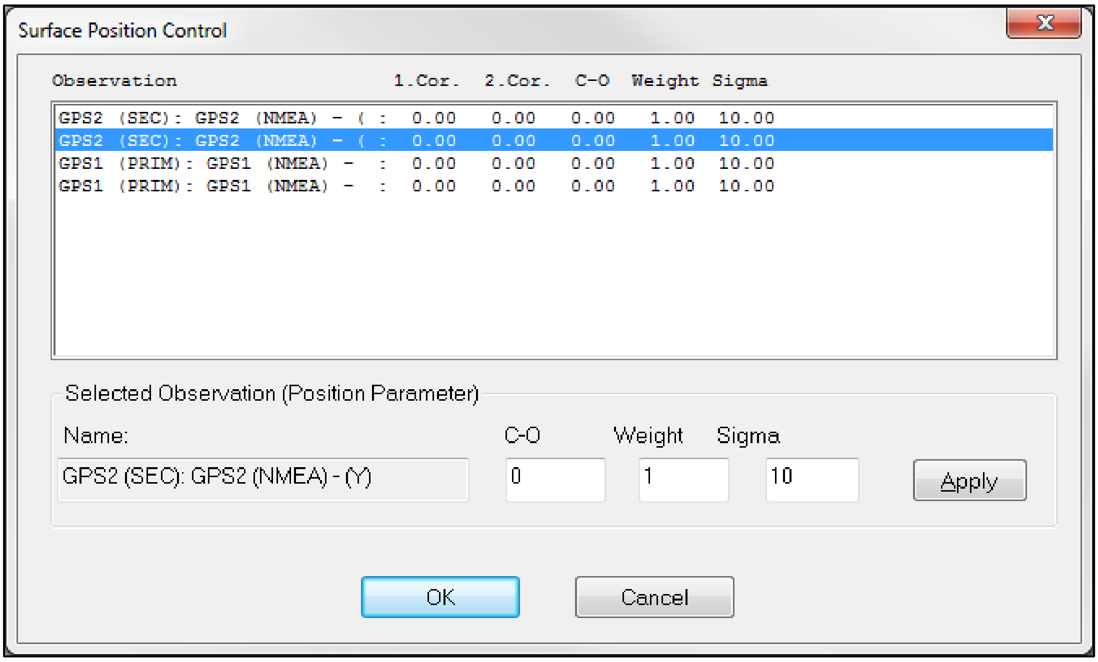


Figure 17 Surface Position Control dialogue box

Each station/system in the current navigation setup (Online database) can be equipped with one or two pre-defined correction values. These corrections will automatically be used in all navigation computations. Furthermore, NaviPac allows the operator to specify local corrections (C-O) values. The above list include one line per navigation observation (eg Ashtech GPS) and one line per Online instrument (gyro, roll, pitch etc).

NaviPac uses a **Weight** value for each station in use, where the value 1 (On) indicates full use of the data and the value 0 (Off) indicates that the station/system won’t be used.

NaviPac maintains the weights automatically, but the operator may overrule the setting by selecting the wanted LOP in the above figure.

In the above example some different LOPs are shown with a GPS station selected. The LOP **Name**, **C-O**, **Weight** and **Sigma** values will be updated in the lower 4 fields. Here, new values can be entered. Fields that cannot be changed will be dimmed (read-only).

To compute reference positions (and offset positions), NaviPac uses an acceptance window for each navigation component (LOP). These values, which are named **Sigma**, have influence on the position calculation, as LOPs with large sigma values will be weighted less in the least square computations.

Note: Only experienced operators should change sigma values. The default values will most often be suitable.

3.2.3.1 Observation name

Gives the name (type, name) for each station in use (LOP) and all additional navigation components: roll, pitch, speed etc. The LOP part of the list will always be identical to the list of selected systems.

3.2.3.2 1.Cor.

A read-only field containing the first correction value, as defined during station and/or instrument setup.

3.2.3.3 2.Cor.

A read-only field containing the second correction value (if any), as defined during station and/or instrument setup.

3.2.3.4 C-O

Specify local supplementary correction values for each system/component. The correction will **not** be applied in the permanent setup (Setup database). The value must be interpreted as an add-value (ie the value will be added to the original, which has been corrected for the above two corrections). The default is 0.

3.2.3.5 Weight

Specify the maximum weight of each station (LOP). 1 = On and 0 = Off. The dialogue box shows the currently used settings as default. The weight will only be available for real LOPs, as roll and pitch will be disabled. Range: 0.0 to 1.0.

3.2.3.6 Sigma

Enter new tolerance values for each LOP. A default of 10 will normally be acceptable. The weight will only be available for real LOPs, as roll and pitch will be disabled. Range: 0.1 to 100.0.

3.2.3.7 Apply

If any changes have been performed, they must be acknowledged by clicking the **Apply** button. This makes changes in the selected LOP permanent and updates the upper list view. The dialogue box remains open.

3.2.3.8 Cancel

Close the current dialogue box. Changes performed since last **Apply** will be discarded.

3.2.3.9 OK

Close the current dialogue box. Changes (if any) will be made permanent.

3.2.4 User Defined Offsets

Note: Only present in NaviPac version 2.2 and above.

Open a new dialogue box for adding, removing and changing **Fixed offsets** in NaviPac.

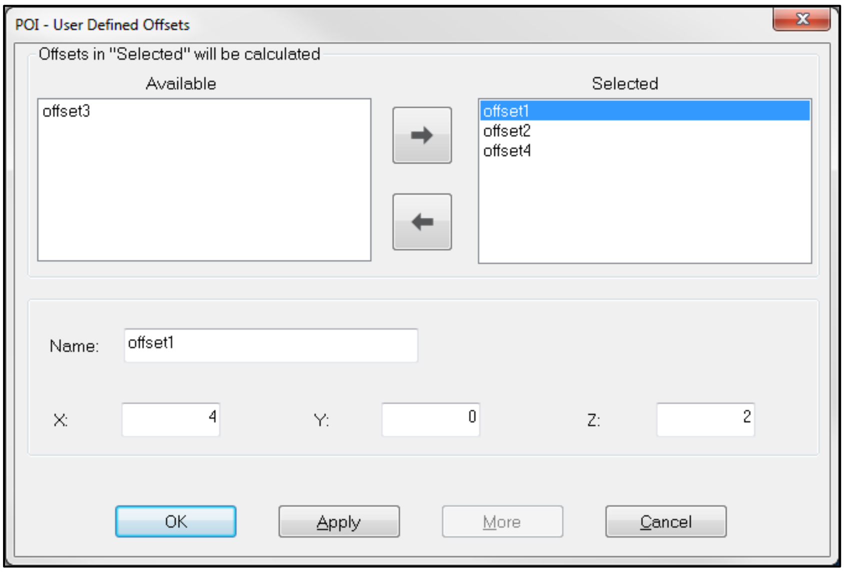


Figure 18 User-defined offsets

3.2.4.1 Available List

Contains all offsets available – but not calculated (mode set to **Off** in the Setup database). To add an item to the **Selected** list, it must be selected in this list. The **Include** button (right arrow) is used to place an item in the **Selected** list. To move an item from the **Selected** list to the **Available** list, select an item by clicking in the **Selected** list and click the **Exclude** button (left arrow).

3.2.4.2 Selected List

Contains all offsets selected to be calculated to the navigation calculations (Mode set to **Calculated** in Setup database). To remove an offset (ie set it to **Off**), it must be selected in this list and then the **Exclude** button must be clicked.

1.1.1.1 Include Button

A selected offset (in the **Available** list) is moved to the **Selected** list, which indicates that the offset is to be used in the navigation computation (Mode = **Calculated**). The Setup database is updated. The Kernel in NaviPac will be updated with the change (eg the selected offset will be calculated now).

3.2.4.3 Exclude Button

Remove a selected offset from the **Selected** list to the **Available** List – do not calculate it (Mode : **Off**). The Setup database is updated. The Kernel in NaviPac will be updated with the change (eg the selected offset will not be calculated any more).

3.2.4.4 Name

Specify/change the name for the selected offset.

3.2.4.5 X

Specify/change the X value for the selected offset.

3.2.4.6 Y

Specify/change the Y value for the selected offset.

3.2.4.7 Z

Specify/change the Z value for the selected offset.

3.2.4.8 OK

Accept the last changes made (XYZ name) in **Selected** list and saves changes in the Setup DB. If fewer than 2 LOPs have been selected, you are not allowed to perform **OK**.

3.2.4.9 Apply

Accept the last changes made (XYZ name) to selected offset in **Selected** list and saves changes in the Setup database. The Kernel in NaviPac will be updated with the changes.

3.2.4.10 Cancel

Close the dialogue box.

3.2.5 Positioning systems

Open a new dialogue box for changing the setup of surface and dynamic navigation systems:

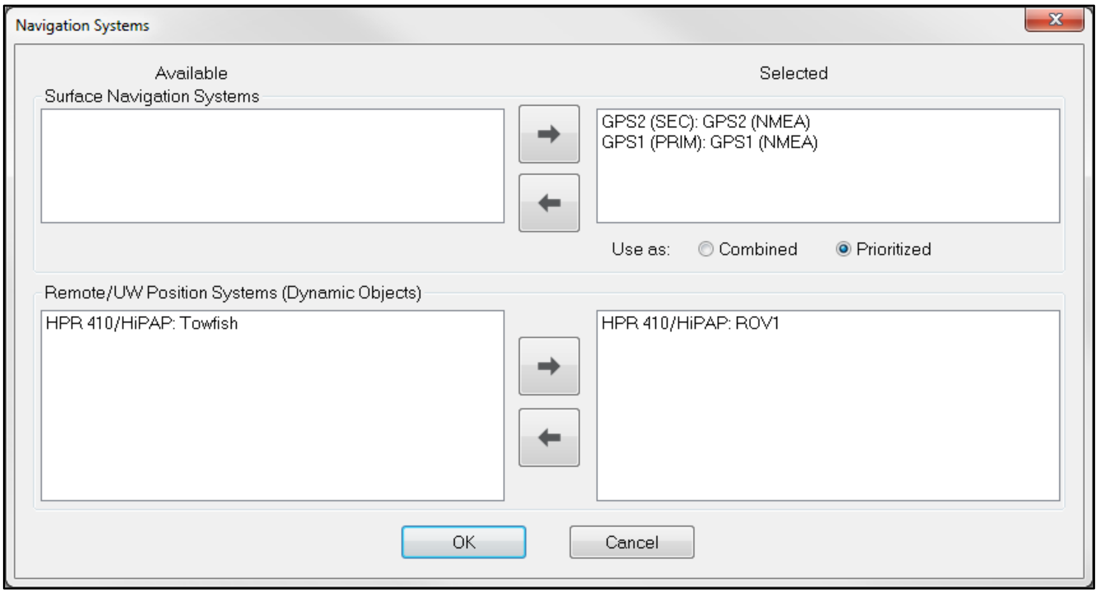


Figure 19 Navigation Systems dialogue box

During Online operation, the operator may change the LOPs used for the Online navigation cycle, as stations may be added or removed. The above dialogue box is also presented to the user during a manual start up.

The dialogue box is divided into 2 sections. Section 1 allows the operator to select the current navigation systems/stations. Section 2 holds offset navigation positioning: like objects (ROV, Sweep, diver, etc) connected to the USBL system or remote vessel GPS positions.

3.2.5.1 Available list

This list contains all items available in each group (Surface Navigation Systems, Remote/UW Position Systems (Dynamic Objects). To add an item to the **Selected** list, it must be selected in this list. The **Include** button (right arrow) is used to place an item in the **Selected** list. To move an item from the **Selected** list to the **Available** list, select an item by clicking in the **Selected** list and click the **Exclude** button (left arrow).

3.2.5.2 Selected list

This list contains all items selected to be used in the navigation calculations. To remove an item, it must be selected in this list. Selecting an item in the **Selected** list will enable the exclude function.

3.2.5.3 Include button

The selected item (in **Available** list) is moved to **Selected** list, which indicates that the items are to be used/calculated in the navigation computation. If any limits are reached (ie 4 Motorola stations are already are included and we try to insert one more) the **Include** button will be disabled.

3.2.5.4 Exclude button

Remove a selected item from the **Selected** list and move it to the **Available** list.

3.2.5.5 Use as

Select whether NaviPac uses the navigation as multi-positioning (Combined) or prioritised. If **Prioritize** is selected then it will always use the top unit as the primary.

Note: This function will only be activated if you have made changes in the LOP list. It is not intended to be used just to switch between multi- and prioritised positioning.

This feature is extremely helpful during a manual start, as it reduces start-up time.

3.2.5.6 OK

Accept changes performed for the entire dialogue and saves the included systems in the Online database. If less than 2 LOPs have been selected, you are not allowed to perform **OK**.

3.2.5.7 Cancel

Close the dialogue box. If any changes have been performed, they will be discarded.

3.2.5.8 Additional object information

Double-click in **Selected** list on a Tritech SeaKing R/B or an AGA fixed-point object to open an additional dialogue box:

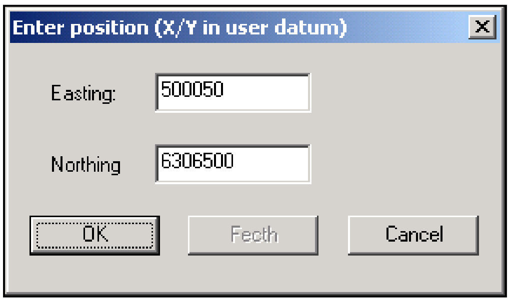


Figure 20 Enter position dialogue box

Here, the references **Easting** and **Northing** for the range bearing system can be defined.

Clicking **OK** will save this position in registry for later use and send the position to the NaviPac Kernel.

Double-click in the **Selected** list on a USBL object, and a **Change Transponder number** dialogue box will pop up:

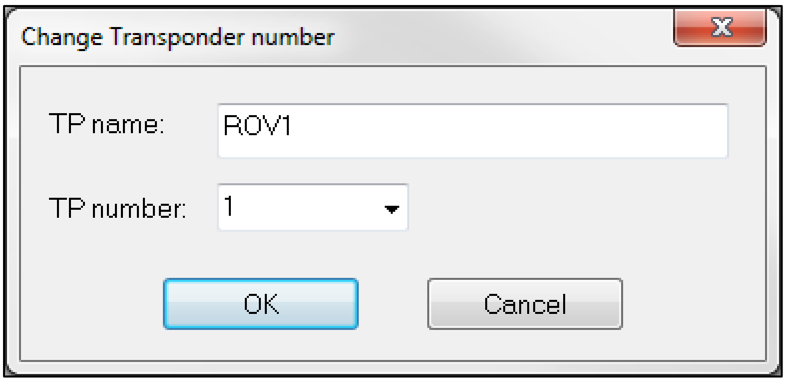


Figure 21 Change Transponder number dialogue box

In this dialogue box the user can change the transponder name (**TP name**) and transponder number (**TP number**).

3.2.6 Vehicle Control

This menu entry allows the operator to control which gyro, motion and depth sensor to use in the primary calculation.

During start-up via the manual start NaviPac uses the setting as defined in the configuration tool. You can re-assign this via this entry – but please be aware that it is reset at the next manual start.

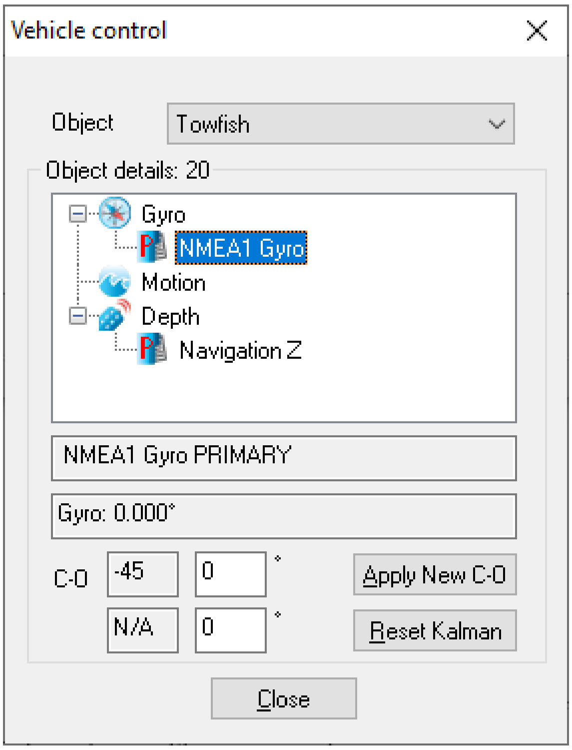


Figure 22 Vehicle control dialogue box

The dialogue box shows:

- **Object**
  Select the object to control (eg **Vessel**).
- **Details**
  Shows a list of gyro and motion sensors attached to the unit. The list shows the user-defined names for the sensors. The primary sensor (the one being used in calculations) will have a red 'P' in the icon.
- **System name**

The EIVA name for the selected unit. The text ‘PRIMARY’ will be added to the primary sensor.

- **Data**
  Shows a snapshot of the data for the selected sensor.
- **C-O**
  Shows the defined correction values. The greyed-out read-only value is defined in the configuration module and the editable field provides for additional correction defined on-the-fly. You may enter new values and click **Apply**, and NaviPac will apply those corrections immediately. The corrections will be reset to 0 when a manual start is performed

To select another unit as primary, right-click the wanted sensor, select **Set as Primary** in the pop-up menu and accept by clicking **Yes**:

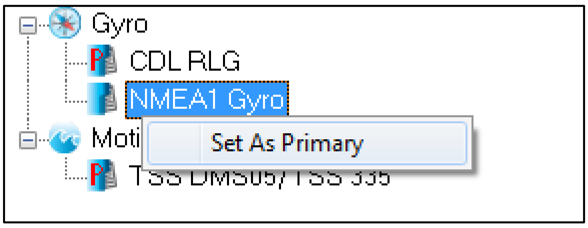


Figure 23 Set as Primary

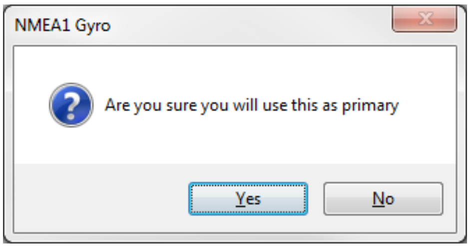


Figure 24 Set as Primary dialogue box

A message is then passed on to the Kernel and a switchover is made. The list will be updated accordingly.

3.3 View menu

The **View** menu holds various functions for inspecting the navigation sensors and calculated navigation data.

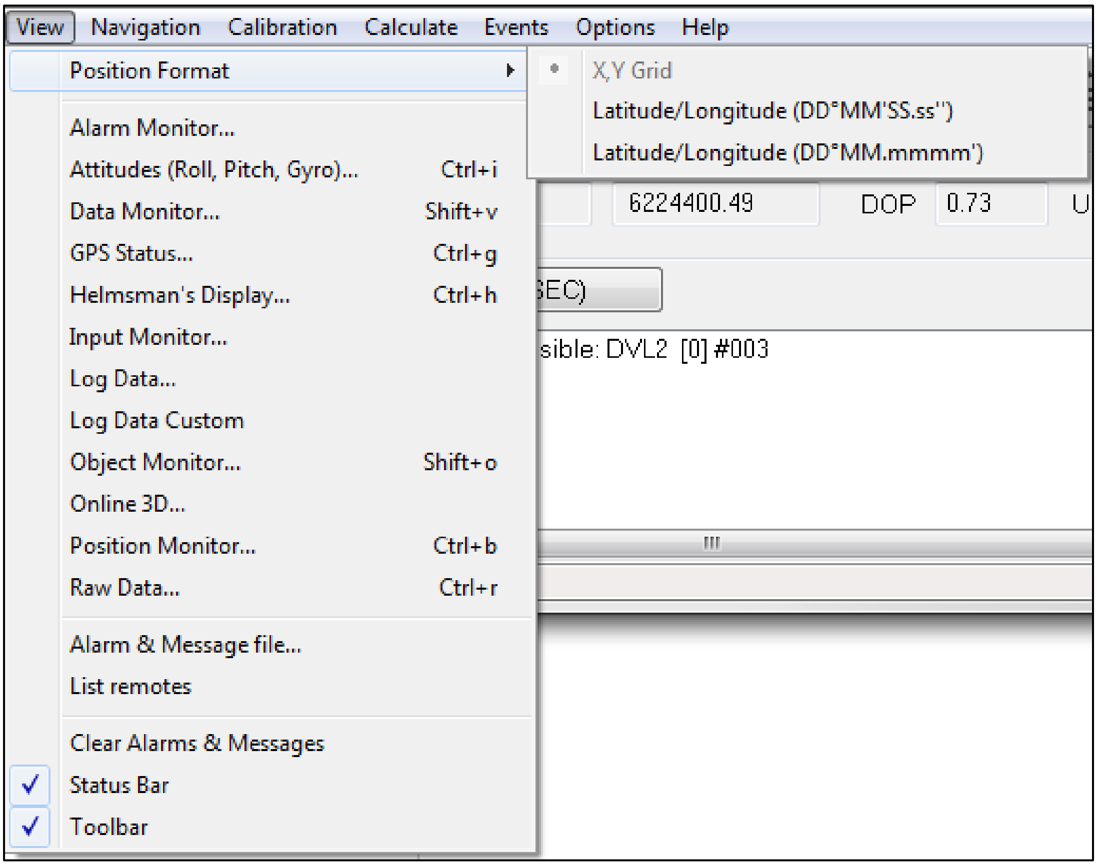


Figure 25 NaviPac View menu

3.3.1 Position Format

Specify in what format the position should be presented in main window. The following formats are available:

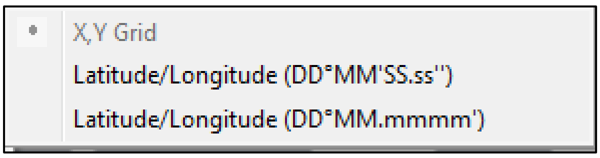


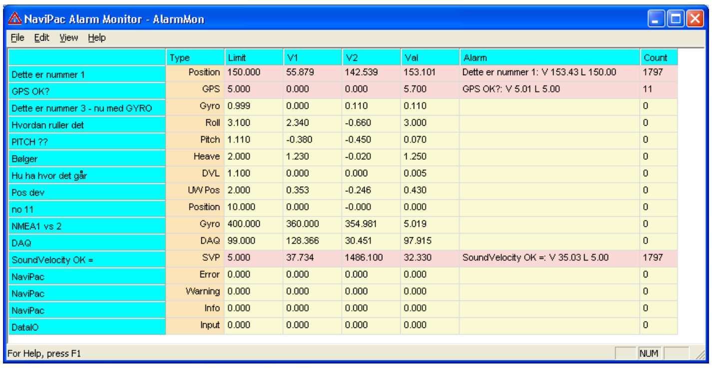
Figure 26 Data display format

- X,Y in local grid (eg 543210.00 , 63501200.78)
- Latitude/Longitude in degree, minutes and seconds (eg 9° 12' 23.66", 53° 47' 45.87")
- Latitude/Longitude in degree and minutes (eg 9° 12. 3943' , 53° 47.7645 ')

If you have more Online windows opened on the network (slave Onlines), changes in one Online will not affect the others.

3.3.2 Alarm Monitor

Open windows for alarm monitoring, alarm definition and control:



	Type	Limit	V1	V2	Val	Alarm	Count
Dette er nummer 1	Position	150.000	55.879	142.539	153.101	Dette er nummer 1: V 153.43 L 150.00	1797
GPS OK?	GPS	5.000	0.000	0.000	5.700	GPS OK?: V 5.01 L 5.00	11
Dette er nummer 3 - nu med GYRO	Gyro	0.999	0.000	0.110	0.110		0
Hvordan ruller det	Roll	3.100	2.340	-0.660	3.000		0
PITCH ??	Pitch	1.110	-0.380	-0.450	0.070		0
Bølger	Heave	2.000	1.230	-0.020	1.250		0
Hu ha hvor det går	DVL	1.100	0.000	0.000	0.005		0
Pos dev	UW Pos	2.000	0.353	-0.246	0.430		0
no 11	Position	10.000	0.000	-0.000	0.000		0
NMEA1 vs 2	Gyro	400.000	360.000	354.981	5.019		0
DAQ	DAQ	99.000	128.366	30.451	97.915		0
SoundVelocity OK =	SVP	5.000	37.734	1486.100	32.330	SoundVelocity OK =: V 35.03 L 5.00	1797
NaviPac	Error	0.000	0.000	0.000	0.000		0
NaviPac	Warning	0.000	0.000	0.000	0.000		0
NaviPac	Info	0.000	0.000	0.000	0.000		0
DataIO	Input	0.000	0.000	0.000	0.000		0

Figure 27 NaviPac alarm monitor

3.3.3 Attitude

Open a new window with detailed information of gyro, roll, pitch, heave and speed info. .

3.3.4 Surface Position Status

Open a new window with detailed information of the position observations included.

3.3.5 Data Monitor

Start the **Data Monitor** program. Many depths (echo sounders) and heights (positions) can be viewed at the same time in this program.

3.3.6 GPS Status

Open a new window allowing the operator to view various status information on the GPS system(s).

3.3.7 Helmsman’s Display

Open a new program with line planning, steering information etc.

3.3.8 Input Monitor

Open a special input monitor window which collects statistics on incoming data.

3.3.9 Log Data and Custom Log Data

Open a new window with logging functions.

3.3.10 Object Positions

If the system is set up with objects, user-defined offsets, dynamic offsets (eg Trackpoint II) or remote positions (external GPS), the data can be viewed in the **Object Positions** window.

3.3.11 Raw Data

Open a new window where it is possible to inspect the raw ASCII data read on the serial ports. This window also functions to interpret the data, and here it is also possible to set port parameters and number of bytes per seconds.

3.3.12 Alarm & Message file

Open a window with logged alarms and online operator actions:

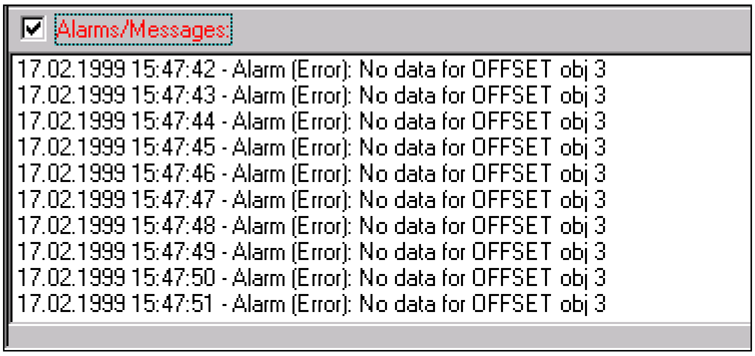


Figure 28 NaviPac Online alarm listing

3.3.13 Clear alarms & messages

Empty the message list in the Online window.

Note: The **Alarm & Message** file is not cleared.

3.3.14 Status Bar

Toggle the status bar on and off.

3.3.15 Toolbar

Toggle the toolbar on and off.

3.4 Navigation menu

Contains menu entries with various functions for changing navigation options. These functions will be described in detail in this section.

The **Navigation Mode** is a submenu to set the navigation mode. **Change Priorities** is enabled, if **Auto Prioritised Positioning** in **Navigation Mode** is chosen, and can be used to create different navigation groups having priority 1-5.

3.4.1 Navigation Mode

Points to the following navigation mode radio buttons:

- **Automatic Multi Positioning**
  All LOPs are combined in one group and the reference position will be calculated as a weighted average, based on weight, sigma and error.
  Note: Combining good (eg dGPS) and less good (eg Syledis) will not be better than using the good alone. Combining different systems should be followed by adjustment of sigma and weight.
- **Auto Prioritised Positioning**
  The selected LOPs can be divided into priority groups (maximum of 5 depending on the total number of LOPs), as the reference position will be calculated on basis of group 1.

3.4.2 Change Priorities

Only available for **Prioritized Positioning** mode. This menu entry results in opening of a dialogue box, allowing the operator to manipulate the LOP grouping (ie to define which stations/systems should be part of which priority group).

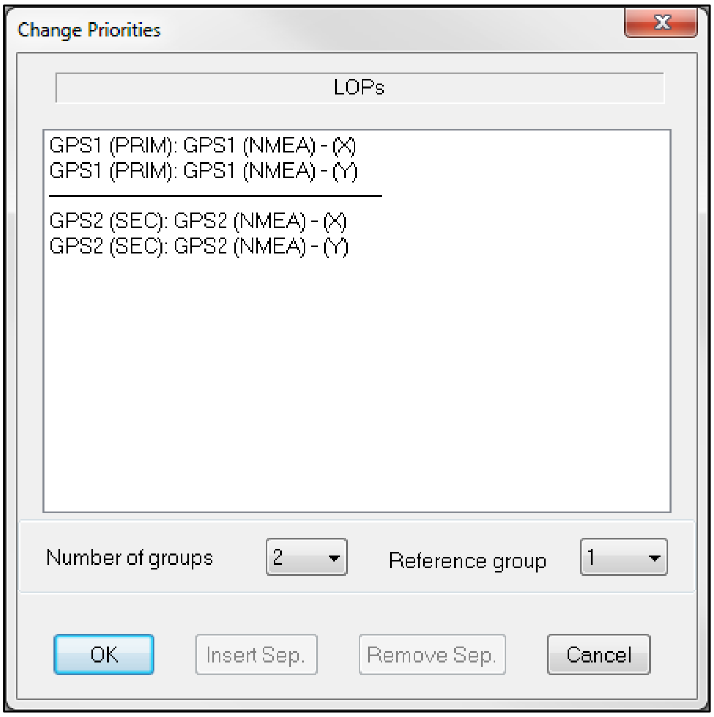


Figure 29 Controlling navigation priority

The user can insert up to 4 separators between the LOPs indicating that they want to use 5 different priority groups. The number of available priority groups will however depend on the number of LOPs selected as included, as each group must include at least 2 LOPs. Only one of the groups can be used to calculate the final reference position. To do this, click the **Reference group** button. The actual wanted **Number of groups** can also be selected.

As default all LOPs are gathered in one group (priority one), but the operator can change this.

The **Change Priorities** dialogue box contains the following:

- **LOPs**
  This list contains all active observations, as specified in **Edit**: **Positioning Systems**. Each LOP will be presented as Instrument, System name, LOP name (eg 'GPS 1:Ashtech1_RTK GPS1 - RTK1', where GPS1 is instrument, Ashtech1_RTK is user-defined system name and GPS1 **-** RTK1 is the user defined station (LOP) name).
  The list will be presented in same order as defined (included) in the Online database. A dashed line will separate each group. If the operator selects an LOP in the list (and the correct number of required priority separators aren't inserted) the **Insert Sep.** button will be enabled. If the user selects (by clicking in the LOP list) a separator, it can be removed by clicking the **Remove Sep.** button.
- **Number of priorities**
  Identify the number of wanted priority groups. If the button selected is 4, 3 separators must be inserted. If the operator increases the number of priorities, new separators must be inserted. Maximum priorities = minimum (number of LOPs/2, 5).[2]
- **Reference group**
  Select which of the priority groups should be used as the reference position group. The reference position group will be the first displayed in the Base Position view. The other groups will be numbered sequentially from the top.
- **OK**
  If any changes have been performed in the dialogue box, the operator must click **OK** to make them permanent. **Note**: If the number of separators inserted does not fit the number of priorities -1, an error message will be given. No update of the Online database will take place, and the dialogue box remains open.
- **Insert Sep.**
  If an LOP is selected and at least 2 LOPs are between selected LOP and prior separator, this button is enabled allowing the user to insert a new separator below the currently selected LOP. **Note**: The number of priorities must also be set.

[2] Equation presented in Microsoft Excel form.

- **Remove Sep.**
  If a separator is selected it can be removed by clicking this button. **Note**: The field will be read-only until a separator is selected.
- **Cancel**
  Close the dialogue box. If changes have been performed, they will be discarded.

3.5 Calibration menu

This chapter describes the built-in calibration features. It is possible to modify:

- Position calibration
- Range calibration

These give different ways of calibrating the main surface navigation sensors.

Each calibration method will be described as follows:

- General description
- Actions to be performed before start
- Actions to be performed during calibration
- Actions to be performed after completion

3.5.1 Position Calibration

The first calibration possibility in NaviPac is the positioning calibration. Performing position calibration in NaviPac results in opening the below dialogue box.

The dialogue box is separated into two parts. The upper part allows the operator to set up the wanted calibration parameters and the lower part is used for displaying the information and applying changes.

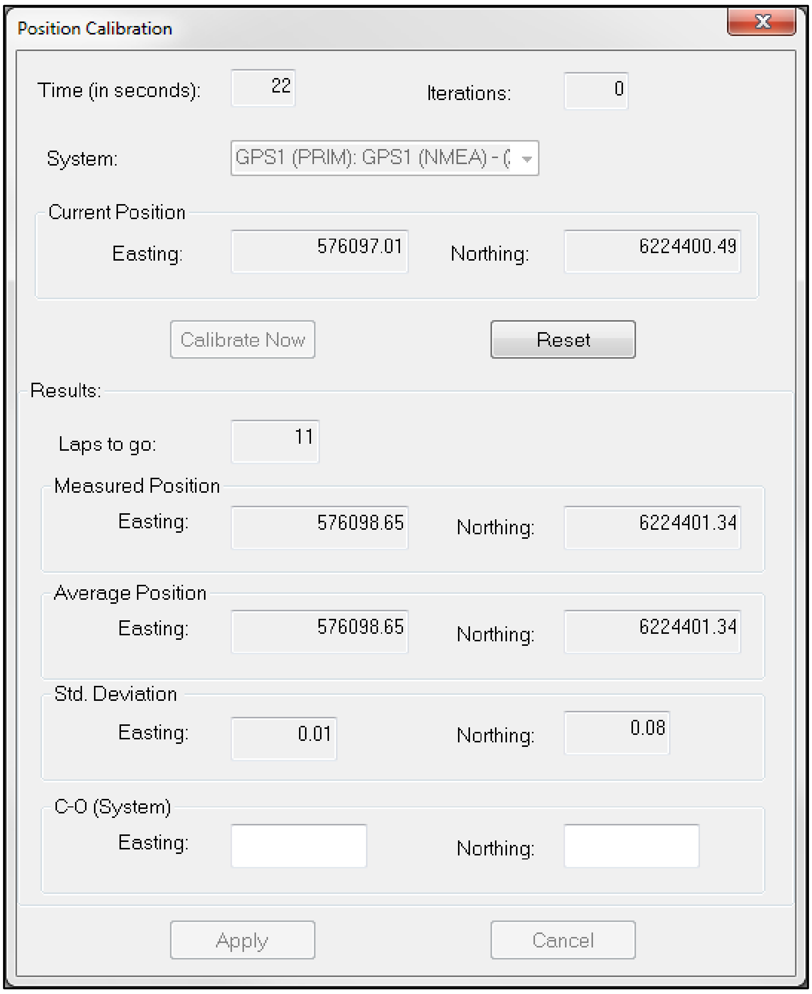


Figure 30 Simple position calibration

The position calibration dialogue box allows the operator to calibrate X/Y based systems (eg GPS1) system by system or to measure stability of complete reference position. Only systems selected in **Positioning** systems can be selected for calibration. The calibration is performed by calculating an average X and Y and comparing it to a manually entered position.

3.5.1.1 **Initial actions**:

The following items must be considered before starting the calibration:

1. The vessel must be kept stable on a fixed position.
2. The system in action must be selected in **Positioning systems**, but it should be weighted to zero.
3. A manual position must be entered before start. The manual position must be entered with antenna position as reference for specific instrument or reference point for **All**.
4. The calibration time (**Iterations/Time**) must be defined. The more noise on the system in action, the more measurements.
5. If corrections for the system have been specified in NaviPac Setup (**Stations**), they should be erased (ie set to 0) before stating the calibration, as it must be performed on raw measurements.

3.5.1.2 **Calibrating**:

During the calibration period, the operator should supervise the incoming values and check if the measurements have an acceptable stability.

3.5.1.3 **Result**:

After completion, the system calculates an average position, standard deviation and proposed correction values (difference between average and correct values).

If the standard deviation is suitably small (within the accuracy of the selected system), the correction can be applied by clicking **Apply**, if a specific system (eg GPS) was selected.

The operator must manually specify a permanent correction in Setup.

If the calibration was performed for the reference position (ie all selected surface navigation instruments), no **Apply** can be performed. The operator must hereafter perform a system-by-system calibration to determine which one introduced the error (if any).

3.5.1.4 Fields and buttons in Position Calibration

- **Time**
  If the calibration must be performed for a specific period of time, the operator can here enter the time in seconds.
- **Iterations**
  If the calibration must be performed for a specific number of program cycles, the operator can here enter the number of iterations. **Note**: if any **Time** value is entered, this will overrule **Iterations**.

- **System**
  In this list, the operator selects the system to be calibrated by selecting between ‘All’ for the reference position or by selecting a dedicated system like ‘Ashtech GPS 2’.
- **Easting**
  In this field the operator must enter a manually calculated X position. As default, the last reference position is given.
- **Northing**
  In this field the operator must enter a manually calculated Y position. As default, the last reference position is given.
- **Calibrate Now**
  When the above parameters are set correctly, the operator clicks this button to start the calibration. This first part of the dialogue will now be inaccessible and the system will update variables in the second part. **Note**: The vessel should be stationary before starting the calibration.
- **Laps to go**
  During the calibration, this field will continuously display the number of iterations to be performed until end of calibration.
  The field will be updated until the end has been reached (number of iterations or amount of time). When finishing, the field will be replaced with the text ‘DONE’.
- **Measured position**
  During the calibration, these fields will continuously display the current position measured in the calibration.
  The fields will be updated until the end has been reached (number of iterations or amount of time).
- **Average**
  During the calibration, these fields will continuously display the average values of the position measured so far.
  The fields will be updated until the end has been reached (number of iterations or amount of time). When finishing, the fields will be replaced with the complete average values.
- **Std. Deviation**
  During the calibration, these fields will continuously display the standard deviation of the position components measured so far.
  The fields will be updated until the end has been reached (number of iterations or amount of time). When finishing, they will be replaced with the complete standard deviation.
- **C-O**
  These fields will show the above mentioned correction values (ie a correction to add to the **Easting** and the **Northing** for the current system).

- **Apply**
  When calibration is finished (**Laps to go** changes to 'DONE'), two C-O values have been computed and the calibration was performed for a dedicated GPS system, the **Apply** button will be enabled. By clicking this button, the computed correction value can be applied to the local correction list. To make the correction permanent, the operator must enter it in the setup.
  Note: Not available when **All** is selected as system
- **Reset**:
  Interrupt the current calibration (ie do not finish the outstanding iterations) if still running. The **Stop** message will be written in the **Laps to go** field. The user can now enter new values in upper part of the dialogue box.
- **Cancel**:
  Close the calibration dialogue box. If **Cancel** is clicked before end of calibration, the calibration procedure will be interrupted.

3.5.2 Range Calibration

Open the following dialogue box for the range calibration task:

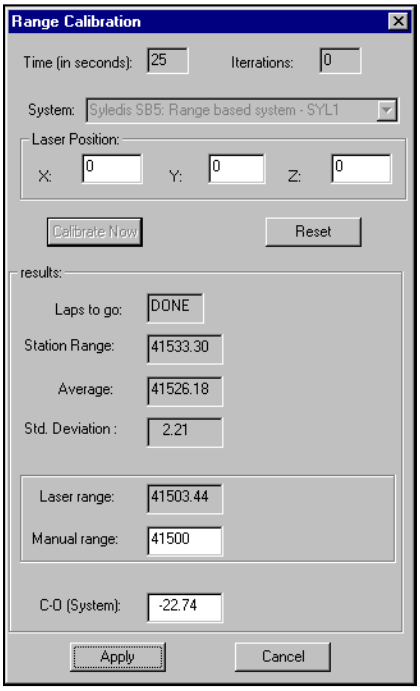


Figure 31 Range Calibration dialogue box

The **Range Calibration** dialogue box allows the operator to calibrate range-based systems (eg Syledis or Microfix) station by station. Only stations selected in **Positioning** systems can be selected for calibration. The calibration is performed by calculating an average range and compares it to either a manually entered range or a range measured by a hand-held laser meter.

3.5.2.1 Initial actions

The following items must be considered before starting the calibration:

1. The vessel must be kept stable on a fixed position.
2. The station in action must be selected in **Positioning** systems.
3. The station must be weighted to zero.
4. The laser meter must be selected in **Positioning** systems, if comparison to laser meter will be used.
5. The laser fire point should be selected as close to the navigation antenna as possible. Offsets must be entered before starting.
6. A manual range must be entered before start, if a manual range must be used for comparison. The manual range must be entered with antenna position as reference.
7. The calibration time (**Iterations/Time**) must be defined. The more noise on the station in action the more measurements.
8. If corrections for the station have been specified in NaviPac setup (**Stations**) they should be erased (ie set to 0) before stating the calibration, as it must be performed on raw measurements.

3.5.2.2 Calibrating

During the calibration period, the operator should supervise the incoming values and check if the measurements have an acceptable stability.

The handheld laser meter must be activated during the calibration period, and only the last measurement will be taken into consideration.

3.5.2.3 Result

After completion, the system calculates an average range, standard deviation and a proposed correction value (difference between average range and correct range).

If the standard deviation is suitably small (below specified accuracy for the instrument in action), the correction can be applied by clicking **Apply C-O**.

The correction will hereafter be applied as a local correction (corresponds to LOP control corrections).

The operator must specify a permanent correction in Setup.

3.5.2.4 Field and buttons in Range Calibration

- **Time**
  If the calibration must be performed for a specific period of time, the operator can enter the time in seconds here.
- **Iterations**
  If the calibration must be performed for a specific number of program cycles, the operator can enter the number of iterations here.
  Note: If any **Time** is entered, this will overrule **Iterations**.
- **Station**
  ISelects the station to perform the range calibration against.
- **Laser Position (X)**
  If the station range will be verified against a laser range meter system, the operator must here specify the exact X-reference point of the laser. Positive to starboard.
- **Laser Position (Y)**
  If the station range will be verified against a laser range meter system, the operator must here specify the exact Y-reference point of the laser. Positive front.
- **Laser Position (Z)**
  If the station range will be verified against a laser range meter system, the operator must here specify the exact height reference point of the laser. Positive up.
- **Calibrate Now**
  When the above parameters are set correctly, the operator clicks **Calibrate Now** to start the calibration. This first part of the dialogue will now be inaccessible and the system will update variables in the second part.
  Note: The vessel should be stationary before starting calibration.
- **Laps to go**
  During the calibration, this field will continuously display the number of iterations to be performed before end of calibration. The field will be updated until the end has been reached (number of iterations or amount of time). When finished, the field value will be replaced with the text ‘DONE’. If stopped by the user, ‘Stop’ will be written in the field.
- **Station Range**
  During the calibration, this field will continuously display the current range measured in the calibration. The field will be updated until the end has been reached (number of iterations or amount of time).
- **Average**
  During the calibration, this field will continuously display the average of the so far measured ranges. The field will be updated until the end has been reached (number of iterations or amount of time). When finishing, the field will be replaced with the complete average value.
- **Std. Deviation**
  During the calibration, this field will continuously display the standard deviation of the so far measured ranges. The field will be updated until the end has been reached (number of iterations or amount of time). When finishing, the field will be replaced with the complete standard deviation.
- **Laser Range**

During the calibration, this field will display the range measured by the hand held laser meter (if any). During calibration it shows the raw value, but after completing the last cycle, the value is corrected for offsets.
Note: Only the newest laser range value will be used.

- **Manual Range**
  If no laser is available, the user can enter a range measured manually. The range must be related to the layback of the antenna in use. The range must be entered before start of range. **Note**: A manual range overrules a laser range.
- **C-O**
  This field will show the above mentioned correction value (ie a correction to add to the range given by the station). The field will be updated as soon the calibration is finished.
- **Apply**
  When calibration is finished (the two first fields change to 'DONE') and a C-O value has been computed, the **Apply** button will be enabled.
  By clicking **Apply**, the computed correction value can be applied to the local correction list. To make the correction permanent, the operator must enter it in the Setup database.
- **Reset**
  Interrupt the current calibration (ie do not finish the outstanding iterations) if it is still running. The 'Stop' message will be written in the **Laps to go** field. The user can now enter new values in upper part of the dialogue box.
- **Cancel**
  Close the calibration dialogue box. If **Cancel** is clicked before the end of the calibration, the calibration procedure will be interrupted.

3.5.3 USBL Calibration

Starts the USBL Calibration tool. Here it is possible to compute the USBL parameters from the **Edit: USBL Parameters** menu item.

3.6 Calculate

Contains menu entries with various helpful calculating utilities, including **Coordinate conversion**, **True Distance**, **Calculate Grid-point**, **Distance to stations** and **WGS84 <-> User Datum**.

3.6.1 Coordinate Conversion

This menu opens a calculator dialogue box for converting positions between the XY grid and geographical coordinates.

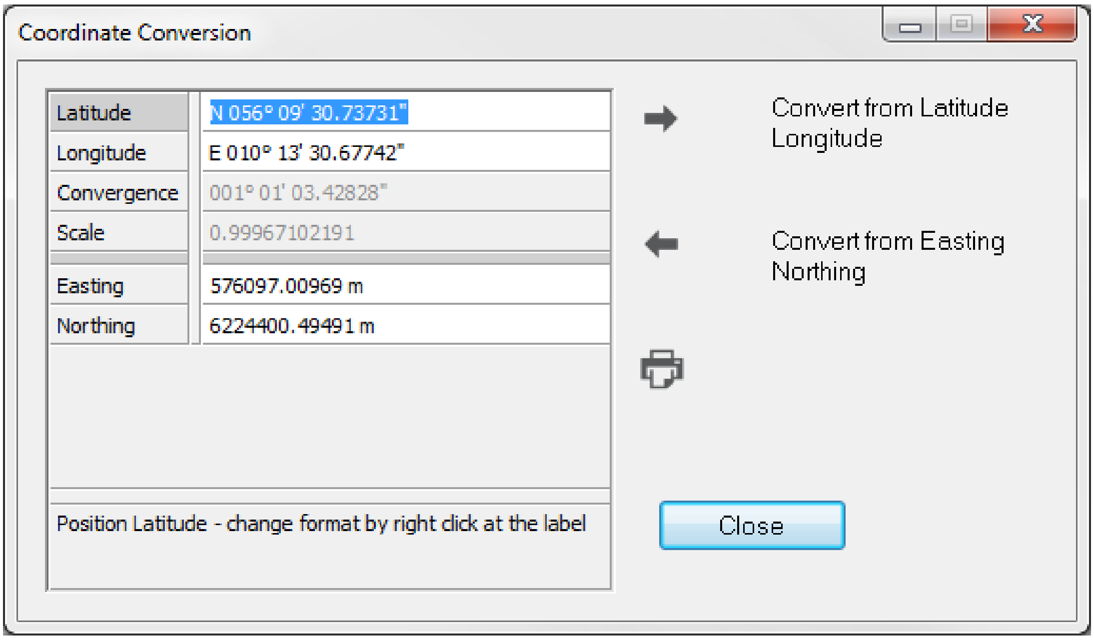


Figure 32 Coordinate transformation

The **Coordinate Conversion** dialogue box allows the operator to convert positions between geographical (latitude/longitude) and XY grid formats. The dialogue box is not modal and can remain open without interfering with other operations.

- **Latitude**
  The user may specify latitude in geographical coordinates for conversion to XY which will include the result of **Convert from Easting Northing** calculations. Format may be given as DD.DDDDD, DD MM.MMMM, DD MM SS.SSS or radians. Select format by right-clicking on the label name.
- **Longitude**
  The user may specify longitude in geographical coordinates for conversion to X, Y, which will include the result of **Convert from Easting Northing** calculations. Format may be given as DD.DDDDD, DD MM.MMMM, DD MM SS.SSS or radians. Select format by right-clicking on the label name.
- **Easting**
  The user may specify easting in XY grid for conversion to geographical coordinates. This will include the result from the **Convert from Latitude Longitude** calculations.

- **Northing**
  The user may specify northing in XY grid for conversion to geographical coordinates.
  This will include the result from the **Convert from Latitude Longitude** calculations.
- **Convergence**
  This field gives the meridian convergence calculated after a
  Convert from Latitude Longitude or a **Convert from Easting Northing** calculation.
- **From Latitude/Longitude (->)**
  Convert the entered geographical values (longitude, latitude) to X, Y and presents the results in easting, northing and convergence.
- **From Easting/Northing (<-)**
  Convert the entered X, Y values (easting, northing) to geographical parameters and present the results in longitude, latitude, and convergence.
- **Close**
  Close the dialogue box.
- **Print icon**
  Print screen capture via default printer setting (requires a high screen-resolution).

3.6.2 True Distance

This menu opens a calculator dialogue box for the calculation of true distance between two points.

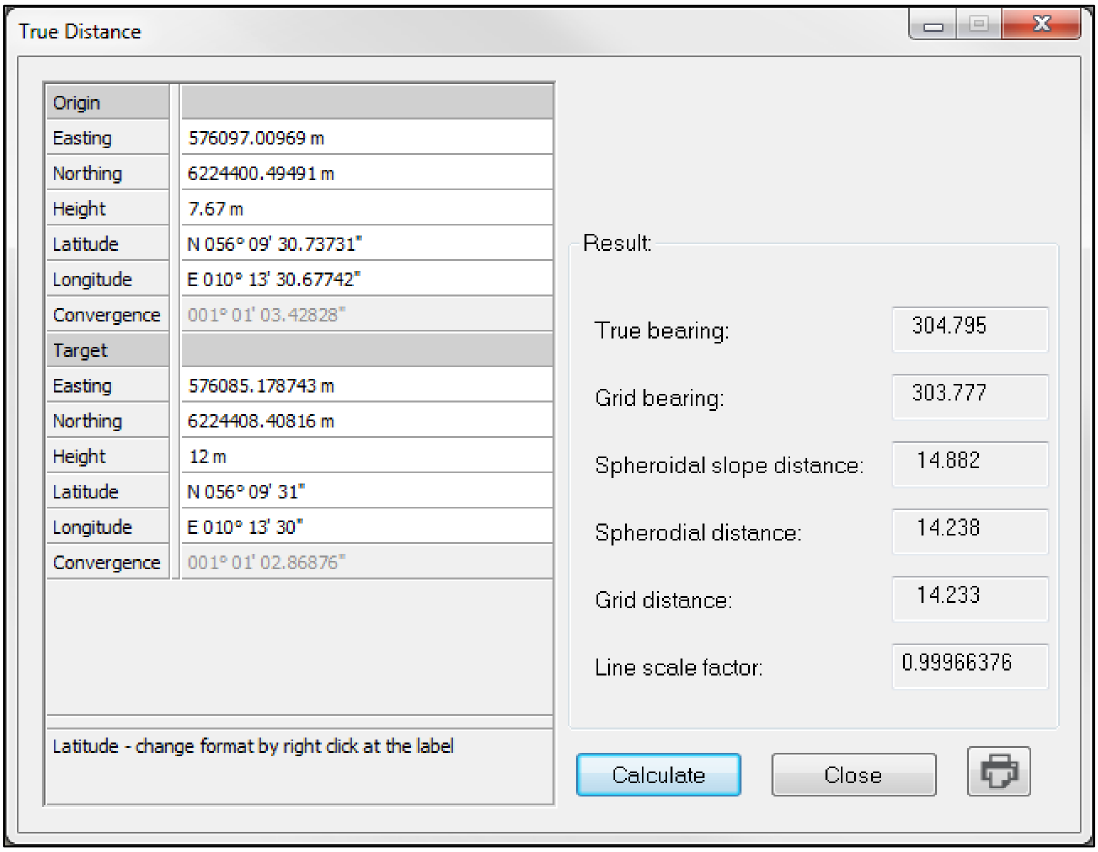


Figure 33 Distance between points

The **True Distance** dialogue box allows the operator to calculate the distance between two points.

- **Origin**
  Enables operator to enter position as either X/Y or Latitude/Longitude and height for the first point. The module automatically converts X/Y to Latitude/Longitude, and vice versa.
- **Target**
  Enables operator to enter position as either X/Y or Latitude/Longitude and height for the second point. The module automatically converts X/Y to Latitude/Longitude and vice versa.
- **True Bearing**
  Shows the true bearing (direction) from the first object to the second object.

- **Grid Bearing**
  Shows the grid bearing (direction) from the first object to the second object.
- **Spheroidal slope distance**
  Shows the spheroid slope distance from the first object to the second object.
- **Spheroidal distance**
  Shows the spheroid distance from the first object to the second object.
- **Line scale factor**
  Shows the line scale factor obtained from the distance calculation.
- **Grid distance**
  Shows the grid distance from the first object to the second object.
- **Calculate**
  When the operator has entered parameters for the two objects, they must press this button to activate the distance computation. The result will afterwards be presented in the above fields.
- **Close**
  Closes the dialogue box.
- **Print icon**
  Prints screen capture via default printer setting. Requires high screen resolution.

3.6.3 Distance to stations

Opens a dialogue box for calculation of the distance to all stations in use.

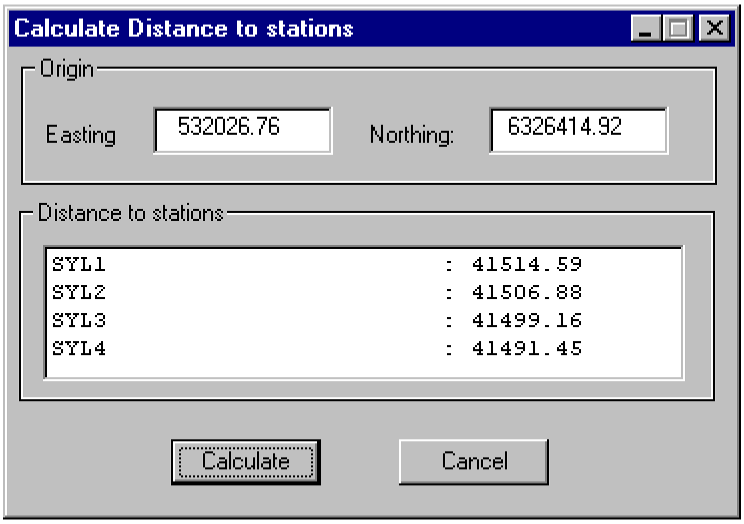


Figure 34 Distance to range/bearing stations

The dialogue box is separated in two parts: position fields and a result list field. The result list (in a scrolled text widget) will contain one line per station in use. In the bullets below, this line will be treated in general.

- **Origin - Easting**
  Easting coordinate of the original point (present as default current position).
- **Origin: Northing**
  Northing coordinate of the original point (present as default current position).
- **Distance to stations**
  For each station in use, the first part of the result string identifies the station by giving station type and name. The second part of the result string shows the exact distance in metres from the origin point to the station.
- **Calculate**
  When the operator has entered the top 2 parameters, she must click the **Calculate** button to activate the distance computation. The result will afterwards be presented in the **Distance to stations** field.
- **Close**
  Close the dialogue box.
- **Print icon**
  Print screen capture via default printer setting (requires high screen-resolution).

3.6.4 Grid Point

Opens a calculator dialogue box for calculating grid points based on range/bearing.

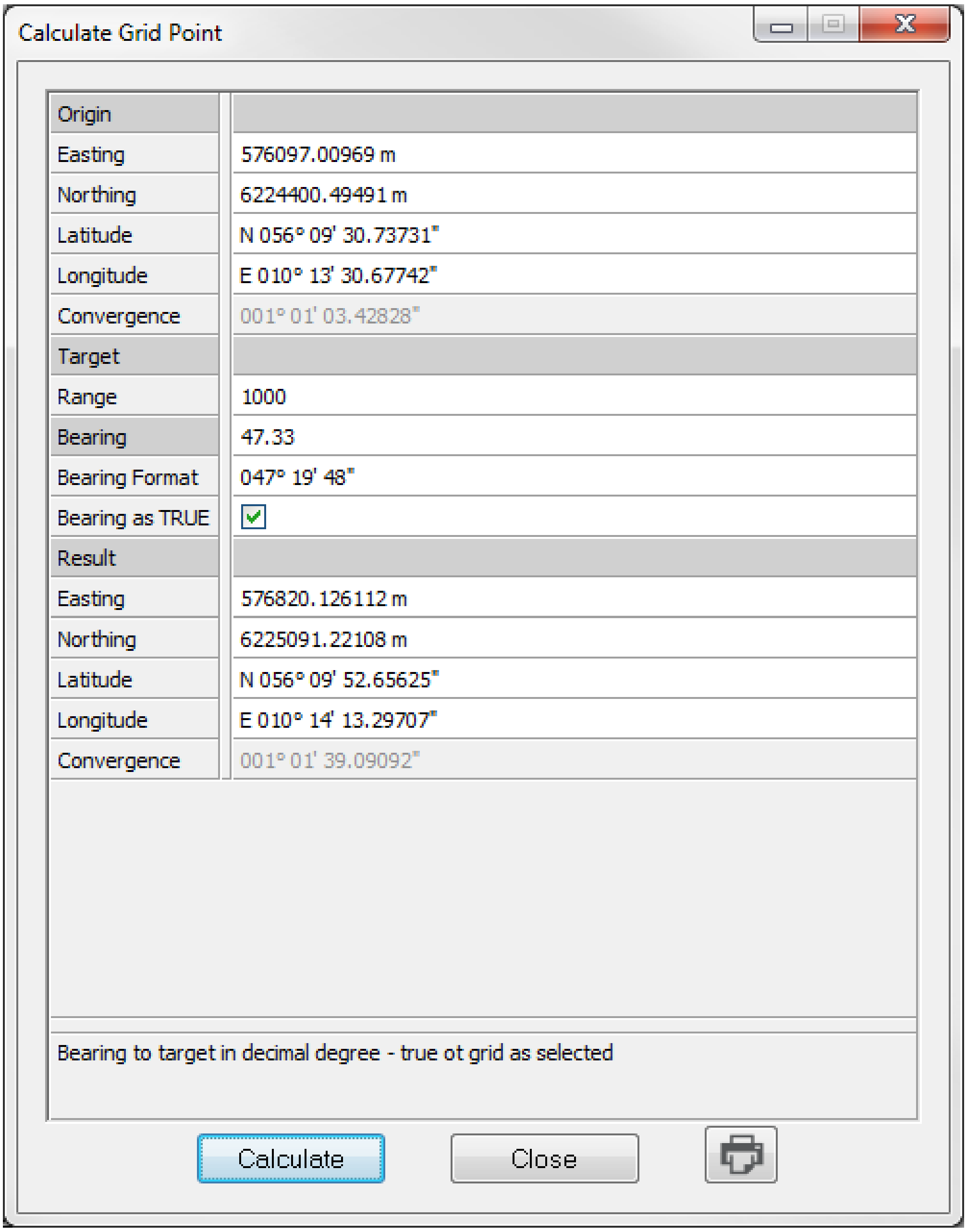


Figure 35 Calculate Grid Point dialogue box

- **Origin**
  This section gives the position (as either **Easting**/**Northing** or **Latitude**/**Longitude**) of the basis point. If entered as, for example, **Easting**/**Northing**, then the system calculates automatically the corresponding **Latitude**/**Longitude** and vice versa. The **Latitude**/**Longitude** fields can be formatted by right-clicking the field label.
- **Target**
  In this section the operator may enter range and bearing to the target. Bearing can be given as either TRUE (checked) or grid. Bearing can furthermore be entered as decimal degree or formatted degree/radians
- **Result**
  Presents the resulting position as both **Easting**/**Northing** and **Latitude**/**Longitude**. It is updated when operator clicks **Calculate**.
- **Calculate**
  When the operator has entered the top 4 parameters, they must click the **Calculate** button to activate the grid computation. The result will afterwards be presented in the calculated fields.
- **Close**
  Closes the dialogue box.
- **Print icon**
  Print screen capture via default printer setting. Requires high screen resolution.

3.6.5 WGS 84

This menu entry opens a calculator dialogue box for conversion of positions between user datum and WGS 84 (eg projection UTM32 and Ellipsoid ED50 and WGS 84 (the GPS system)).

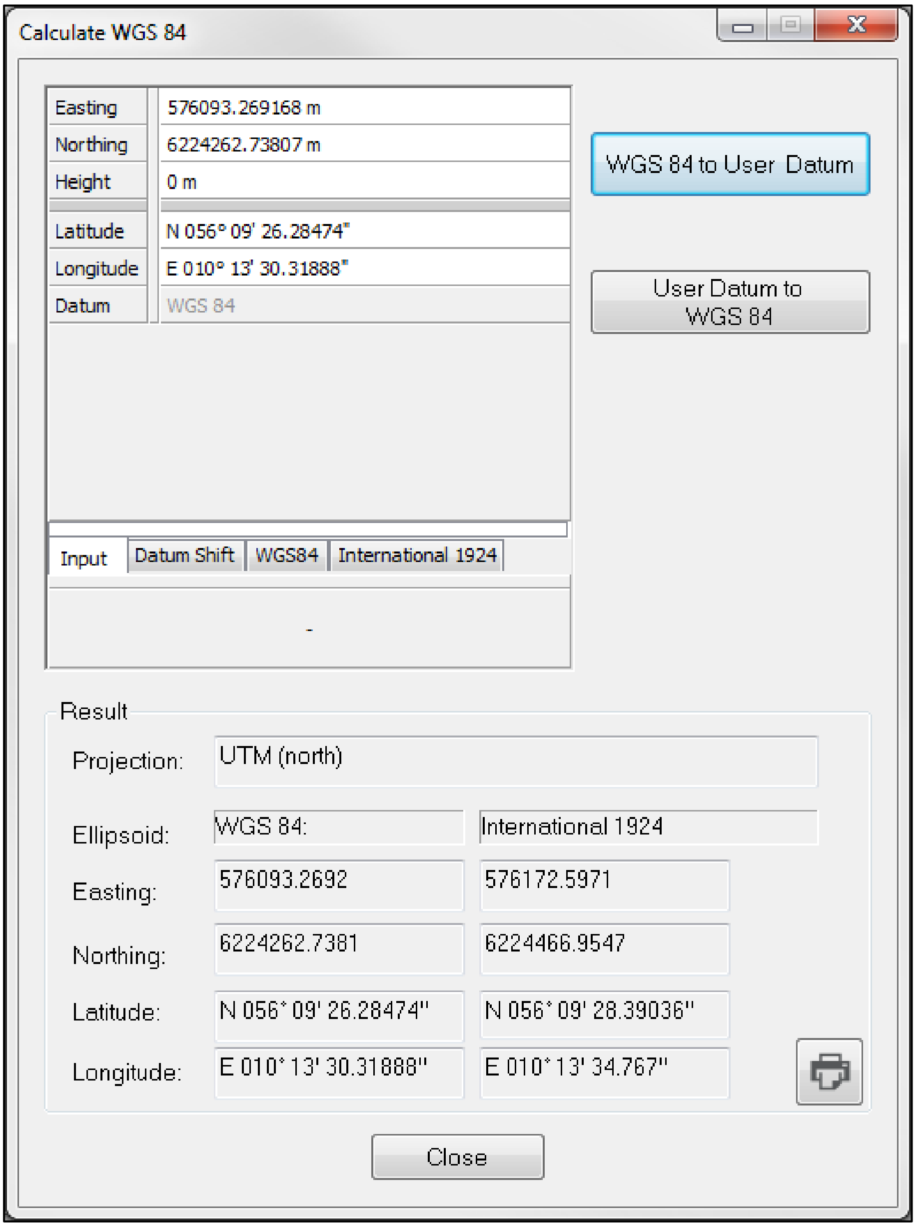


Figure 36 Datum shift calculator

- **Input**
  In this section the operator enters the position that they need to convert. As default, the system displays the current reference position in user datum. The position can either be entered as grid coordinates (**Easting**/**Northing**) or geographical coordinates (**Latitude**/**Longitude**). As soon as the operator accepts one of the two types, the other is forced to zero.
  The geographical coordinates can be entered and presented using various formats. Format can be selected by right-clicking on the label name.
- **Result**
  Presents the resulting position in both **WGS84** and **User Datum**. The same information can be found at the two panels at the top part.
- **Datum Shift**
  Displays the shift parameters being used for this conversion:

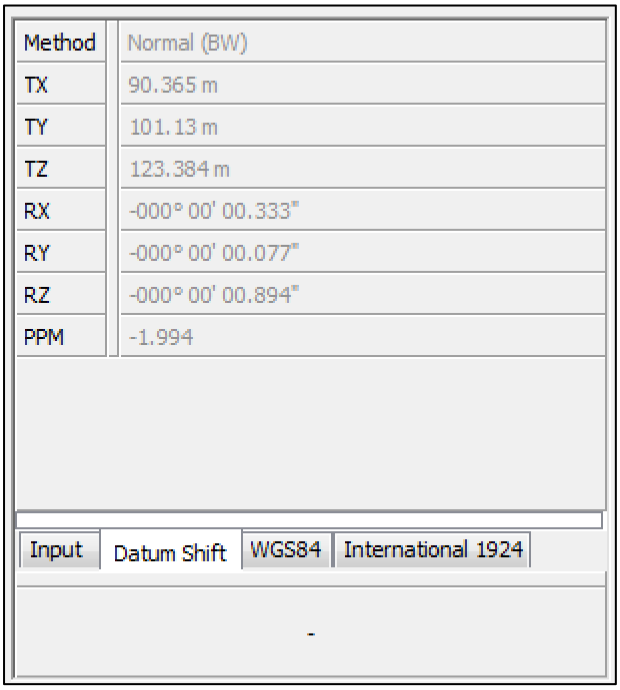


Figure 37 Shift parameters

- **Close**
  Closes the dialogue box.
- **Print icon**
  Prints screen capture via default printer setting. Requires high screen resolution.

3.6.6 ITRF

NaviPac may include time-based datum shift parameters to account for situations where the datum shift is changing over time. The basic NaviPac datum shift parameters will be adjusted daily using the ‘speed of change’ parameters based on the reference date.

This type of datum shift can, for example, be relevant in North America where the use of ITRF to NAD83 is widely used, and in Europe to shift from ITRF to EUREF89.

This calculation may be tested here:

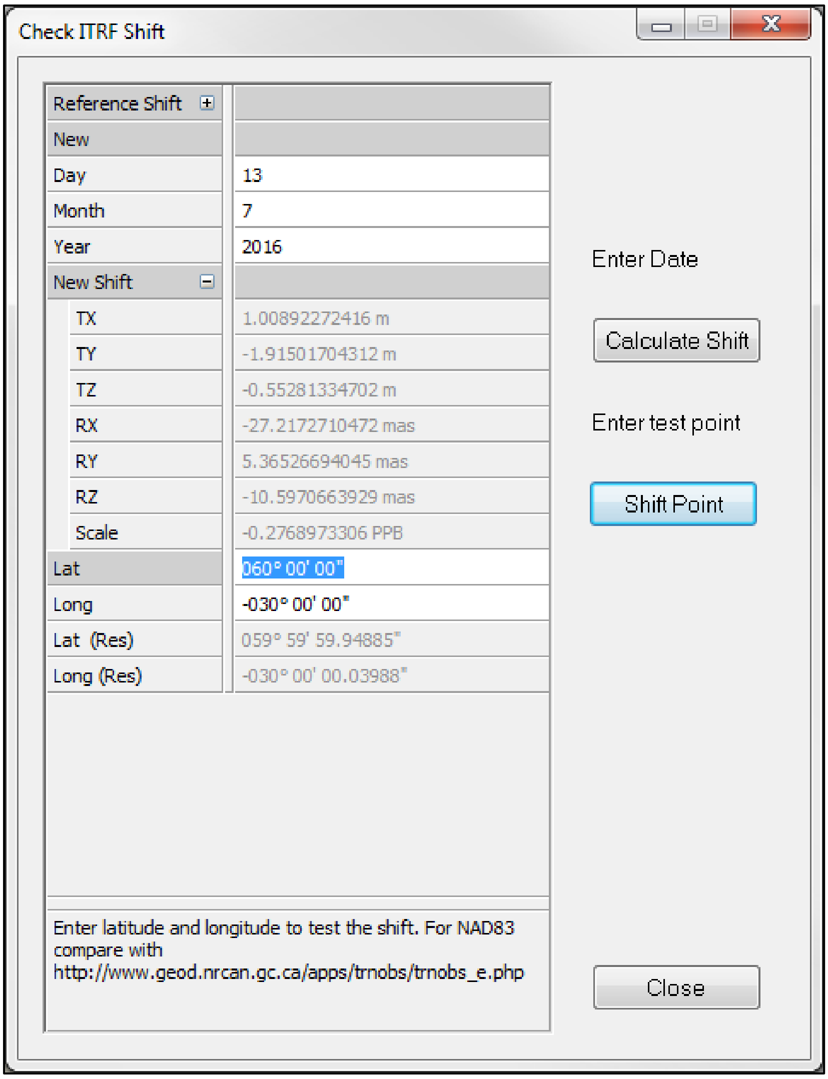


Figure 38 Testing ITRF

Enter the date you want to test, click **Calculate Shift**, enter the source Latitude/Longitude and click **Shift Point**. The result is shown in **New Shift** (coordinate corresponding to the date) and **Lat/Long (Res)**.

The result has been validated with the Canadian test site for NAD83.

3.6.7 Chen & Millero 1977

The **Calculate Chen & Millero** dialogue box allows you to perform calculations on CTD data:

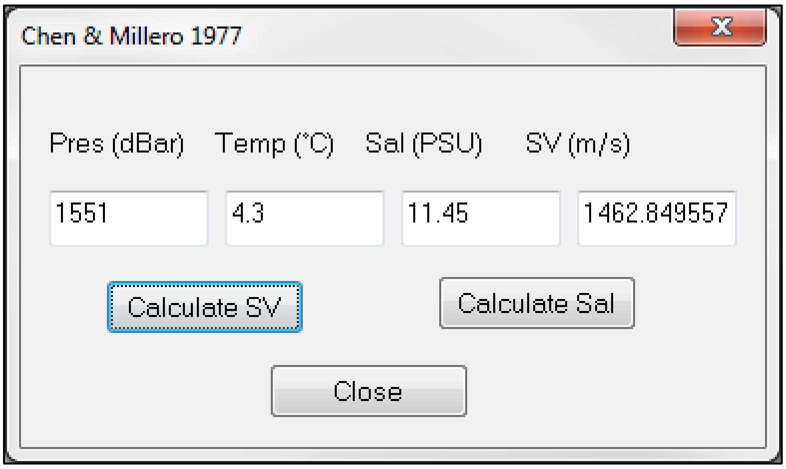


Figure 39 Calculating sound velocity

If you enter pressure (in d(eci)Bar), temperature (degree Celsius) and salinity (PSU) and click the **Calculate SV** button, then it calculates the sound velocity based on the official UNESCO formula.

If you instead input pressure, temperature and sound velocity and click the **Calculate Sal** button, then it makes an iterative calculation on the corresponding salinity. The calculation is done in a cyclic process, where the function searches for the salinity that gives the best fitting sound velocity.

3.7 Events

Contains menu entries with various event utilities.

3.7.1 Manual Event

Generates a manual event. The event will be displayed on Helmsman's Display if enabled there. Also, if logging is enabled, the event number can be logged.

3.7.2 Manual event (Note)

Generates a manual event with a note. The event will be displayed on the Helmsman's Display if enabled there. Also, if logging is enabled, the event number can be logged.

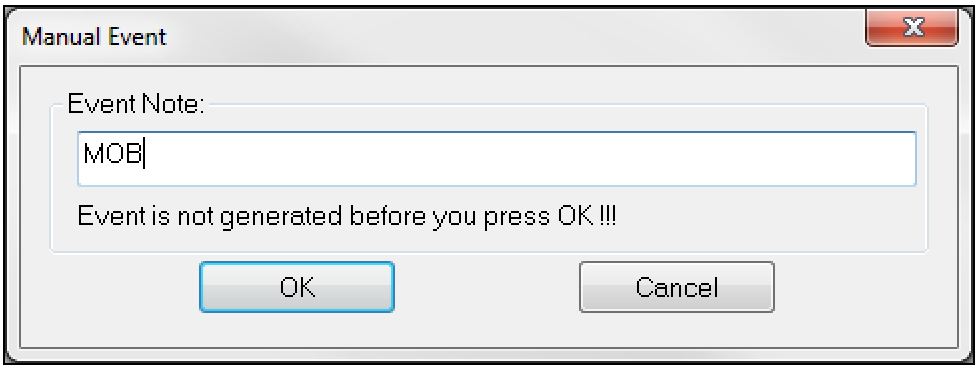


Figure 40 Manual Event dialogue box

If so desired, you can specify a range, bearing and symbol number in the **Event Note** field. This can be used to add a range and bearing to current position (Vessel) and the events will be stored in a file in the current logging directory (Julian day) and named NAVILINE.EVT.

Syntax:

#<range> <bearing> <symbol_no>

Example:

#45 350 67

Range=45 m, bearing=350, symbol=67 in NaviLine symbol table.

3.7.3 Predefined events

If you have defined some fixed event texts, they can be activated by right-clicking in the message window:

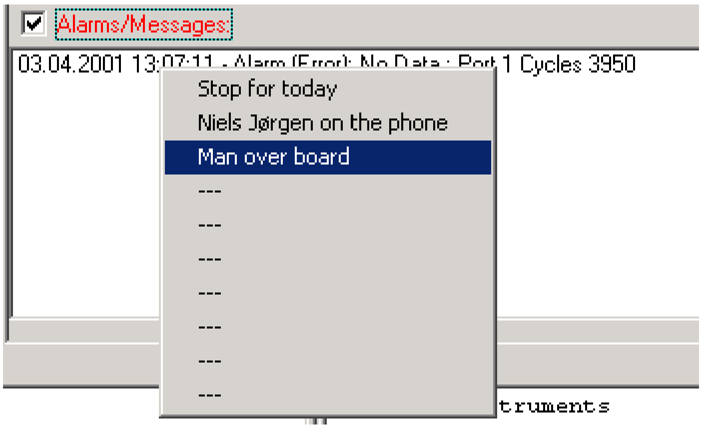


Figure 41 Predefined event texts

This gives a faster event generation than entering the texts manually.

3.7.4 Event Settings

Opens a dialogue box to set up how to generate events in Online. This feature can also be set up in the Setup program.

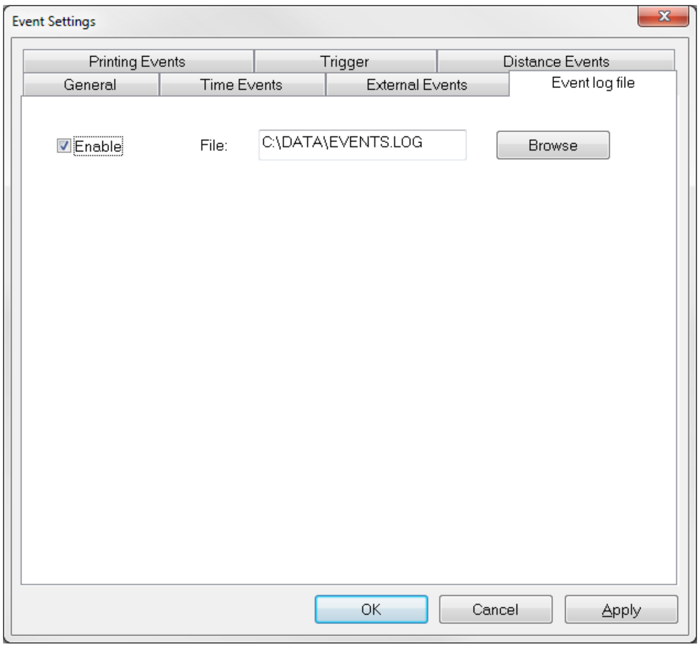


Figure 42 Event log file

Note: You cannot change COM port settings for **Trigger** events and **External Events** in Online.

3.7.5 Re-shoot partly surveyed line

If NaviPac is operated in distance events mode (like in typical seismic jobs), and something goes wrong in the middle of a line, you may not want to start from beginning of the line. Instead, the distance events can be set in a re-shoot mode.

In the **Event Settings** dialogue box, click into the **Distance Events** tab:

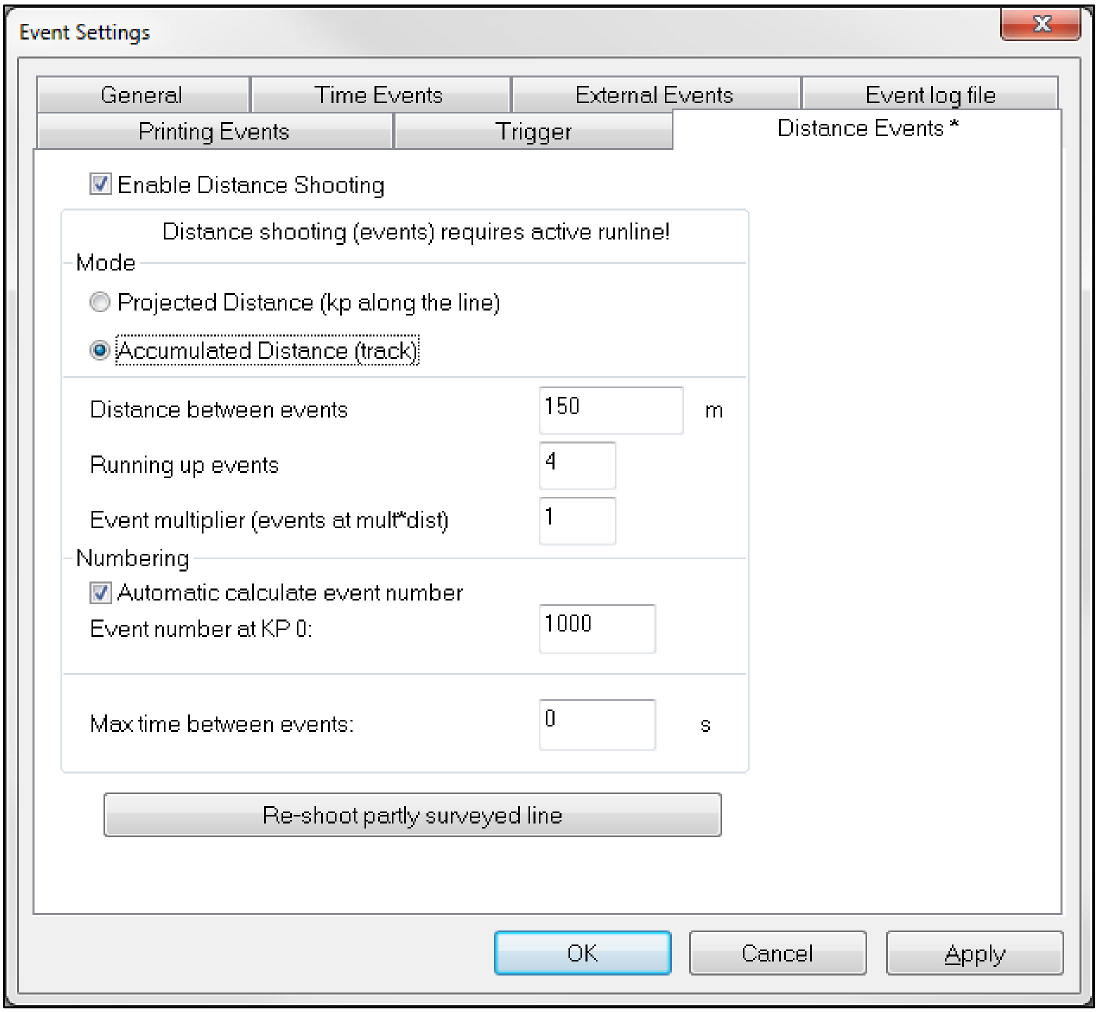


Figure 43 Distance shooting

The **Re-shoot partly surveyed line** button activates the function. The button is only enabled when distance events is selected by selecting the **Automatic calculate event number** checkbox.

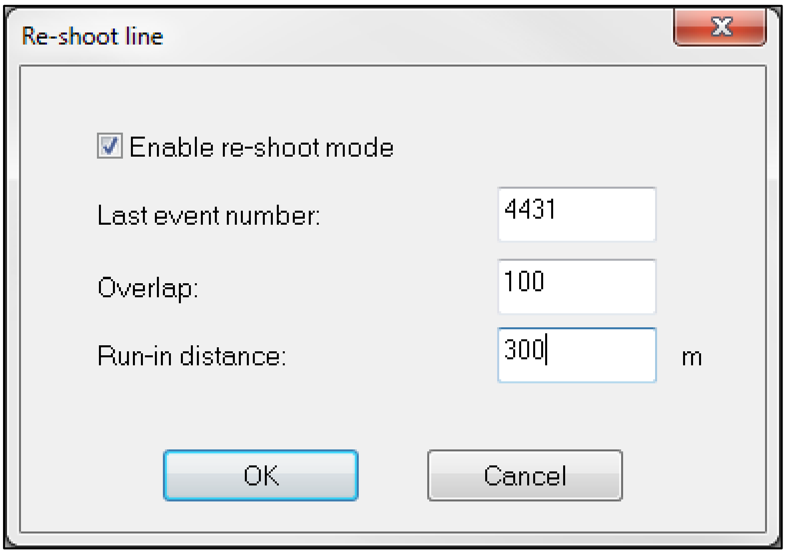


Figure 44 Partial re-shoot of line

If enabled, the operator can select:

- **Last event number**
  Enter the last accepted event number from last time the line was surveyed.
- **Overlap**
  Enter in how many events desired in an overlap. Typically, this would correspond to the length of the streamer. The sign must follow the event step size etc.
- **Run-in distance**
  Enter the desired run-in distance in metres required.
- **OK**
  Accept the changes and enable (or disables) the re-shoot mode. When clicked, a message is sent to the Helmsman's Display.
- **Cancel**
  Skip any changes and leave the setting as it is.

Note: The runline in action must be selected in the Helmsman's Display.

When NaviPac goes into re-shoot mode, it generates three waypoints:

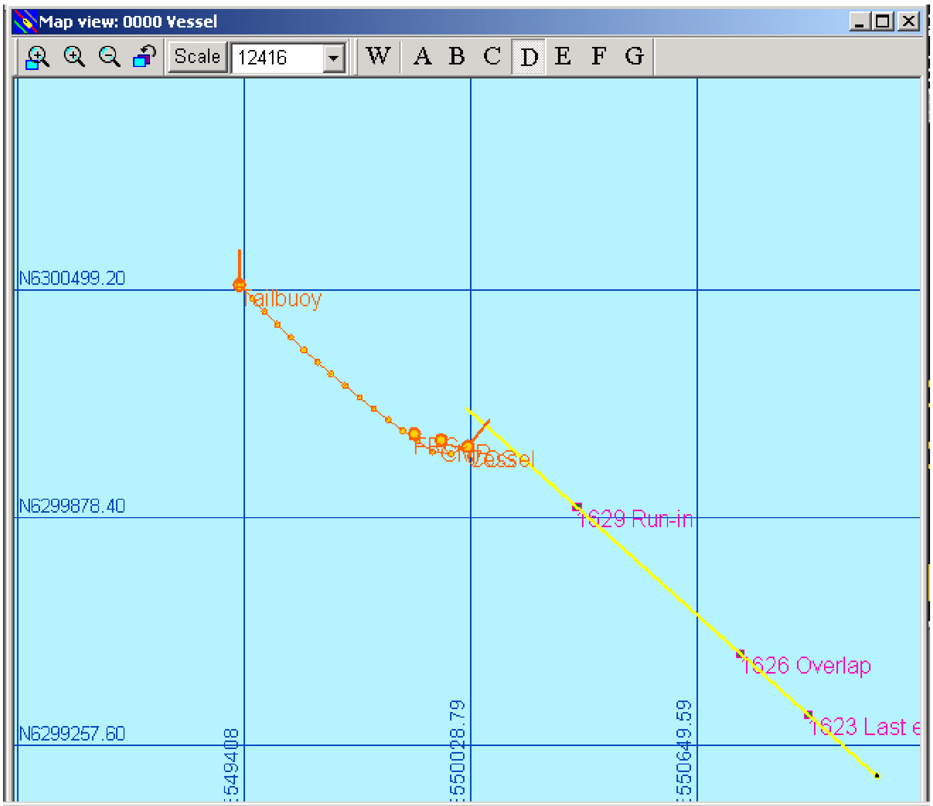


Figure 45 Helmsman's Display during re-shoot

- **Run-in**
  The run-in point
- **Overlap**
  The overlap point
- **Last event**
  The point corresponding to the last accepted event

When the runline is in survey mode, no event will be generated until the vessel (or other selected point) crosses the overlap point.

3.7.6 Distance Event Info

The distance event window displays information about the actual event calculation:

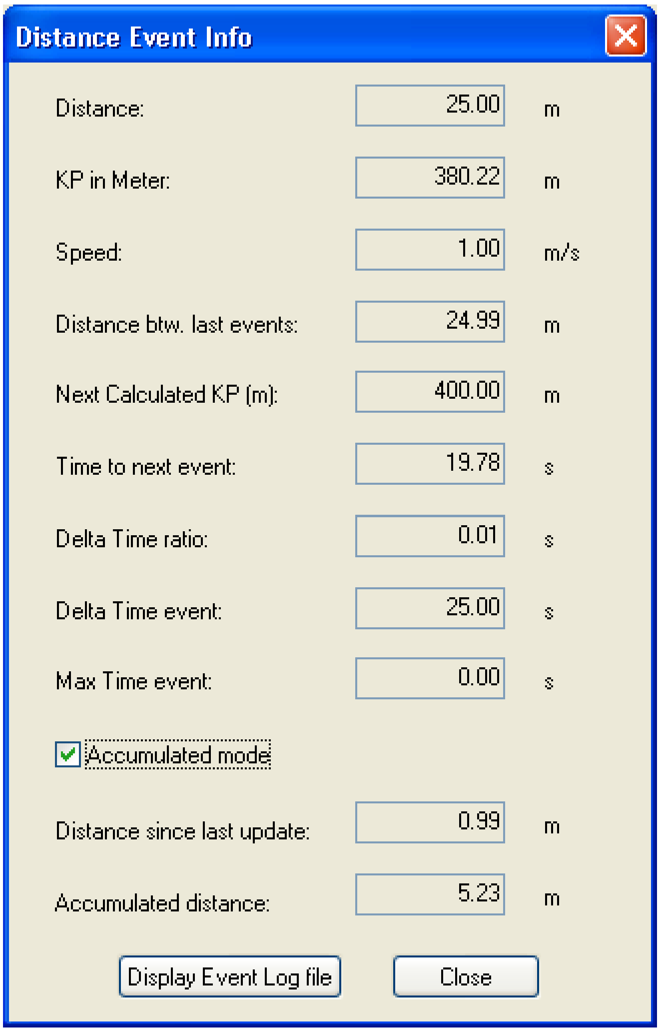


Figure 46 Distance Event Info dialogue box

- **Distance**
  The selected distance in metres
- **KP**
  Actual KP value in metres.
- **Speed**
  Speed of vessel.

- **Distance between last events**
  Distance between the two last generated events in metres.
- **Next calculated KP**
  The KP at which the next event will be generated.
- **Time to next event**
  Time until the next event will be generated.
- **Delta time ratio**
  Difference between expected time between events (distance divided by speed) and observed time.
- **Delta time event**
  Time between the two last events.
- **Max time between events**
  The maximum time allowed between events, as specified by operator. 0.0 implies infinity.
- **Accumulated mode**
  If selected, then the shooting is performed as distance along the track rather than along the line.
- **Distance since last**
  Distance since last update (track).
- **Accumulated distance**
  Distance since last event (track).

3.8 Options

This part contains menu entries concerning various options, including what to display in the **Message** window.

3.8.1 Display events in message list

If selected, then Online displays events in a message list. Default is to display events.

Note: This option is local to Online. Other Online programs can have other settings.

3.8.2 Display warning in message list

If selected, then Online displays warnings in message list. Default is display warnings.

Note: This option is local to Online. Other online programs can have other settings.

3.8.3 Alarm filtering

If NaviPac is used in dynamic scenarios where multiple vehicles are operated at the same time (vessel, ROV, towed ScanFish etc) then we often see that some objects are inactive during some of the operation.

If you, for example, have ROVs on deck for a period, then you either get a lot of inactivity alarms or must restart navigation with the involved instruments turned off.

From NaviPac 3.4D patch 2, you may handle alarms more smoothly using alarm filters. The filters will apply to the following set of alarms:

- ‘No Data: Port %d Cycles %.0f’
- ‘Syntax error: Port %d’
- ‘No data for OFFSET obj %d’
- ‘No data from radar’
- ‘Radar data don't fit’
- ‘Change in USBL X too high (Check Setup - USBL tolerance)’
- ‘Change in USBL Y too high (Check Setup - USBL tolerance)’
- ‘Motion sensor is not aided’

3.8.3.1 Objects

In this dialogue box you may enable and disable all alarms related to selected objects:

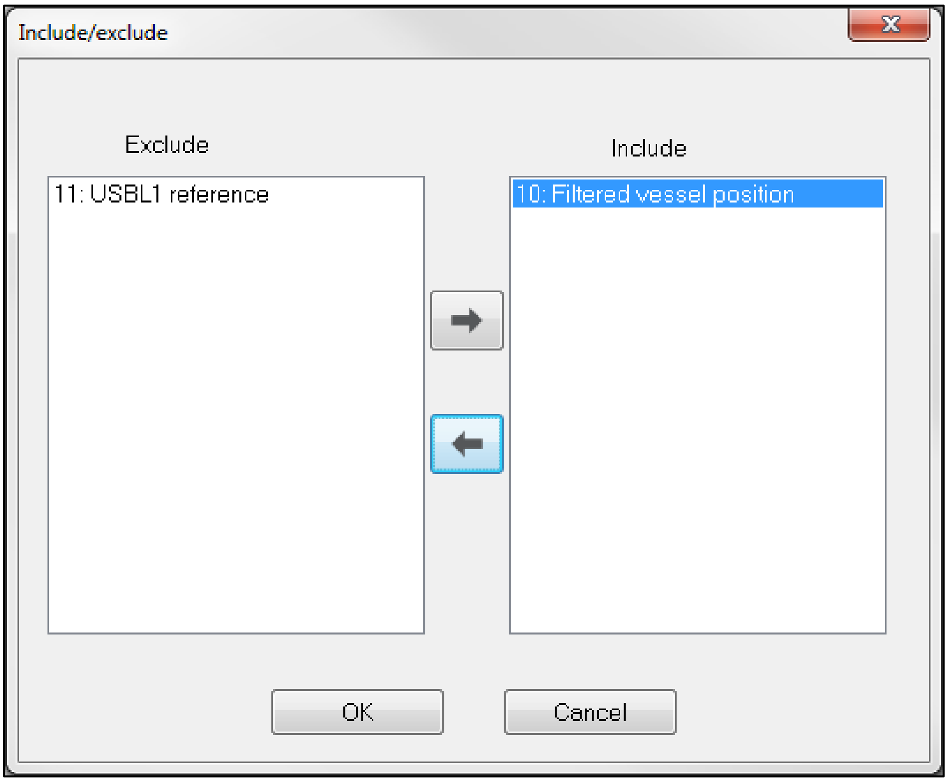


Figure 47 Vehicle-based alarm filtering

The dialogue box shows as default all dynamic objects defined in the setup. To ignore alarms for an object just move the object to the **Exclude** field and click **OK**.

3.8.3.2 Instruments

In this dialogue box you may enable and disable all alarms related to specific instruments:

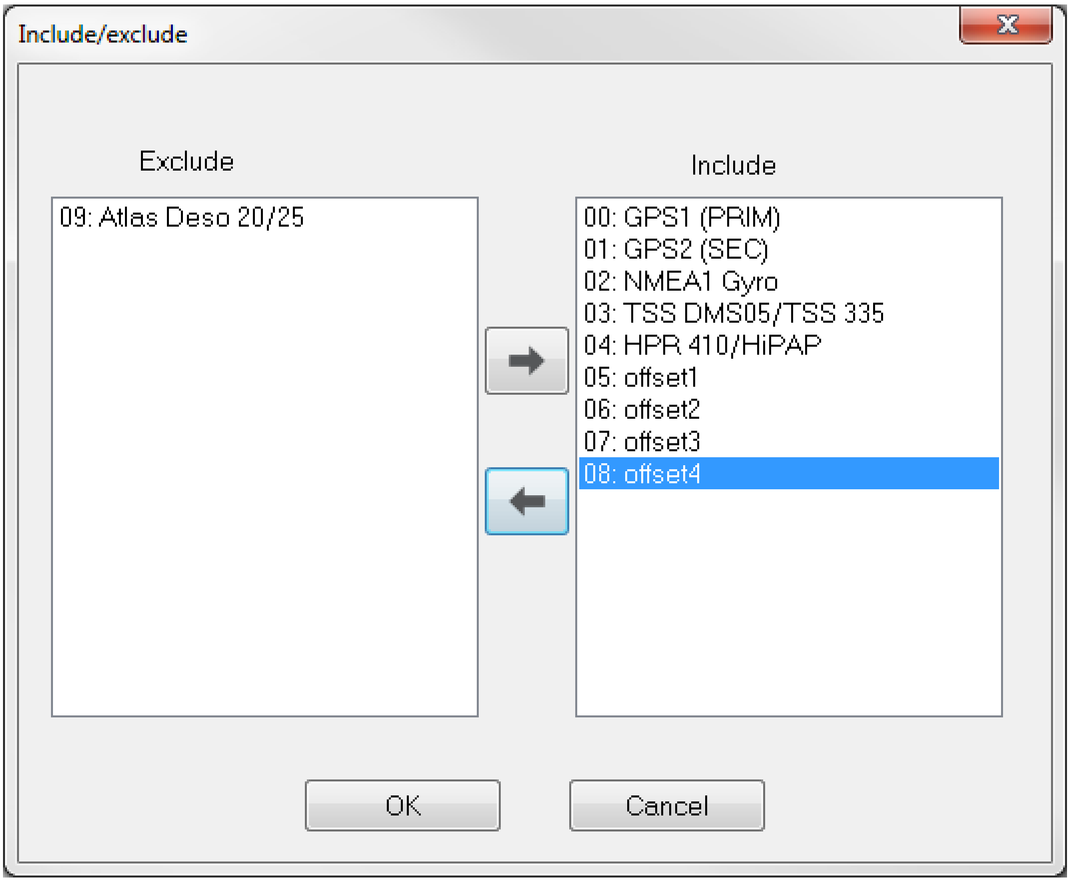


Figure 48 Instrument-based alarm filtering

The dialogue box displays as default all instruments (numbered by internal index) as included. To ignore alarms for an instrument, move it to the **Exclude** field and click **OK**.

3.8.3.3 Reset on warm start

NaviPac will as default reset the alarm filtering each time Online is restarted (warm or cold) as this protects against forgotten filter settings etc.

This can be deselected in this option menu.

3.8.4 Depth calculation

If operating an ROV or ROTV, you need to inform NaviPac how to convert the pressure to depth, as there exist several methods.

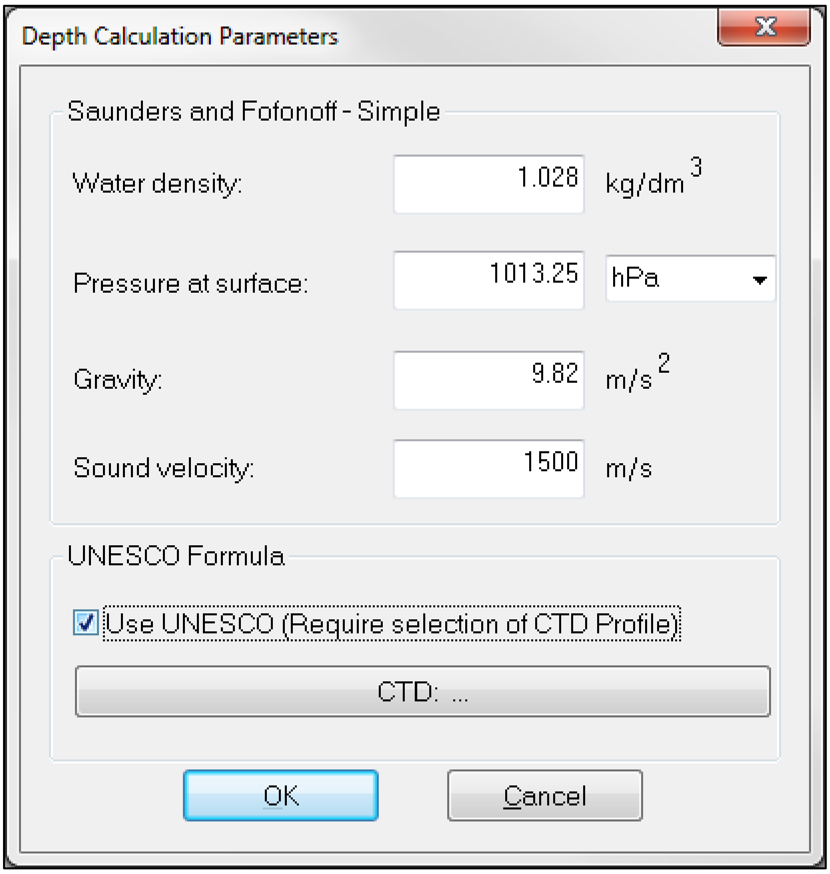


Figure 49 NaviPac's pressure-to-depth calculation

Water density:

Specify the water density, given in kg per cubic decimetre.

Pressure at surface:

Specify the local pressure at surface given in various units. By default, the selected unit is hectoPascal (hPa). You may change the unit via the unit drop-down list box on the right.

Gravity:

The gravity, given in m/s^2.

Sound velocity:

Defines the current valid speed of sound in water. Sound velocity is used, for example, for calculations between range and time.

The parameters will be used in a depth calculation as:

Depth = (Pressure – PressureAtSurface)/(1000 * Gravity * WaterDensity).

Use UNESCO Formula:

You may improve the depth calculation by adding a CTD profile and performing a full integration through the water column. The file is selected by selecting the **Use UNESCO** checkbox and then clicking the **CTD** button.

CTD:

Select and parse CTD file. A special **Choose CTD Template** dialogue box pops up for this, as seen below.

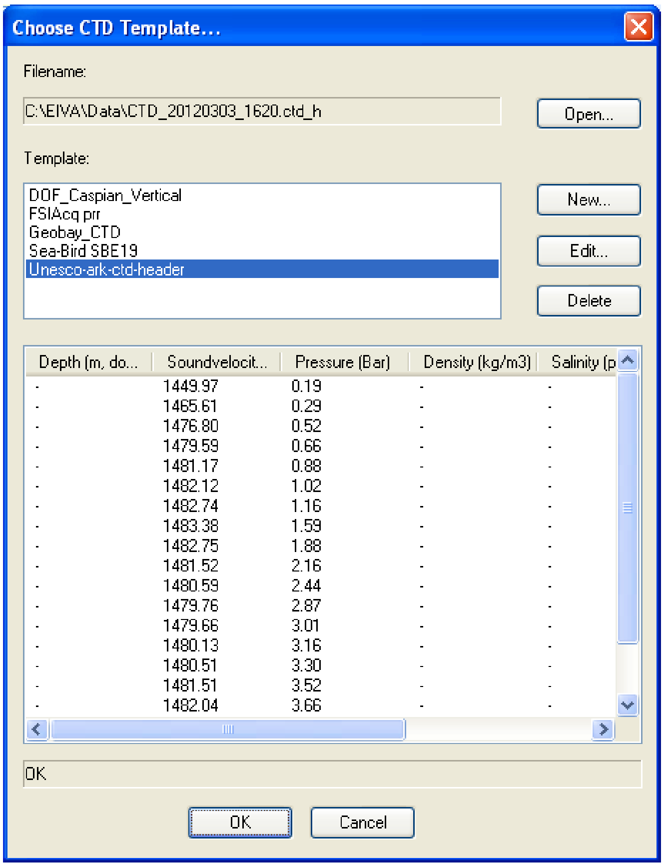


Figure 50 Choose CTD template

This is based on the general ASCII importer in EIVA (like known in NaviEdit).

At the top level you select the file and action. **Note**: The file at minimum must include **Conductivity**, **Pressure** and **Temperature**. The middle part (the Template field) includes the supported templates, where you select the one to use. You may modify the list via **New**, **Edit** and **Delete**.

The lower part of the dialogue box shows interpretation of the first rows of data.

4 Navigation principles

This section gives a detailed description of navigation principles, used terms and attributes, typical scenarios etc.

NaviPac is a real-time integrated navigation and data acquisition system, which makes it possible to escalate one or more positions from various sensors.

Combining this information with real-time roll and pitch values gives the best-suited data resolution and correctness.

4.1 Special features

NaviPac includes a series of special features such as:

4.1.1 Flexible choice of geodesy

- Mercator
- Transverse Mercator (UTM, RT-38, Gauss Krueger, NGGB)
- Equatorial Stereographic
- Polar Stereographic
- Oblique Stereographic
- Lambert's Conical
- etc

4.1.2 Flexible choice of navigation instruments

- Latitude/Longitude (GPS receivers)
- Range/Range (Mini-ranger, Microfix, Syledis, etc)
- Range/Bearing (Polartrack, AGA, Leica)
- Hyperbolic Range (Hyperfix)
- Doppler log (RDI)
- Gyro (S.G.Brown, Robertson, Lemkühl etc)

4.1.3 Precise time tagging of all sensor data

- Surface navigation
- Gyro, roll, pitch, speed log
- Subsea and remote positioning systems
- Data acquisition

4.1.4 Kalman filter used for position prediction

- Reduces computation time
- Checking of LOPs using robust estimation techniques

4.1.5 Correction of antenna swing

- Correction will be made using gyro, roll, pitch with the correct age
- Correction will be 3D

4.1.6 Local coordinate system for calculation of offsets

- A three-dimensional calculation will be performed.

4.1.7 On-line transformation of WGS 84 coordinates

- A 7-parameter transformation will be used to transform the WGS 84 position from the GPS instruments to user datum
- Furthermore, the North Sea method is available
- The US NADCON method is also available

4.2 Surface navigation

NaviPac Online uses least squares computation of position and quality of fix from any positioning system, using up to 50 LOPs for each position.

An LOP may be range, bearing, hyperbolic range, position in geographical or UTM grid, gyro reading or speed.

LOPs of different types (range, coordinate, reading from radar) can be combined to give an integrated position.

For each LOP the operator can set the following parameters:

- First -, second -, third -, fourth-, fifth-position
- LOP weight [0...1]
- LOP sigma [0,1...999]

Any position may be selected as the primary reference position.

All sensors (surface navigation, gyro, roll, pitch, etc) can be selected as:

- **On**
  This is the normal selection for instruments. The data from the sensor will be read from the interface.
- **Simulated**
  The simulation mode may be switched on by itself to allow for preliminary testing of the navigation system. A random number generator varies the sensor data to each parameter selected in order to simulate a typical seagoing operation. This is a very useful function for operator training.
- **Calculated**
  Under certain conditions (such as if, for example, there is no gyro onboard) it is convenient to select a sensor as **Calculated**. These sensors can be gyro, speed log etc.

The mode of LOPs can be changed online at any time without disturbance to the survey task. C-O corrections can be made online to establish local calibration. All measured LOPs are checked using robust estimation techniques. This technique will trace and weight measurement blunders.

All LOPs are corrected for antenna swing, and the output of the position calculation is in the selected datum of the vessel.

A second-order Kalman filter is incorporated for position prediction in order to reduce computational time spent in the position calculation. The filter has no effect on the quality of the position calculations.

The surface position calculation can be swapped online between the following modes:

Method 1: Using all LOPs to give a multifix

If gyro and speed log are amongst the selected LOP's a dead-reckoning position can be calculated using these two sensors.

Method 2: Using each individual positioning system separately or in any combination for an on-line comparison between calculated positions.

The primary position can be selected from any positions.

Before using a measurement in the position calculation, the following actions are taken:

- For each navigation cycle, a line scale factor will be computed for each LOP. The line scale factor will be computed using Bessel's method.
- For each navigation cycle, the convergence will be calculated.
- A range will be multiplied with the appropriate line scale factor.
- Position will be converted from WGS 84 to the ellipsoid in use.
- A bearing will be compensated for convergence, if it is a true bearing.

Because the LOPs are measured in different instances in time, the LOPs are de-skewed to the same instant in time. The data output from many surface navigation instruments has an age of up to two seconds. This age will be taken into account when de-skewing the data.

4.2.1 The measurement is gated

The measurement is first checked for the presence of errors. For this purpose the measurement is compared with its predicted values. The Kalman filter from the predicted position at the time of measurement computes the latter. The measurement is first corrected for the projection system and other physical and geometrical aspects.

The difference between measurement and prediction is compared to its standard deviation (mean square error). A gate of two times the standard value is used. If the difference is acceptably small, the measurement is conditionally accepted for further calculations. Otherwise, the measurement may be either fully rejected or weighted depending on the magnitude of the difference found (robust estimation).

4.2.2 The measurement is corrected for layback

In using the measurement for positioning one has to remember that ranges of direction are usually not measured to the ship's reference point for which primary coordinates are required, but to various antenna positions on the vessel.

Thus, the relative position of the antenna to the ship's reference point and the roll, pitch and heading of the vessel must be taken into account. In NaviPac a rigorous treatment of this layback is made, and corrections to measured values are avoided. This both speeds up the computation and eliminates inaccuracies with large layback values or with short ranges, and is achieved by relating the measurement directly to the proper position.

4.2.3 Least squares adjustment

In NaviPac a weighted least squares adjustment is performed, considering simultaneously all measurements at one instant in time. If one particular measurement is not available or is not desired, its weight is set to zero.

A least squares adjustment requires a linear relationship between the measurements and the unknowns. For this purpose the observation equations are based around the predicted position that results from the Kalman filter.

The corrections dX and dY resulting from the least squares adjustment are applied to the predicted position of the ship's reference point and the computation is repeated to compensate for errors in the linearisation. In NaviPac, however, due to the accurate prediction of the ship's position, no new compensation is necessary, and in fact not even a repetition of the least squares method is necessary. This repetition (iteration) is only necessary in the presence of errors. This saves a considerable amount of computation time.

4.2.4 Accuracy of least squares:

After least squares adjustment, NaviPac estimates both the accuracy of the original measurement and the adjusted coordinates. In commencing the least squares adjustment, variance and weights were assumed for the individual measurements. Finally, the exact variance is estimated based on the adjusted result and the assumed estimate. If these variance properly describe the accuracy behaviour of the sensors, the conversion factor will be a round unity.

The conversion factor, also called **variance of unit weight**, is computed to:

$$Variance = \sum \frac{E(I)^2 \times P(I)^2}{\delta^2 \times (acc - 2)}$$

Where:

E(I) = RC(I) - RA(I)

RC = Range Converted

RA = Range Adjusted

Acc = Total number of measurements (accuracy)

If this variance factor (accuracy) differs very strongly from unity, and the previously assumed variance was chosen to the best knowledge, an error in the measurements must be suspected. NaviPac will during the next fix adapt itself to the erroneous sensor using robust estimations. Thus, no user interaction is necessary.

Accuracy of the coordinates is monitored by computing error ellipse, which shows shape and direction of the cloud of points that would emerge if the same fix were to be taken a large number of times. Around 39% of the fixes would be inside the ellipse and 86% inside two times the error ellipse.

4.2.5 The Kalman filter

NaviPac uses a Kalman filter to correct adjusted vessel position for an assumed smooth movement. This is implemented as independent filtering of X and Y coordinates or as cooperate filtering. The filtered values can be used to obtain corrected positions or to predict future positions. Filters may also be applied to data sources (eg gyro or ranges may be included).

In NaviPac, the user is also allowed the option to choose a robust Kalman filter, which automatically adapts to changing vessel behaviours. This is a very significant feature because it avoids problems with determination of the position at the end of survey lines, when the vessel starts a turn or with other sudden changes of the ship's course.

4.2.6 Weighting and robust estimation

The least squares algorithm in NaviPac is a weighted least squares algorithm, thus allowing the user to make optimal use of his knowledge of different accuracies of different ranges, bearings or sensors. It also allows the user to enhance or diminish the influence of individual measurements on the results. Weight changes may be introduced online.

This weighted least squares adjustment is a prerequisite for the possible interpreted adjustment of all sensor types in NaviPac and it creates a unique feature for the user as compared with competitive systems.

Using least squares and the Kalman filter yields only optimal results in case of purely normal distribution of the measurements and errors. Any deviation from this normal distribution (eg the presence of errors in the measurements) makes the classical least squares and Kalman methods extremely ineffective. In fact, errors often become completely unnoticeable in the least square result, although they seriously distort the adjusted position.

Thus, even though the least squares method and Kalman filter have found acceptance in offshore survey systems, we seriously warn against the uncritical application of these methods.

NaviPac gives the user the option to use robust estimation principles both in the least square module and in the Kalman module. We regard this option of robust adjustment and filtering as a very important improvement in comparison with the classical computation methods, as errors are automatically and properly detected without time delay and have no influence on the resulting position determination.

4.2.7 Automatic computations

Depending on the processor and number of LOPs the system can achieve a navigation cycle-time of 0.1 to 1.0 seconds and a stacking sampling speed of 0.1 second.

As the navigation sensors are sending data asynchronously the NaviPac program will de-skew the data forward in time so all sensors can be used and compared at the same instant in time.

Because processing time can take 1 - 2 seconds, the data output from various navigation sensors is old when it is being output to the NaviPac system. In NaviPac, it is possible to insert the age of the data, and the data will be de-skewed forward in time to compensate for the age.

If a roll and pitch sensor is available, the navigation data will be corrected for antenna swing. Again, because the measurements are done asynchronously, it is important to use the correct roll and pitch with respect to age. The NaviPac system will collect and time tag all roll and pitch data available so the correct inclination value can be used for the correction.

If more than one navigation sensor is available, the NaviPac software can integrate many systems into one position or calculate many position for comparison between systems. When many systems are integrated into one position, the influence of each system can be controlled by the operator by inputting the weight of each LOP. Weight settings of each LOP will be stored on files for use next time the system is switched on.

If two navigation systems are available it is possible to specify one system as primary and the other as secondary. The secondary system could typically be speed log and gyro. If the secondary system consists of gyro and log (dead reckoning) they can continuously be calibrated from the primary system. If the data from the primary system is discontinued, the operator is warned and he may switch over to the secondary system as a fallback system.

4.2.8 Semiautomatic computations

It is possible to do semiautomatic position calculations using a radar or a laser range meter. Before a position can be calculated, the operator must specify the target location by pointing at the target on the electronic map. The coordinates will automatically be fetched from the map database or calculated from the cursor position.

4.2.9 Manual computations

Using the **Utility** library it is possible to manually input data for position calculation. The target positions can be obtained from the electronic chart or manually input.

4.3 Alarm handling in NaviPac

NaviPac Online displays alarm messages in different situations (see example below). If, for example, a position system is not sending any data, Online will go from ‘green’ to ‘red’. The messages will continue each cycle until the error source has been found and fixed.

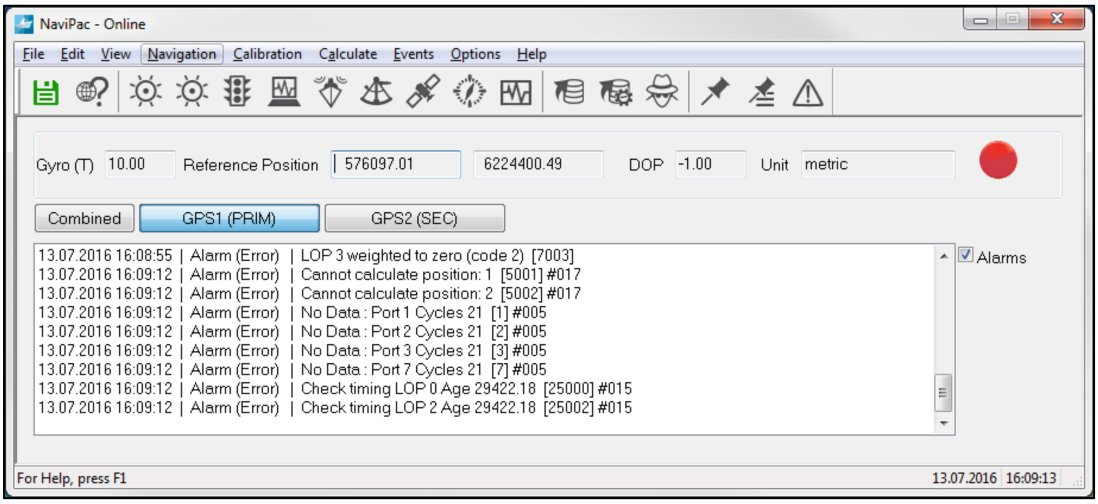


Figure 51 NaviPac red alert

Each alarm is given a unique code (No data: Port 1 Cycles 21 [1] #005 etc) –this number is currently shown in the above figure as [1].

A repeated alarm will not result in continuous scrolling – instead the alarm line will be updated and a number (#0004) will indicated how many times it has occurred.

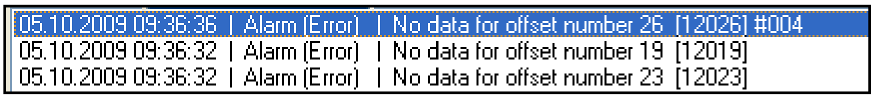


Figure 52 Alarm details

When the system generates an alarm, you may configure Online to give an acoustic alarm (.WAW file) and the window start to flicker. If the Online view is minimised, the icon in the task bar will flicker too.

The label to the top of the **Alarms/Messages** check box becomes red when one or more alarms occur. This indicates that new alarms have appeared. The user can accept the alarm by un-checking the button. This should normally only be done when the reason that the alarm appeared has been solved.

The following major alarms will be generated in NaviPac:

- **No Data: Port <P>**
  Warning: This message is generated if the instrument on port <P> hasn't delivered data within the expected delivery time.
- **Syntax error: Port <P>**
  Warning: The message received on port <P> cannot be interpreted correctly.
- **No data: Object**
  If no data arrives from USBL-system for object (ROV, Sweep, fish, diver etc) or no data from Remote GPS.
- **GPS: non-differential**
  Warning: This message is generated if the GPS was operating in differential mode and suddenly changed to non-differential.
- **GPS error value high**
  If a GPS system is selected as the only primary navigation system, this alarm will appear if the received GPS position differs from the calculated filtered position (Kalman filtering) with more than (sigma).
- **GPS: Differential**
  This message is generated if the GPS changes from non-differential to differential and has proved stable for one minute.
- **GPS: Non RTK**
  This message is presented if an attached GPS loses the RTK state.
- **GPS and system clock differs**
  When the GPS clock and the computer's internal clock differs more than one hour, this alarm will be generated.
- **Age for GPS type <T> = aa.aaa TOO HIGH**
  The GPS receiver has reported an age above 5 seconds.
- **The GPS positions differ too much: Std. Dev dd.ddd**
  If more than one GPS is attached; the reported GPS position is monitored continuously. If they differ too much (see global parameters), a warning is given.
- **The GPS height differs too much: Std. Dev dd.ddd**
  If more than one RTK GPS is attached; the reported GPS height is monitored continuously. If they differ too much (see global parameters), a warning is given.
- **Cannot calculate position**
  If NaviPac, by four cycles, cannot calculate the vessel reference position, the above alarm will be generated (Status -> Red).
- **Alarm on standard deviation (<G>)**
  If the standard deviation gets too high for priority group G (1 to max 5), this message is generated. The message will be generated every time the group changes from below to above the limit.

- **LOP <L> weighted to zero**
  This message will be given if an LOP (number L) is weighted down to zero by NaviPac. This is caused by the comparison between estimated and observed values or similar.

  An additional code defines the exact reason:

1:	Error to big (raw data vs. prediction)
2:	No data on port or zero measurements (eg range = 0)
3/5:	GPS non RTK and RTK required
4/6:	GPS non diff and diff required
8/11:	GPS HDOP above limit
9/10:	Unknown GPS quality flag (code 0)

Table 1 Weighted code reasons

- **LOP <L> disabled**
  This message is generated if the operator has disabled an LOP by setting the weight factor to zero (LOP Control, Weight).
- **LOP <L> enabled**
  This message is generated if the operator has enabled a previously disabled LOP by setting the weight factor to a value greater than zero (LOP Control, Weight).
- **Position adjusted with GPS**
  The position could not be calculated, and the system has performed automatic estimated position using input from GPS.
- **Position outside Geoidal area**
  If the system uses a geoidal file for establishment of local datum, this warning is generated if the vessel moves outside the area.
- **Event generated**
  This info is given each time an event is generated.
- **Too few RTK GPS for gyro calc.**
  If the system uses two RTK GPSs for heading calculation, this message is given if less than two RTKs exists.
- **Distance Event OBJ <no> not selected**
  The object defined for distance events is not active.

- **Time since last event too high: <time>**
  The time since last event has exceeded maximum allowed.
- **Check timing USBL <id> -> Age <time>**
  NaviPac has calculated a strange age of USBL data. Check if time sync is OK on both NaviPac and USBL.
- **Check timing LOP <no> Age <time>**
  NaviPac has calculated a strange age of navigation data. Check if time sync is OK.
- **Age for port xx (GPS aa.aa) wrong - resync time?**
  NaviPac has calculated a strange age of GPS data. Check if time sync is OK.
- **Primary vessel gyro lost - changing to secondary ...**
  The first gyro has dropped out – NaviPac shifts to secondary.
- **Primary vessel motion sensor lost - changing to secondary ...**
  The first motion sensor has dropped out – NaviPac shifts to secondary.
- **Could not open the selected EGG97 file \n Please check settings in NaviPac Geodesy setup**
  The selected EGG97 geoidal file could not be opened.
- **Could not allocate memory for the EGG97 file - %ld bytes was required**
  Could not allocate memory for EGG97 file. Please try to minimize the file size.
- **Event log path is invalid - no events in ASCII format!**
  The specified event log file path is invalid, and no event recording will take place.
- **LEM30 Height changed from %.3lf to %.3lf**
  The input from LEM30 dynamic antenna offset has changed.
- **Change in USBL X/Y too high (Check Setup - USBL tolerance)**
  The USBL data have produced erroneous data – please verify against USBL tolerance settings in the instrument setup.

You may get a better overview of alarms and info messages using the special alarm monitor program called **Alarm Monitor**.

4.4 Navigation modes

NaviPac can be operated in three modes: automatic, semi-automatic and manual.

As default, NaviPac offers the automatic mode, where all surface navigation systems (GPS, Range/Range, Range/Bearing, Gyro, and Log) will be used for computing the ship’s reference position with the wanted update rate. This will happen without any interference from operators.

During operation, all data will be validated through check-sum, predicted filtered values etc, and if problems occur, one or more LOPs will be weighted up or down. If the navigation program changes any parameters used for navigation, a warning will be generated, and the operator may perform actions to solve possible problems.

During operation, the operator may change the LOPs used for navigation, as they may select new stations and de-select existing station.

The automatic mode may be separated in two sub-modes, where the operator can choose between multi-positioning and prioritised positioning.

As default, NaviPac selects the multi-positioning mode, where all LOPs are used for calculating the final ship's reference position, as the user-defined weight factor will be taken into consideration. All components will be shown on the **Base Positions** window, where each LOP will be displayed with measured, converted and predicted values, which allow the operator to monitor quality of each component.

If needed, LOPs can be grouped in up to 5 priority groups using the **Navigation**: **Change Priorities** function. Doing this, the operator can monitor each priority group and compare the groups. This might, for example, be used for checking correctness of one system against another etc. The ship's reference position will only be calculated on basis of priority one LOPs. All components will be shown on the **Base Positions** window, where each LOP will be displayed with measured, converted and predicted values, which allows the operator to monitor quality of each component. When using the prioritised setup, each priority group will be displayed together, and all secondary groups will contain comparison values, which allows operator to compare quality of two or more systems (groups).

If no radio-based surface navigation systems are functional, NaviPac allows semi-automatic or manual navigation, which can be combined with dead reckoning.

Changing the mode from automatic to semi-automatic or manual can only be performed without errors if gyro and speed-log is selected as navigation instruments. Doing the change, the system automatically weights down all ordinary instruments (GPS etc) and weights up gyro and speed log. Furthermore, the navigation state is changed to yellow.

In semi-automatic navigation mode, NaviPac can compute actual position based on ranges to known objects. The ranges can be calculated on basis of either hand held laser meter or radar. These semi-automatically calculated estimations may be performed from time to time (can be calculated automatically with the radar tracking function) or can be used as a base position for dead reckoning.

If laser or radar is not available, the operator may choose the last possibility: manual navigation. Here the operator may enter the position manual, fetch it from a map or calculate it on basis of ranges (or bearings) to known objects. This calculation can be done from time to time or can be used as basis for dead reckoning.

4.5 Navigation state

The Navigation state (ie the quality factor for the calculated position) depends on the selected mode and the amount of generated alarms.

The following table lists the state dependencies for automatic navigation:

Type See section 6.2	Alarm	Status change in Online	Status change in quality control (group)	Note
No data - Surface Nav	Yes	Yes: If less than 2 LOPs accepted in group 1	Yes: If all less than 2 LOP's accepted in group	Status: Yellow first time, then red
No data - Laser meter	No	No	No	Data displayed in laser navigation window
No data - Gyro	Yes	Yes	Yes	Yellow first time, then red
No data - Log	Yes	Yes: If part of priority 1 and number of acc. less than 2	Yes: If number of accepted less than 2	Yellow first time, then red
No data - TSS332	Yes	Yes	Yes	Yellow first time, then red
No data: TP-II obj	Yes	No	No	
No data: SAM (1/2)	Yes	No	No	
GPS: no diff.	Yes	No	Yes (special GPS icon)	GPS quality control icon red
GPS: diff.	Yes	No	Yes (special GPS icon)	GPS quality control icon green
GPS error	Yes	Yes: If less than 2 LOPs accepted in group 1	Yes: If all less than 2 LOPs accepted in group	Yellow first time, then red
Cannot calculate Pos	Yes	If priority 1	Yes	Yellow first time, then red
Std deviation too high	Yes	If priority 1	Yes	Yellow
LOP weighted to 0	Yes	Yes: If less than 2 LOPs accepted in group 1	Yes: If all less than 2 LOPs accepted in group	Results in a 'Cannot calculate Pos' alarm if too few LOPs accepted.

Table 2 State dependencies for automatic navigation

4.6 Navigation scenarios

NaviPac includes three error detection and avoidance functions, which will be described in the following sections: LOP drops out, LOP weighted down and estimated position.

4.6.1 LOP drops out:

Let us assume that the surface navigation is a Range-Range system with 4 LOPs. The mean error on each LOP is 2 m. The NaviPac program will continuously calculate the mean error for each LOP.

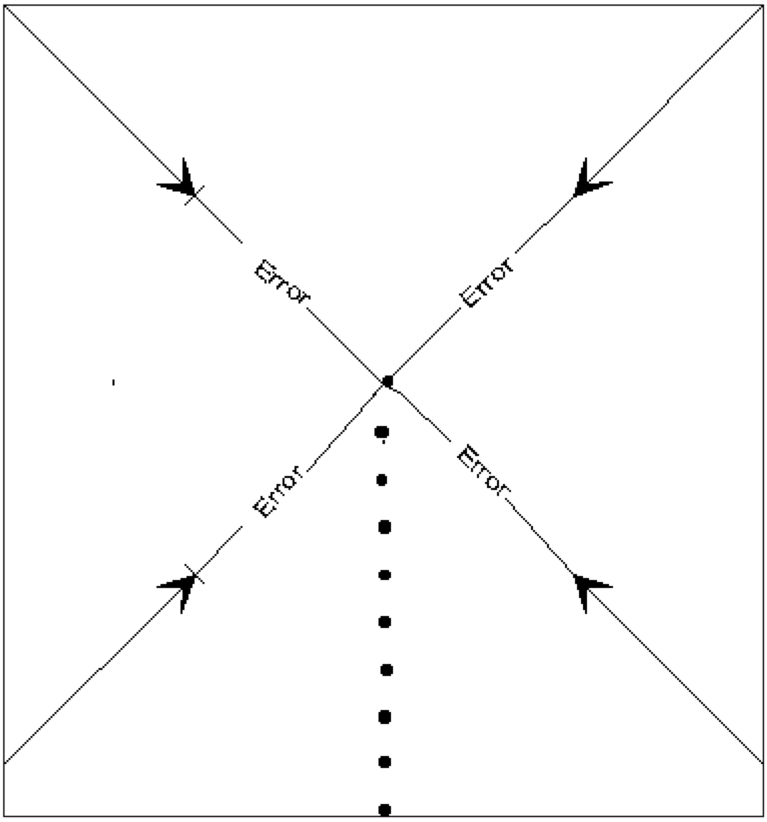


Figure 53 LOP error

If an LOP drops out the NaviPac program will use the predicted range from the Kalman filter and will add the mean error to the range. The result is that no jump in position will take place.

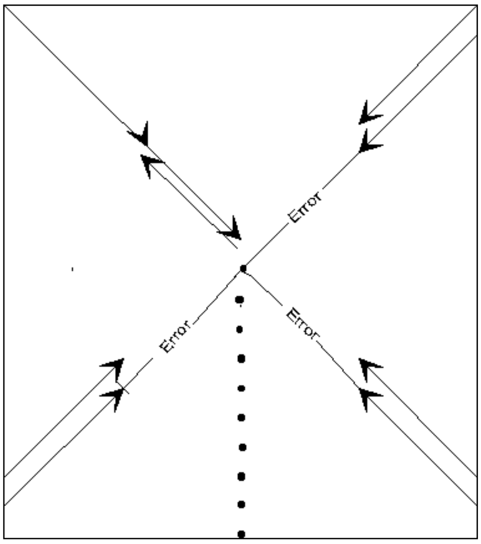


Figure 54 Add mean error to range

If the LOP does not come back, the error value for that LOP will converge to zero at a speed determined by the LOP filter setting. The influence on the position is shown below.

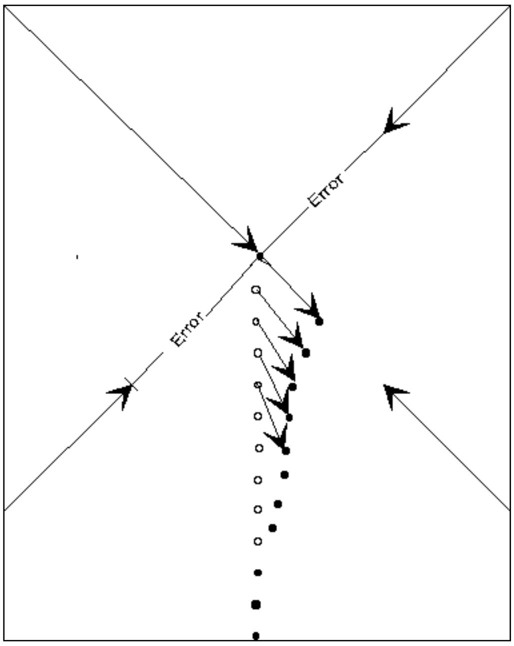


Figure 55 LOP convergence

4.6.2 LOP automatically weighted down

Let us assume that the surface navigation is a Range-Range system and a GPS system. The program will calculate a combined position using all 6 LOPs. As the Range-Range system has 4 LOPs and the GPS system only 2, the combined position will bias towards the Range-Range system, as shown in the figure below.

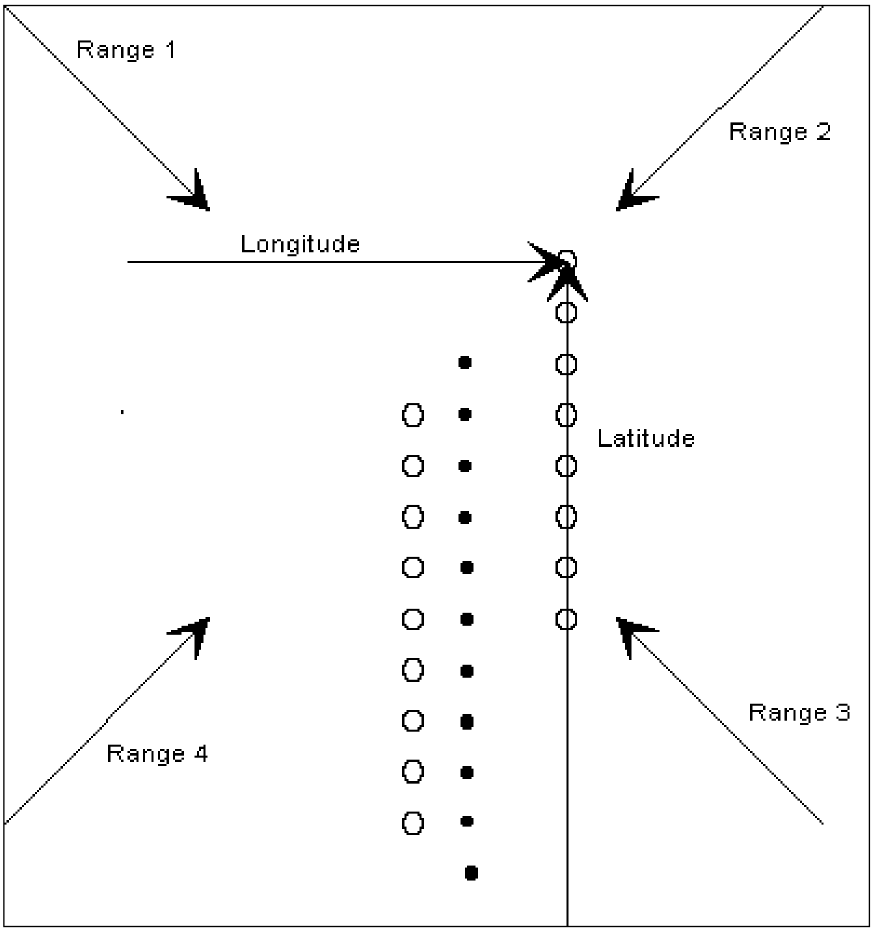


Figure 56 Position bias towards Range-Range system

If the GPS system starts to drift away the combined position will naturally be influenced from the GPS system, but after a while the combined position will fall outside the acceptance window for the GPS system and will slowly be weighted to zero. This means that the combined position will converge toward the Range-Range system, as shown in the below figure.

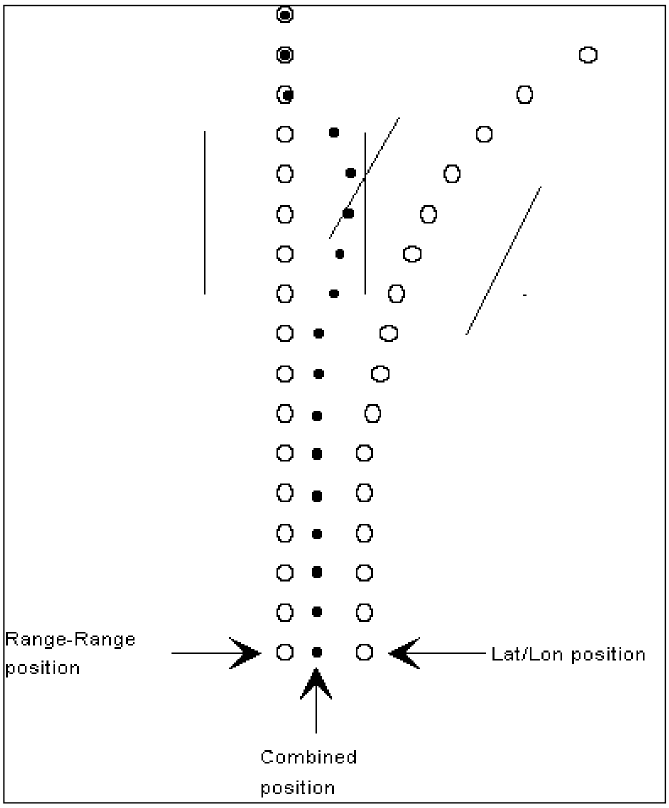


Figure 57 Position convergence towards Range-Range system

4.6.3 Estimated Position

If the calculated (eg on basis of dead reckoning or pure Kalman filter) is too far away from observed values (ie weight of each LOP is below 0.05), the operator must manually bring the calculation back on track. This is done by the Estimated Position function

4.6.4 Differential GPS

The GPS system operates in three quality levels--RTK, differential and ordinary—which can be detected in the **GPS Status** window. The RTK and differential mode offers the highest accuracy, and is preferable. Because of this difference, it is very important that NaviPac handles the RTK and differential modes differently.

When the GPS changes from RTK/differential to ordinary, the following actions will be taken:

- NaviPac generates an alarm telling that the system has changed to ordinary navigation. The alarm will be handled by the main system and presented in online window.
- The GPS LOPs are weighted to a lower weight factor, which is defined as half of the defined maximum.

When the GPS changes from ordinary to differential, NaviPac waits until it has proven stable (RTK/differential for minimum 1 minute) before the following actions will be taken:

- NaviPac generates a message (alarm) telling that the system has changed to differential navigation. The alarm will be handled by the main system and presented in online window.
- The GPS LOPs are weighted back to their maximum weight.

If GPS is used as the only navigation instrument, the state of the GPS also has influence of the calculated standard deviation:

RTK, dGPS: StdDev = (Sigma * HDOP)/10

GPS: StdDev = Sigma*HDOP

4.7 Filtering components

As indicated in the introduction, the NaviPac Kernel uses three complex attributes in the calculation process: sigma, weight and filter value.

We will not give the mathematical definition of the attributes, but to be able to understand and use the components correctly, we will give a popular (and sufficient) description.

4.7.1 Sigma

The sigma setting allow an operator to specify tolerance windows on each LOP in use (range, bearing, GPS reading, gyro and speed log), or in other words, to specify how much a reading may vary before it must be considered as an error.

The sigma is used by NaviPac in comparing the actual LOP reading with the value compared by the predicted value (Kalman estimation), where the difference must be lower than or equal to the sigma. If an LOP value lays outside the tolerance, it is considered wrong, and the LOP will be weighted down (or simply use the predicted value instead of the actual).

If the operator has specified a maximum weight lower than 1, the system will use Sigma/Weight as the tolerance window instead. If, for example, the weight is set to ½, the tolerance window will be doubled.

4.7.2 Weight

As described in previous sections, NaviPac uses a weight attribute for each LOP to handle unreliable readings. A weight can be between 0.0 (none) to 1.0 (full). If an LOP is known to be incorrect in certain areas or just unstable or out of spec for a period, the operator may use the weight figure in the LOP control, where he may specify the maximum weight to use.

As default all LOPs (except gyro and speed log) are given full weight (1.0), and if the operator at any time change a weight to, for example, Ω, this value will be used as the maximum weight (ie the LOP will at maximum contribute with 50% in the final computation).

As described above, the weight has also an influence on the tolerance window.

4.7.3 Filter value

Probably the most important feature in the navigation kernel is the data filtering using least square adjustment for computing CMG/SMG, which helps removing errors and navigation without data.

The filter theory is quite complex, but in short, the filtered value at time *t* can be calculated with the following algorithm:

$$Vf_t = (1 - GAIN) \times V_t + Gain \times Vf_{t-1}$$

where *Vt* gives the unfiltered value at time *t* and Vf_{t-1} the filtered value at time *t*-1.

In the above equation you see that Gain close to 0 implies that filtered values are most influenced by the new raw values and Gain close to 1 result in more influence from old filtered values.

For large vessels or stable ROVs, this implies that the use of relative large Gain is preferable, as the movement will be stable. This will most certainly allow NaviPac to remove errors and produce a smooth and realistic track for low event quality navigation systems.

If the system is used for small unstable vessels, where fast turns and jumpy movements might occur, you have to specify low Gains to allow these movements.

The above equation is simplified, as the Gain must include information about time difference between each computation. If you let CT denote the time (eg ½ second) between each navigation cycle and let F denote a filter setting, NaviPac uses the exponential definition of Gain:

$$GAIN = E^{\frac{-Ct}{F}}$$

In this example, we then obtain the following Gain values, with CT = ½.

CT	0.5
F	GAIN
1	0.606531
2	0.778801
3	0.846482
4	0.882497
5	0.904837
6	0.920044
7	0.931063
8	0.939413
9	0.945959
10	0.951229
20	0.97531
30	0.983471
50	0.99005
60	0.991701
70	0.992883
100	0.995012
200	0.997503

Figure 58 Correlation between Gain and filter value

For most common vessels, the default value of 60 is sufficient. For dead reckoning, the default value of 200 is usually sufficient.

Current and incorrect sensors might cause the difference between the dead reckoning position and the correct position.

4.8 Simulation

NaviPac includes a simulation feature, where one or more sensors may be selected as ‘simulated’. Instead of reading physical data on serial ports, NaviPac calculates realistic data allowing operators to practice in realistic environments.

The selection of sensors to be simulated is performed in the NaviPac Setup program.

If NaviPac Online is started with one or more simulated instruments, a dedicated simulator window is opened. The window will remain open until no instruments are set to simulated.

Note: The simulator window will not be present on next start/restart when no instruments are simulated.

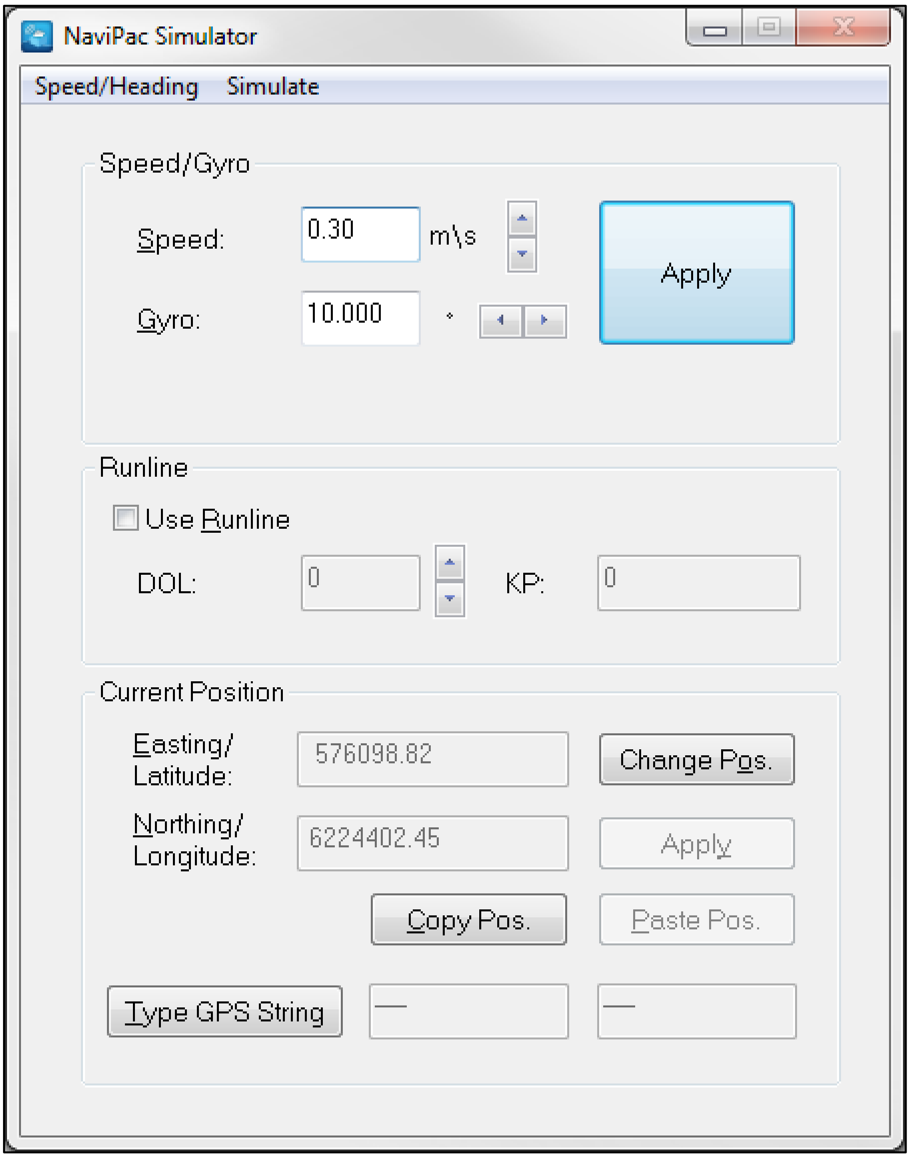


Figure 59 NaviPac simulator

In the simulator window, the operator may specify the current position, current heading and current speed.

Based on this information, NaviPac generates simulated data from the sensors, where the data will include noise to make it as realistic as possible.

Realistic simulations will be performed for the following sensors:

- Gyro based on the given course.
- Speed based on the entered speed.
- Surface navigation LOPs based on the given position, the given course and the given speed.

All other instruments can also be simulated, but the simulation will be more random/static.

4.8.1 Description of fields and buttons

4.8.1.1 Speed

This field shows the current speed in metres per second. The operator may change the speed by typing a new value or clicking **Spin** (interval of 0.1 m/s). Clicking **Apply** will activate the new speed component. Range: -50 to 50 (m/s).

4.8.1.2 Gyro

This field shows the current heading in degrees (ie the simulated gyro). The operator may change the heading by entering a new value or clicking **Spin** (interval of 5 degrees). Clicking **Apply** will activate the new component. Range: 0 to 359.99 °

4.8.1.3 Current Position (Easting)

This field shows that the current estimated position's easting component (ie the base position used by the simulator). The operator may change the easting component by clicking **Change Pos.** and entering a new easting value. The value will be active after clicking **Apply**.

4.8.1.4 Current Position (Northing)

This field shows that the current estimated position's northing component (ie the base position used by the simulator). The operator may change the northing component by clicking **Change Pos.** and entering a new northing value. The value will be active after clicking **Apply**.

4.8.1.5 Change Pos.

When this button is clicked the user can insert a new current position. This enables the current position button **Apply**, which must be clicked to accept changes. **Note**: The simulator stops during **Change Pos.**.

4.8.1.6 Apply

Apply the entered speed and heading to the simulator, and calculate new positions based on these quality factors.

This section summarises the various quality factors offered by the navigating system during operation.

4.8.2 LOP monitoring

Each LOP measurement is compared to the Kalman prediction. The obtained error can be seen in the **Position Monitor** window.

4.8.3 Reference position

During the computation of the final position (primary, secondary etc for prioritised navigation mode), NaviPac computes standard deviation of the position. The standard deviation can be monitored in the **Position Monitor** window.

Furthermore NaviPac computes error ellipse parameters (size of the two axes and the directions) for each priority group.

4.8.4 Dynamic positioning

Each object (SAM, Sweep etc) is also monitored for positioning quality.

All objects will give a raw position, a filtered position and a quality factor (sigma), which gives a total accuracy factor in metres.

Filtered positions will be calculated using a linear filter:

$$X_{Filtered}(T) = (1 - Gain) * X_{Filtered}(T-1) + Speed_X * \Delta_T + Gain * X_{Raw}(T)$$

The GPS-based objects (SAM 1-a and SAM 1-b) gives a direct quality factor in the HDOP factor.

All subsea objects are calculated based on the reference position and partial XYZ from the Trackpoint-II system. Therefore the corresponding quality factor consists of two parts: quality of reference position plus quality of subsea positioning. The system uses the maximum values of **Error Ellipse** for surface navigation and the distance between the raw and the filtered position.

5 Definitions

In this chapter, terms and definitions related to NaviPac will be explained.

Keyword	Description
CMG	Course Made Good. Calculated course based on selected navigation LOPs.
Custom ID	A customer-specific number, which opens for special routines, inputs and outputs.
Data I/O	The program that collects data in real time from various instruments.
EIVAHOME	A path set in the environment which identifies where NaviPac is installed.
GUI	Graphical User Interface.
Gyro	Positive clockwise, zero against north. Rotation around z-axis.
Heave	Movement of vessel due to waves. Positive above datum.
Heave Correction	Height error calculated on basis of GPS RTK height or 3D laser tracking system corrected for geoidal separation, 3D offsets and heave. (Gives a value for eg tide and heave bias.)
Kernel	Program (non-interactive) that among other functions, calculates a reference position based on selected LOPs in the Online program.
LBL System	Long Base Line. Underwater positioning system (eg Sonardyne and Kongsberg).
LOP	Line Of Position. Each sensor that can input data to NaviPac and be used to the position calculation.
Navigator	The NaviPac operator (eg a surveyor, the helmsman).
Object	The term covers all static and dynamic offsets (ie position of offset on vessel, position of ROV, position of remote vessel etc).
Online	The online GUI program in the NaviPac Software for Windows NT.
Online DB	A database file where the current selected set-up (actual used LOPs in position calculation etc.) is saved. Located in $EIVAHOME/DB/onlsetup.DB.
Pitch	Positive, when bow raises from horizontal plane. Rotation around x-axis.
QC	Quality Control in NaviPac. Calculations made in a GUI program started from Online (View menu).
Roll	Positive, when starboard (right side of ship) sinks from horizontal plane.
Set-up	The program to set up projections, instruments etc in NaviPac. (From 3.5 onwards, this is handled in NaviPac Configuration.)
Setup database	A database file where the setup (created in Setup program) is stored. Located in $EIVAHOME/DB/gensetup.DB
SMG	Speed Made Good. Calculated speed on basis of selected LOPs.
USBL system	Ultra Short BaseLine (eg HiPap APOS, Trackpoint II, etc).
User ID	See Custom ID.

X offset	Offset across vessel/object; positive starboard.
X position	East or west direction, given in selected projection.
Y offset	Offset along vessel; positive front.
Y position	North or south direction, given in selected projection.
Z Offset	Offset height; positive up.

Table 3 Terms and definitions

6 Figures and tables