WinFrog Device Group:	**GPS**
Device Name/Model:	**MX9400**
Device Manufacturer:	**Leica Geosystems Inc** 23868 Hawthorne Boulevard Torrence, CA 95050 USA Tel: (310) 7915300 Fax:(310) 791-6108 E-mail: info@leica-gps.com
Device Data String(s) Output to WinFrog:	Configurable: can incl. NMEA and Leica proprietary
WinFrog Data String(s) Output to Device:	A series of $PMVXG type strings for unit initialization and enabling of output options. (See Configuration Details for more info.)
WinFrog Data Item(s) and their RAW record:	POSITION 303

DEVICE DESCRIPTION:
There are two different MX 9400 models: the MX9400N and MX9400R. The MX9400N is designated as a navigator model, whereas the MX9400R is a reference station model. (Note that the MX9400R can also be used for mobile operations). There is also a MX9401R model that is the same as the MX9400 except that it is packaged in a weatherproof housing. All references below will refer to these units simply as the MX9400.

The MX9400 processes both the C/A and P Code measurements to generate three-dimensional positions. The MX9400 can accept standard RTCM SC-104 input to generate and output a differentially corrected position. The MX9400 can also output pseudorange, ephemeris, and time and date information, which can be used by WinFrog's GPS Calculations extension module to internally calculate a GPS position.

The MX9400 utilizes 4 serial interface ports that communicate via a set of proprietary sentences in accordance with the NMEA –0183 standard to command and control the equipment. These 4 ports are combined into a 25 pin "DB" type multi-port interface connector found at the rear of the unit. A special cable must be used in conjunction with the multi-port interface. This cable splits the single port into 4 separate connectors, each representing an individual "port" and providing a specific purpose.
Port 1,2, and 3 are RS-232 ports; Port 4 is a RS-422 port. Port 1 is fixed as the Control Port. All ports are factory set to 9600 baud, but are configurable to range from 300 to 38,400 baud.

The MX9400's four ports have the following default configurations:

Port 1: RS232, PC control and data messages, 9600 baud default–Input/Output
This port is used to receive control commands from WinFrog.
Port 2: RS232, Instrumentation/Raw data – Output

This port is used to output the raw GPS measurement data (ie Pseudorange and Ephemeris data) to WinFrog
Port 3: RS232, Differential Corrections (MX41R, MX 51R, &MX52R) – Input only for MX9400N/ Input and Output for MX9400R
Port 4: RS422, Equipment/ NMEA – Input/Output

There are also 2 additional connections found in the MX9400's rear panel:

- Time: 1PPS - 8.0 to 9.5 VDC; 250 msec pulse; 25 nsec rise time
- Event Input: Closure

NOTE: These default functions can be modified. WinFrog sends the MX9400 a type 71 message to reconfigure the MX9400's port functions. Depending on the user made selections (described below), the Instrumentation / Raw Data Port (Port 2) and NMEA (Port4) data output may be reassigned to Port 1.
This allows WinFrog to receive multiple data messages from a single MX9400 port (Port1), into a single computer port.

This device can provide time synchronization using 1PPS with $--ZDA. See chapter 8.

DEVICE CONFIGURATION INSTRUCTIONS

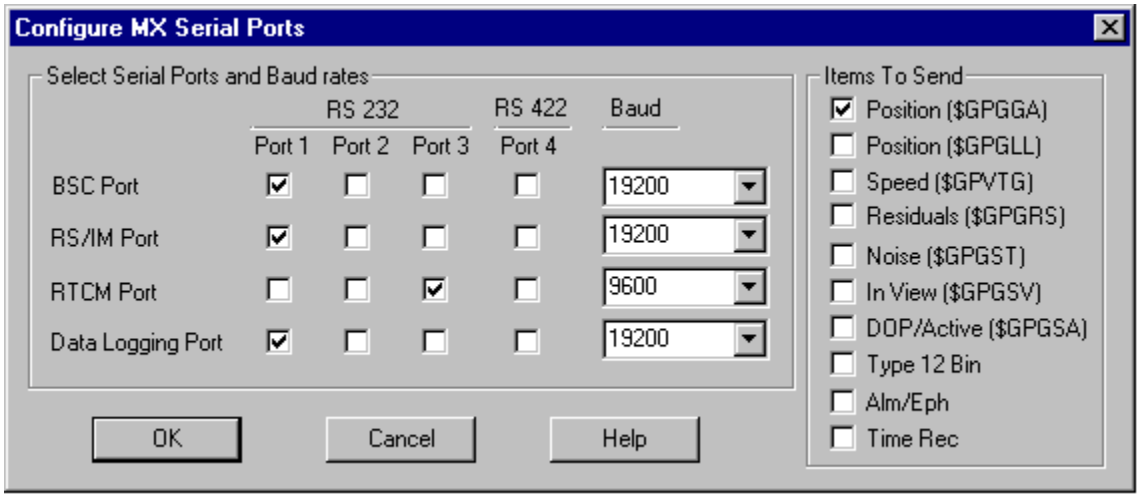
WINFROG I/O DEVICES > EDIT I/O:
Serial
Configurable Parameters

The MX9400 is added to WinFrog from the **GPS** device group. Configure the *Device I/O Parameters* dialog box for the appropriate Baud Rate, Data Bits, Stop Bits, Parity, and Comm Port. These selections refer only to the WinFrog computer port that is connected to the MX9400 CDU port (i.e. Port 1 on the MX9400, see below for more on the MX9400's ports). Select the **OK** button to confirm the port configuration.

The *Configure MX Serial Ports* dialog box now appears, as seen below. This dialog box allows you to configure the MX9400's 4 serial ports; defining what data will pass through which port, the Baud rates for the selected ports, and which items are to be sent through the selected ports.

Make the required selections (as described below), then click the **OK** button to send this data to configure the MX9400.

Note that the MX9400's 4 ports are all combined into a single standard DB25 type connector found in the back of the MX9400. A special cable is required to "split" the single port into 4 separate cables that represent the 4 individual ports.



Select Serial Ports and Baud Rates:
As mentioned above, each of the MX9400's serial ports is designated for specific tasks. The default configuration of WinFrog's **Configure MX Serial Ports** dialog box (as seen above) reconfigures the MX9400's ports' duties so that the MX9400 uses Port 1 for both input of CDU commands and output of Instrumentation/Raw data and NMEA messages.

This dialog box also allows you to define which Data Items are to be output by the MX9400. The **Items to Send** are defined as follows:

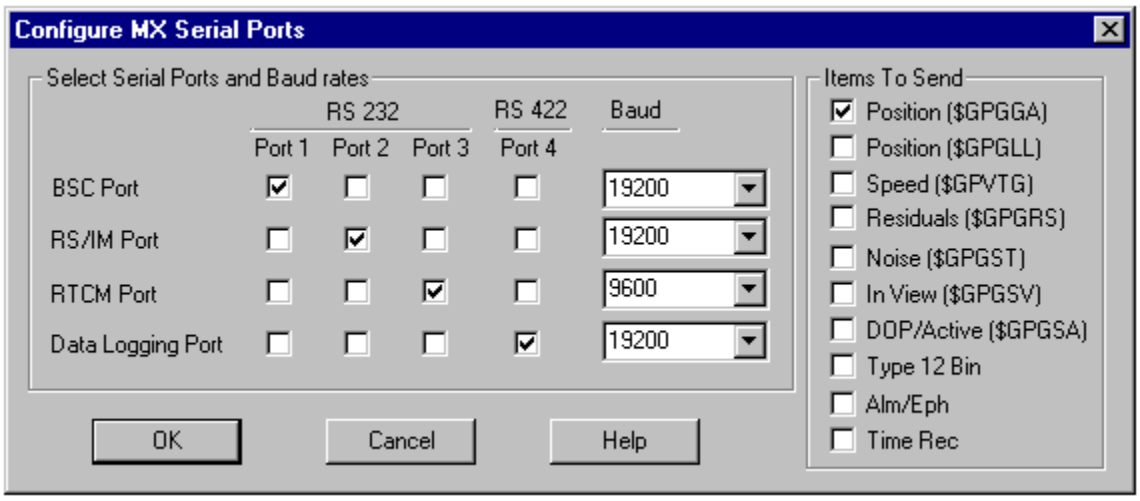
Position ($GPGGA):
This is a standard NMEA format type message (containing GPS Latitude / Longitude/Status data), output through the "Data Logging " port.
Position ($GPGLL):
This is a standard NMEA format type message (containing GPS Latitude / Longitude data) output through the "Data Logging " port.
Speed ($GPVTG):
This is a standard NMEA format type message (containing Track and Speed Over Ground data), output through the "Data Logging " port.
Residuals ($GPGRS):
This is a standard NMEA format type message (containing GPS Residual data), output through the "Data Logging " port.
Noise ($GPGST):
This is a standard NMEA format type message (containing GPS Pseudorange Error Statistics), output through the "Data Logging " port.
InView (GPGSV):
This is a standard NMEA format type message (containing GPS Satellite in view data), output through the "Data Logging " port.
DOP/Active(GPGSA):
This is a standard NMEA format type message (containing DOP values and which satellites are used), output through the "Data Logging " port.

Type 12 Bin:
This is a Leica proprietary data format containing satellite measurement data in a compressed binary format, output through the Instrumentation / Raw Data port
Alm/Eph:
This refers to the output of GPS Ephemeris and Almanac data in a Leica proprietary format though the Instrumentation / Raw Data port. The Ephemeris data records (Leica type 200 proprietary format), are output once an hour for each satellite being tracked. The Almanac data records (Leica type 100-150 proprietary format), are output at the request of WinFrog by sending the $PMVXG,074 message).
Time Rec:
This refers to the output of GPS Time recovery data (values computed by the navigation filter relating to the receiver clock state) through the Instrumentation / Raw Data port.

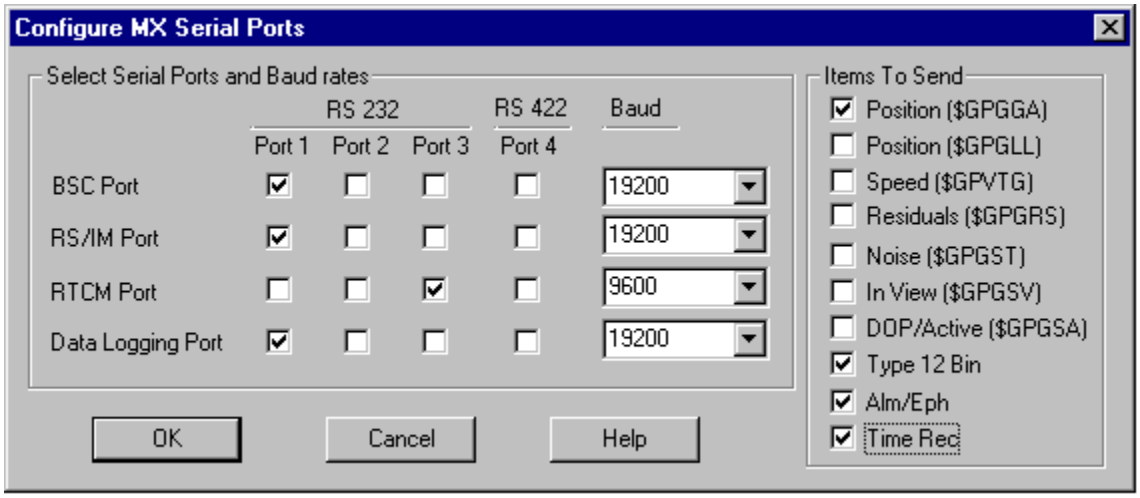
If you are using the MX9400 to simply provide a position to WinFrog, you can select to send only the $GPGGA (preferred) or the $GPGLL item. As defined above, by default, these NMEA messages are output from the Data Logging port (i.e. port 4). In order to interface to the MX9400 through just one of its ports, you must reassign this output to another port - port 1. (Port 1 must be interfaced to WinFrog in order for the CDU commands to be received, so this is the port of choice). To reassign the output of NMEA data to Port 1, select the bottom left checkbox.

To further clarify the re-assignment of the MX9400 ports, shown below are several different configurations of the Configure MX Serial Ports dialog box.

The first configuration shown below retains the MX9400's default port configuration: i.e. the Control and data messages (referred to as "BSC" in WinFrog) are made through port 1, the Instrumentation/Raw Data ("RS/IM") are output through port 2, Differential RTCM (RTCM) is input/output through port 3, and Equipment/NMEA (Data Logging) messages are output through port 4. This configuration would require you to connect all four of the MX9400's ports to the WinFrog computer.



As mentioned previously, in order for WinFrog to communicate with the MX9400 using only one of the MX9400's four ports, WinFrog reassigns the data output to port 1 of the MX9400, as seen below.



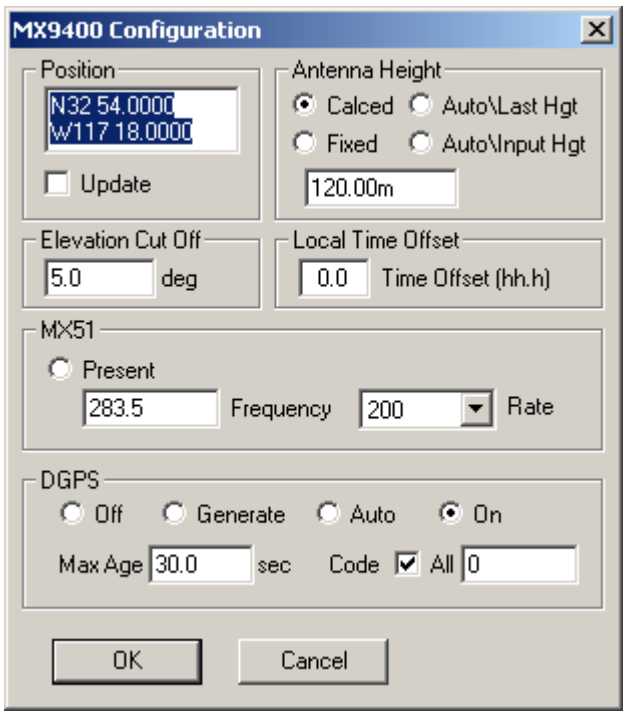
This configuration has assigned PC Control input, Raw data Output, and NMEA output to port 1. Differential correction data (RTCM) is still assigned to port 3 - this is to where you would connect the DGPS receiver.

The configuration above has also defined the output of NMEA format $GPGGA positional data, and raw Pseudorange/Ephemeris/Time data required for WinFrog's Multi-Ref positioning. This configuration is typical of that used in most WinFrog operations. If you are only using the MX9400's internally calculated position, you need only select a Position ($GPGGA or $GPGLL) item.

Once this dialog box is correctly configured, click the **OK** button. WinFrog sends the configuration commands to the MX9400, and closes the dialog. To reconfigure any one of these options, select the MX9400 device in the I/O Devices dialog box, then right click and select Edit I/O. Click OK to close the standard Edit I/O dialog box, at which point the **Configure MX Serial Ports** dialog box appears.

WINFROG I/O DEVICES > CONFIGURE DEVICE:

This device must be configured at the I/O Device window level. In the I/O Devices window, click the device name to select it, then right-click and select Configure Device. The MX9400 Configuration dialog box appears, as seen below.



Position:
A valid initial position should be entered. This provides an initial estimate of receiver position for Rover operations, and reference station coordinates if the MX9400 is used as a DGPS reference station. You must select the Update Box for the entered value to be used.

Antenna Height:
Set the MX9400's Antenna height calculation mode by selecting the appropriate radio button. Select one of the 4 different modes of height calculation, as desired:

Calculated – This selection forces the MX9400 to use pseudo-range calculations to compute the GPS antenna's Height. In this mode, the MX9400 requires a minimum of four satellites in order to calculate a valid 3-dimension position.

Fixed – This mode selection fixes the MX9400's height to the ellipsoidal height value entered in the *Ellipsoid Height* box. In this mode, the MX9400 is able to calculate valid positions using a minimum of three satellites.

Auto\Last Height – The MX9400 will calculate a valid 3D position if four or more satellites are available. If only three satellites are available, the height is fixed to that of the last valid calculated height. In this mode, the MX9400 is able to calculate valid positions using a minimum of three satellites.

Auto\Input Height – The MX9400 will calculate a valid 3D position if four or more satellites are available. If only three satellites are available, the height is fixed to the value entered in the *Ellipsoid Height* box. In this mode, WinFrog is able to calculate valid positions using a minimum of three satellites.

Note: Ensure that the value entered in the Ellipsoid Height dialog box refers to the WGS 84 ellipsoid, not Mean Sea Level height.

Elev. Cutoff:
Enter the elevation limit value (in degrees above the horizon). If a satellite drops below this value, it will not be used in the position calculations.

Local Time Offset:
This value will be added to the observed GPS time to offset WinFrog system time.

MX51:
If the ***Present*** radio button is selected, WinFrog will accept RTCM 104 data from the MX 51R/52R Beacon Receivers. You must also define the Frequency and Rate settings to match the MX51 settings.
The MX 51R/52R are fully compatible with U.S. Coast Guard and IALA DGPS beacons and operate with any DGPS beacon broadcasting in the 283.5 to 325.0 KHz band.

DGPS (mode):
The MX9400's DGPS mode is set within this box. There are four different DGPS modes: Off, Generate, Auto, and On:

Off – The MX9400 will not use differential corrections in its position computations for that device even if they are available. Instead it will compute only a single point GPS solution.

Generate – The MX9400 will generate base station corrections based on the GPS data being received and the position input at the top of the window.

Auto – The MX9400 will automatically use differential corrections in its GPS position calculations if those corrections are available to the receiver. If no corrections are available, the MX9400 will compute a single point solution.

On – Th MX9400 will always attempt to use differential corrections. If no corrections are available, the MX9400 will not compute a position.

The **Maximum Age of Corrections** must also be defined. If the age of the received RTCM corrections exceeds the entered value, the corrections are not applied to the single point position.

If the **All** box is checked, then RTCM corrections from any received base station will be used;

If the **All** box is not checked, you must define which particular reference station to use by entering the reference station's code. The **Code** entry box allows you to specify which Differential Base Station will be used by the MX9400.

Once you have configured this dialog box and clicked the **OK** button, WinFrog sends the configuration option messages to the MX9400. It may take a few moments for the changes to take affect in the MX9400.

WINFROG VEHICLE > CONFIGURE VEHICLE DEVICES > DEVICE DATA ITEM > EDIT:

Adding the MX9400 device creates three data items: POSITION, PSEUDORANGE and EPHEMERIS.

The MX9400 can provide WinFrog with an internally calculated (DGPS) position message in one of two NMEA formats; GGA and GLL. This is added to the vehicle by adding the **GPS,MX9400, POSITION** data item.

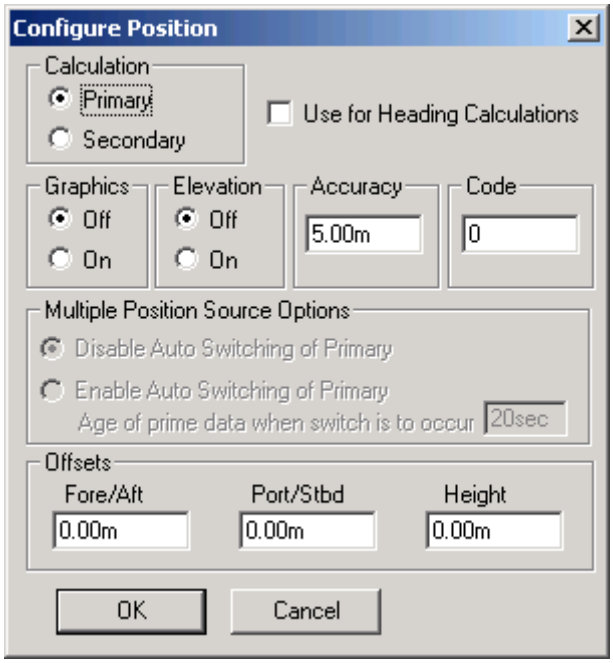
The MX9400 can also output raw Pseudorange and Ephemeris data for WinFrog to calculate the position itself (using WinFrog's GPS Calculations extension module). This is setup by adding both the **GPS, MX9400, PSEUDORANGE** and the **GPS, MX9400, EPHEMERIS** data items to the vehicle's device list.

Typically, both options are desired; the internally configured position provides a backup position to WinFrog's more flexible Multi-Ref solution.

As per any and all devices, once you've added a MX9400 data item to a vehicle's Device list, it must be edited to suit the vehicle's configuration. Note that not all data items require this vehicle specific configuration.

Data item: GPS, MX9400, POSITION

The POSITION data item must be edited once it is added to a vehicle's device list. Highlight the data item in the vehicle's device list and click the Edit button. The Configure Position dialog box appears as seen below.



Calculation:
Set the Calculation selection to Primary or Secondary. Devices set to Primary calculation are used to provide a vessel position. Note that more than one Primary positioning device can be added to a vehicle's device list; data from these devices will be combined in a weighted mean solution. (See the paragraph on Accuracy below for more on the weighting of Primary calculation device data).

If the Calculation type is set to Secondary, WinFrog will simply monitor the device's data. WinFrog will not use the data from a secondary device in the final solution of the vehicle's position.

If auto switching is enabled (see below) a secondary may automatically become a primary should all the primaries fail.

Use For Heading Calculations:
Select this checkbox if the device is to be used in conjunction with another GPS device for determination of the heading of the vessel.

Graphics:
If On is selected, a labeled square will show the raw (offset but unfiltered) location of the GPS antenna in the Graphics and Bird's Eye windows. This provides a means of comparing raw device and filtered vehicle positions.

Elevation:
Setting the Elevation option to On will result in the elevation determined by GPS to be used as the elevation of the vessel referencing the GPS (WGS84) Ellipsoid. The sounder data recorded in WinFrog's .RAW data files will not be affected.

This option is meant only for those applications where there is no fixed vertical reference (i.e. mean sea level), such as on a river. For acceptable results, this option requires the use of high accuracy “RTK” GPS data.

Accuracy:
The Accuracy value entered provides WinFrog with the expected accuracy of the position from this device. This value is used in the weighting of this device compared to other positioning devices that may be added to the vehicle’s device list. The smaller the value entered, the more accurate it is considered to be, and hence the more weight that will be applied to the device’s data.

The Accuracy parameter can be changed from the suggested values. Changes should be made with caution, however, as they will affect the final filtered position of the vehicle.

Code:
This entry window is used when the GPS data is being received by a remote GPS receiver connected via telemetry link. If this is the case, set the Code to coincide with the code parameters associated with the GPS unit being used.
For all other applications, the Code entry must be set to 0.

Multiple Position Source Options:
This group box allows you to enable automatic switching of a secondary to primary should the data from all POSITION and PSEUDORANGE data items set to primary timeout. The **Age** entered is the length of time that the secondary will wait in the absence of data from all primaries, before taking over as primary. This age is only entered for the secondary.

For example, if the POSITION or PSEUDORANGE data items associated with two GPS receivers were set to primary and the POSITION or PSEUDORANGE data item of a third GPS receiver was set to secondary, both primary GPS receivers must time out before the secondary will become the primary. Upon the recovery of either of the original primary data items, the original primary will be reset to primary and the original secondary will be reset to secondary.

Note for the auto switching feature to work, there must be at least one primary and one secondary enabled. For example, given two data items, one set to primary with the auto switching disabled and the other set to secondary with the auto switching enabled, if the primary fails the secondary is not set to primary and the vehicle positioning stops until the primary data item recovers.

Disable Auto Switching of Primary:
If this data item is not to be involved in the auto switching process, check this box. As stated above, this data item is then not involved in the auto switching process in any way.

Enable Auto Switching of Primary:
If this data item is to be involved in the auto switching process, either as a primary or a secondary, check this box. If set to secondary, enter the Age of data the primary data items must reach before this secondary is switched to act as the primary.

In order for this option to be effective you must have at least one primary and one secondary. If there are multiple secondary data items that are enabled for switching, the first one to receive data will become primary.

Note: This option is not enabled unless WinFrog determines that there is more than one POSITION and/or PSEUDORANGE data item associated with the respective vehicle. The exception to this is the case of a WinFrog with the Remote module operating as a Controlled Remote being configured remotely from the Controller. In this case, the option is always enabled even though it may not be applicable. The operator must be aware of what is available on the Remote and configure the data item accordingly.

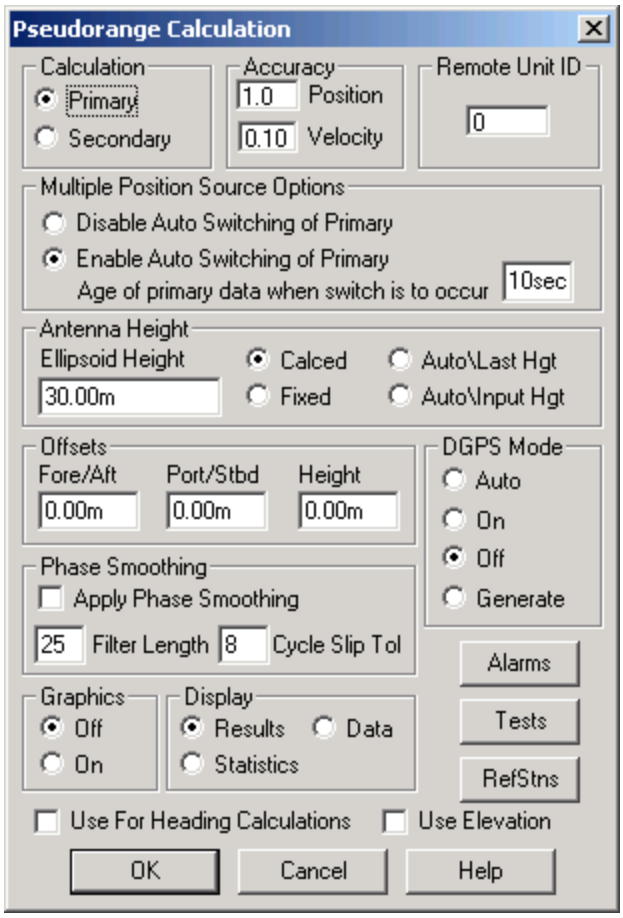
Note: This option is not available in the WinFrog Remote package.

Note: This option is not available for USBL based POSITION data items.

Offsets:
Offsets are required to associate the GPS antenna position with the vessel's Common Reference Point (CRP). The offsets are applied *from* CRP (of the vehicle) *to* the GPS antenna location.
Forward Offsets are entered as positive values.
Aft Offsets are entered as negative values.
Starboard Offsets are entered as positive values.
Port Offsets are entered as negative values.
Height Offsets are positive upwards. (It is suggested that the vessel's Height origin should be at the water line.

Data item: GPS, MX9400, PSEUDORANGE
As mentioned above, both the Pseudorange device and the Ephemeris device must be added to the vehicle's device list. You must edit the Pseudorange device to suit the vehicle. There is no configuration required for the Ephemeris device.

In the vehicle's Devices list, highlight the GPS, MX9400, PSEUDORANGE device and click the Edit button. The Pseudorange Calculation dialog box appears, as seen below.



Calculation:
Set the Calculation selection to Primary or Secondary. Devices set to Primary calculation are used to provide a vessel position. Note that more than one Primary positioning device can be added to a vehicle's device list; data from these devices will be combined in a weighted mean solution. (See the paragraph on Accuracy below for more on the weighting of Primary calculation device data).

If the Calculation type is set to Secondary, WinFrog will simply monitor the device's data. WinFrog will not use the data from a secondary device in the final solution of the vehicle's position.

If auto switching is enabled (see below) a secondary may automatically become a primary should all the primaries fail.

Accuracy:
The Accuracy value entered provides WinFrog with the expected accuracy of the position from this device. This value is used in the weighting of this device compared to other positioning devices that may be added to the vehicle's device list. The smaller the value entered, the more accurate it is considered to be, and hence the more weight that will be applied to the device's data. The Accuracy parameter can

be changed from the suggested values, although changes should be made with caution, as they will affect the final filtered position of the vehicle.

The Velocity value is used in positional filtering. The lower the value entered, the more smoothing that is applied.

Remote Unit ID:
The Remote Station ID parameter is set to zero (0) unless the GPS device is interfaced to WinFrog via a telemetry device.

Multiple Position Source Options:
This group box allows you to enable automatic switching of a secondary to primary should the data from all POSITION and PSEUDORANGE data items set to primary timeout. The **Age** entered is the length of time that the secondary will wait in the absence of data from all primaries, before taking over as primary. This age is only entered for the secondary.

For example, if the POSITION or PSEUDORANGE data items associated with two GPS receivers were set to primary and the POSITION or PSEUDORANGE data item of a third GPS receiver was set to secondary, both primary GPS receivers must time out before the secondary will become the primary. Upon the recovery of either of the original primary data items, the original primary will be reset to primary and the original secondary will be reset to secondary.

Note for the auto switching feature to work, there must be at least one primary and one secondary enabled. For example, given two data items, one set to primary with the auto switching disabled and the other set to secondary with the auto switching enabled, if the primary fails the secondary is not set to primary and the vehicle positioning stops until the primary data item recovers.

Disable Auto Switching of Primary:
If this data item is not to be involved in the auto switching process, check this box. As stated above, this data item is then not involved in the auto switching process in any way.

Enable Auto Switching of Primary:
If this data item is to be involved in the auto switching process, either as a primary or a secondary, check this box. If set to secondary, enter the Age of data the primary data items must reach before this secondary is switched to act as the primary.

In order for this option to be effective you must have at least one primary and one secondary. If there are multiple secondary data items that are enabled for switching, the first one to receive data will become primary.

Note: This option is not enabled unless WinFrog determines that there is more than one POSITION and/or PSEUDORANGE data item associated with the respective

vehicle. The exception to this is the case of a WinFrog with the Remote module operating as a Controlled Remote being configured remotely from the Controller. In this case, the option is always enabled even though it may not be applicable. The operator must be aware of what is available on the Remote and configure the data item accordingly.

Note: This option is not available in the WinFrog Remote package.

Antenna Height:
Set the Antenna Height using the radio buttons and the (input) Ellipsoid Height field. Settings are as follows:

Calculated – Select this option to force WinFrog to calculate the GPS antenna Height, as well as its Latitude and Longitude. In this mode, WinFrog requires a minimum of four satellites to be visible.

Fixed – Select this option to fix the GPS antenna ellipsoid height to the value entered in the **Ellipsoid Height** field. In this mode, WinFrog is able to calculate valid positions using a minimum of three satellites.

Auto\Last Height – If this mode is selected, WinFrog will calculate a 3D position if four or more satellites are available. If only three satellites are visible, or if the VDOP of the solution exceeds the value set in the Alarms dialog box, the height is fixed to that of the last valid position. In this mode WinFrog is able to calculate valid positions using a minimum of three satellites.

Auto\Input Height – If this mode is selected, WinFrog will calculate a valid 3D position if four or more satellites are available. If only three satellites are available, or if the VDOP of the solution exceeds the value set in the Alarms dialog box, the height is fixed to the value entered in the **Ellipsoid Height** field. In this mode, WinFrog is able to calculate valid positions using a minimum of three satellites.

Note**:** The Antenna height entered in the **Pseudorange Calculation** dialog box refers to the WGS 84 Ellipsoid.

Offsets:
Offsets are entered to relate the GPS antenna position to the vessel's Common Reference Point (CRP). Offsets are entered as measured from the CRP (of the vehicle) to the device (antenna) location. Offsets Fore and Starboard are entered as positive values, offsets measured Port and Aft are entered as negative values. Rule of thumb suggests the CRP "Z" reference should be at the water line.

DGPS Mode:
Select the desired mode of DGPS operation

There are four different DGPS modes: Auto, On, Off and Generate.

Auto: WinFrog will automatically use differential corrections in its position calculations, when available. If no corrections are available, WinFrog will compute a single point (autonomous) position solution.

On: WinFrog will always attempt to use differential corrections. If no corrections are available, no position will be computed.

Off: WinFrog will not use differential corrections in its position computations, even if they are available. Instead it will always compute a single point GPS solution.

Generate: WinFrog will generate differential corrections based on a fixed reference position. This option is used for Base Stations only.

Phase Smoothing:
Phase smoothing utilizes the GPS receiver's observations of the GPS satellite's carrier signals. Because the GPS L1 frequency has a wavelength of only 19 cm., measurements made using this signal will provide higher accuracy than measurements made on the C/A code message modulated onto the L1 signal. Note, however, that since the carrier phase position is derived from the C/A code position, it does not offer an improvement in precision.

If the Phase Smoothing feature is enabled, WinFrog will use the C/A Code derived (DGPS corrected) position to derive the number of L1 wavelengths to each of the observed satellites. Over the length of time entered into the **Filter Length** field (value in seconds), WinFrog will switch the GPS calculated position from the C/A code position to the derived Carrier Phase position.

WinFrog will continue to use the carrier phase data to provide positioning until the **Cycle Slip Tolerance** is exceeded. A Cycle Slip is the loss of lock on a satellite's signal. This loss of lock forces WinFrog to re-establish the number of wavelengths from the antenna to the satellite. If the number of cycle slips exceeds the Cycle Slip Tolerance, WinFrog will resort back to the C/A code position and re-calculate the number of wavelengths to all received satellites.

Graphics:
Select the On radio button to display a labeled square in the Graphics and Bird's Eye displays depicting the raw (unfiltered) location of the GPS antenna. This provides a means of comparing raw and filtered positions between different sources.

Display:
The selection made here determines which type of information will be displayed in WinFrog's Calculations window (when the GPS Pseudorange device is turned on for display in that window). Select from the three provided options:

Results – The Calculations window will show the results of the GPS Calculations, including the Multi-Ref position and all individual solutions.

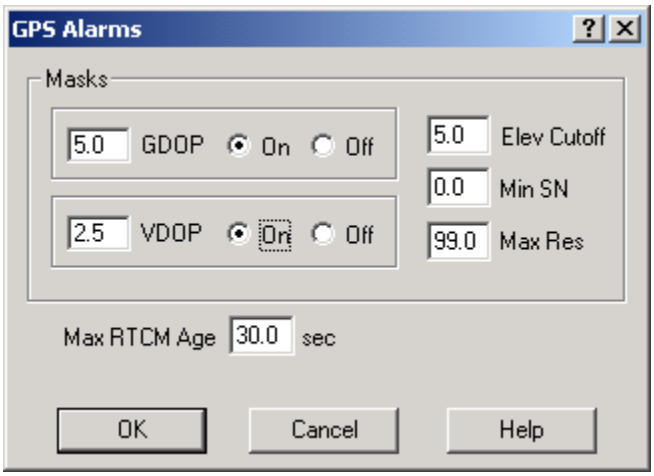
Data - The Calculations window will show the results of the GPS Calculations, including the Multi-Ref position and data related to each individual carrier phase solution (when Phase Smoothing is enabled).

Statistics - The Calculations window will show the results of the GPS Calculations, including the Multi-Ref position and statistical data related to each individual solution.

Use For Heading Calculations:
Select this checkbox if the device is to be used in conjunction with another GPS device for determination of heading of the vessel. In most cases, only high accuracy receivers should be used for heading calculations as WinFrog simply inverses the individual sensors' raw positions to derive the bearing between them.

Use Elevation:
Setting the Elevation option to "On" will result in the elevation determined by GPS to be used as the elevation of the vessel's CRP referencing the GPS (WGS84) Ellipsoid. The height of the antenna above (below) the CRP must be entered. Do not enable this option unless you are utilizing high accuracy (centimeter level) RTK type GPS positioning.

Alarms:
Click this button to view and enable various GPS alarms, as described below.



GDOP – Geometric Dilution of Precision. GDOP is a numerical value that serves as a measure of the effect of the satellite constellation's geometry on the derived positional accuracy. In other words, the GPS receiver's measurement accuracy is multiplied by the GDOP value to derive the overall positional accuracy of the GPS receiver (including the three positional dimensions and clock offset). If the GDOP mask is set to On and the calculated GDOP exceeds the entered value,

WinFrog will not compute a position solution using pseudoranges. If the Calculations window is enabled, an alarm will sound to indicate that the GDOP has been exceeded.

VDOP – Vertical Dilution of Precision. This parameter is also calculated from satellite geometry and gives an indication of the expected accuracy of the vertical component of the GPS position solution. If the VDOP mask is set to On and the calculated VDOP exceeds the entered value, WinFrog will automatically initiate 2D or fixed height mode using either the last valid calculated height or the height entered in the Antenna Height **Ellipsoid Height** field. If the Calculations window is enabled, an alarm will sound to indicate that the VDOP has been exceeded.

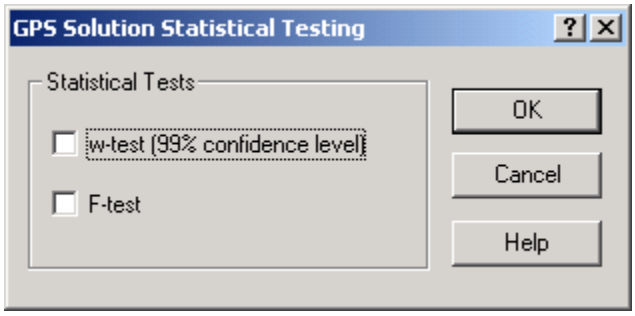
Elev. Cutoff – (Elevation Angle Cutoff). WinFrog will not use measurements from any satellites with elevation angles below the angular value input in the Elevation Angle Cutoff field. Any satellites not used in the pseudorange position calculations are indicated in the Calculations window by a change of color.

Min SN – Minimum Signal to Noise. This field is used to set the minimum signal to noise ratio for the pseudorange calculations. If a satellite's signal to noise ratio falls below the entered value, the satellite will not be used in position computation by WinFrog. Satellites not used in the position computation due to low signal to noise values are indicated in the Calculations window by a change of color.

Max Res – Maximum Measurement Residual. WinFrog will not use any satellite measurement with a residual greater than the Maximum Measurement Residual in its pseudorange position computations. Satellites not used in the position computation due to measurement residuals are indicated in the Calculations window by a change of color.

Max RTCM Age – Maximum RTCM Differential Correction Age. This parameter sets the maximum latency of real time differential corrections for pseudoranges. If the maximum latency is exceeded, WinFrog will not apply the corrections from that RTCM source. To indicate this condition, the **STAT** light in the Position portion of the Calculations window will turn yellow. Click on the **ACK** button to acknowledge this alarm.

Tests:
Click this button to open the **GPS Solution Statistical Testing** dialog box, as seen below.



This dialog box provides you with the ability to enable or disable statistical w test and F tests. By default, both of the w-test and the F-test are turned off.

w-Test:

The w-test entails normalizing the residuals of a GPS pseudorange solution and testing these against a 99% confidence limit for outliers. This limit is 2.576. If outliers are found, they are removed and the solution is re-executed excluding that satellite data pertaining to the outlier. If more than one satellite is found to produce a residual outlier, only that satellite with the largest normalized residual is eliminated. This continues until no outliers are present *or* until the exclusion of any more data would result in insufficient data for a solution (four satellites for 3D and three for 2D). Since the normalized residuals tend towards being equal with reduced redundancy (as the number of satellites used in the solution approaches the minimum required), it is unlikely that WinFrog will ever have to stop the exclusion of data due to insufficient satellites. Nonetheless, WinFrog still checks for this condition.

Caution should be exercised when using this option. If the vessel is too far away from the selected reference stations and/or there are few satellites in common with the vessel and the reference station(s) the w-test option may eliminate data to the point where the solution approaches the minimum required.

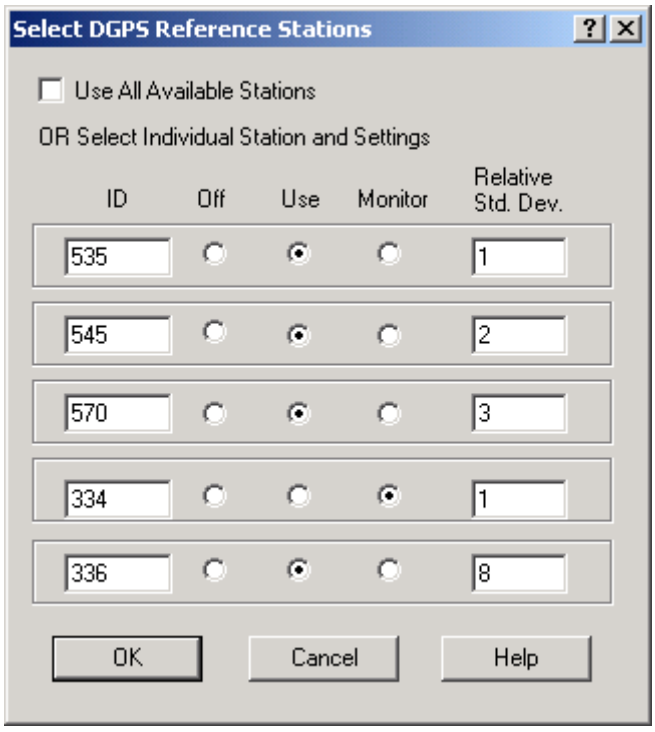
F-Test:

The F-test is a check of the unit variance of the GPS pseudorange solution. This confirms the validity of the model used for the solution and the weighting of the observations used. Note that it is only a confirmation check, no data or solution results are thrown out based on the results of the test.

The unit variance is the sum of the weighted, squared residuals, divided by the degrees of freedom (number of redundant measurements) in the solution. The F-Test should result in unity. If the unit variance is consistently different from unity, it indicates that there may be a problem with the stochastic model used, or an unmodeled bias in the data.

RefStns:

Click the RefStns button in the Pseudorange Calculation dialog box to open the Select DGPS Reference Stations dialog box, as seen below.



The Select DGPS Reference Stations dialog box allows you to define which reference stations will be used by WinFrog in its Multi-Ref solution. You can either configure WinFrog to simply use all received stations (to a maximum of 5), or you can control the use of corrections, as deemed proper.

To use all received DGPS corrections, select the **Use all Available Stations** checkbox. When this checkbox is selected, all available RTCM corrections are utilized in the solution, each with the same Relative Standard Deviation.

The individual station method is preferable as it allows you to remove or de-weight solutions that may not agree with the weighted mean solution. If this method is used, you should add the RTCM data item to the vehicle's device list once for each solution, then edit that solution entering the proper code and coordinates. For example, if there are five Reference stations to be used in the Multi-Ref solution, add the **RTCM,RTCM1,DGPS-COR's** data item to the vehicle's device list five times.

From the Configure Vehicle-Devices dialog box, highlight and edit each RTCM data item to indicate a unique Code.

Now, back in the **Select DGPS Reference Station** dialog box, ensure that the Use all Available Stations checkbox is not selected. Now the individual reference station ID's must be entered, along with station usage and relative standard deviation values, as detailed below:

Select DGPS Reference Stations:
Selection of individual stations is as follows:

ID – The Reference Station identification code. See SkyFix documentation for a listing of all SkyFix reference station ID Codes. Coast Guard Beacon corrections also contain unique codes for each station.

In the above example, SkyFix stations 535, 545 and 570 are used with assigned relative standard deviations along with Coast Guard station 336. Coast Guard Station 334 is monitored and is therefore not utilized in the position solution.

Off – Corrections from the selected Reference Station will not be used in the Multi-Ref position solution. This individual solution and will appear in red text in WinFrog's Calculations window and not update.

Use – Reference Station is used in the Multi-Ref position solution, and will appear in the Calculations window in black text. This individual solution will appear in red text if no solution (refer to DGPS Mode) can be calculated from the data.

Monitor – Reference Station is simply monitored by WinFrog, and is not used in the Multi-Ref position. This solution will appear in yellow text in WinFrog's Calculations window.

Rel. Std. Dev – This value defines the relative standard deviation of this solution as compared to the other solutions used in the Multi-Ref position. Equal Rel. Std. Dev. values indicate that all individual solutions will be equally weighted in the Multi-Ref solution. Entering a higher Rel. Std. Dev value will de-weight an individual solution compared to the others in the Multi-Ref solution.

CONFIGURE CALCULATIONS WINDOW

A Calculations window can be configured in WinFrog, allowing you to monitor the status of the Mulit-Ref solution and make appropriate adjustments. To open the Calculations window select **View > Calculations** from the main menu. In the Calculations window, select the appropriate vehicle from the dropdown list and click the Setup button.

In the Setup Calculation Views dialog box, select the **Position** and **Data Item Text** checkboxes. Next, highlight the **Pseudorange data item**, click the **On** button and exit with OK. Refer to Chapter 14, GPS Calculations Displays section of the WinFrog User's Guide for more detailed descriptions of the various options and displays available with the Calculations window.

CONFIGURATION DETAILS:

Refer to the MX9400 operator's manual and CDU programming documentation for information on setting up the receiver to output a NMEA GGA positioning string.

RAW DATA LOGGING:

WinFrog sends various $PMVXG messages to the MX9400,depending on operator option selections:

- $PMVXG,035,0,,,"); // set receiver mode to "navigator"
- $PMVXG,007,,1,,,,,,"); // stop proprietary outputs on CDU port
- $PMVXG,026,,1,,,,"); // turn off equip port output
- $PMVXG,007,412,,1,,5,,,"); // turn psn output to CDU port
- $PMVXG,007,100,,1,,2,,,"); // turn SV trking status output to CDU port
- $PMVXG,007,000,,1,,5,,,"); // turn RCVR status output to CDU port
- $PMVXG,001,%d,,%.3lf,%.3lf,,,%.1lf,%c,%.0lf", tempHgtMode,
- $PMVXG,053,%d,%.0lf,0,,6,%d,0,0,0,", tempDgpsCode
- $PMVXG,034,%d,0,0,%.1lf,%d,0,,,", tempBitR. Rate of 50 (1), 100 (2) or 200 (3).

Items to Send Messages:

$PMVXG,026,XXX,,1,1.0,6,"); // turn on GPXXX message, where XXX can be:

- GGA
- GLL
- VTG
- GSA
- GST
- GRS
- GSV
- Type 12 Bin
- Almanac / Ephemeris
- Time Record

Note: Refer to NMEA0183 Sentence formats for the above data sentences.

MX9400 SPECIFICATIONS (Manufacturer's):

Receiver Description

- Tracking: 12-channel continuous tracking of code and phase.
- Sensitivity: -143dBm Costas threshold
- Measurement Accuracy: 10cm code (single epoch) 5mm phase

Connectors

- Multiport I/F: DB25S
- Time: SMB (Jack receptacle)
- Event Input: SMB (Jack receptacle)
- Antenna: SMA (Jack receptacle)
- Power: DC Power Jack (0.1 dia.)

Navigation Mode

- Operating Modes: 2D or 3D ,DGPS, GPS or auto selection
- DGPS Input: RTCM SC-104 format
- Time to First Fix: 1 minute typical
- Accuracy: Position: 30 cm RMS/15 cm RMS (AccucodeTM)
- Velocity: .05 m/s RMS
- Dynamics: 3g