

WinFrog Device Group:	GPS
Device Name/Model:	MX7140
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:	Binary
WinFrog Data String(s) Output to Device:	Binary
WinFrog Data Item(s) and their RAW record:	POSITION 303 PSEUDORANGE 303 EPHEMERIS NONE TIMEDATE 999

DEVICE DESCRIPTION:

The MX7140 is a 6 channel GPS receiver capable of outputting a DGPS position, as well as pseudorange, ephemeris and time synchronization data. The pseudorange and ephemeris data can be used in WinFrog's GPS Calculations Module to derive a DGPS position using multiple reference stations. The TimeDate data can be used to synchronize WinFrog's virtual time with the more accurate GPS time.

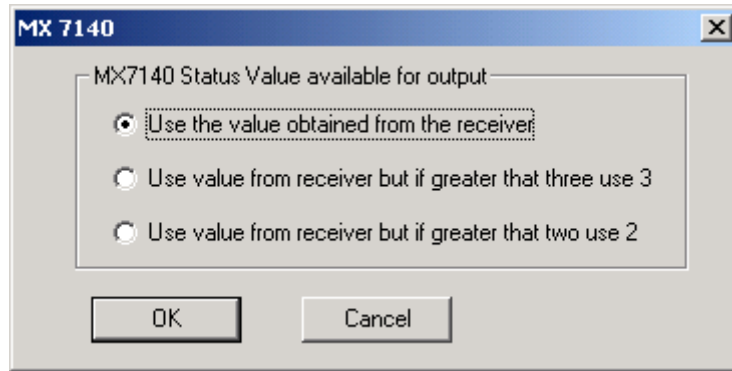
DEVICE CONFIGURATION INSTRUCTIONS

WINFROG I/O DEVICES > EDIT I/O:

Serial
Configurable Parameters

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 MX 7140 dialog box appears, as seen below.



Select the desired Status Value option. For the NMEA GGA message, the GPS status (quality) codes are:

- 0 = Fix not available or invalid
- 1 = GPS SPS Mode, fix valid
- 2 = Differential GPS, SPS Mode, fix valid
- 3 = GPS PPS Mode, fix valid

Refer to MX7140 documentation for more information on the Status Values output by the MX7140.

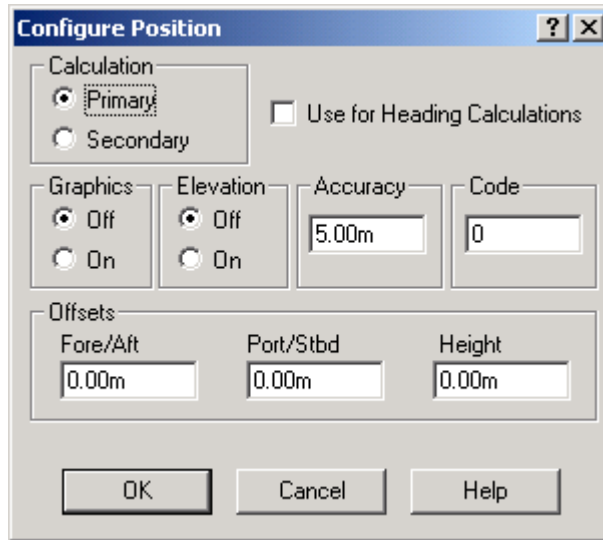
WINFROG VEHICLE > CONFIGURE VEHICLE DEVICES > DEVICE DATA ITEM > EDIT:

Adding the MX7140 device creates four data items: POSITION, PSEUDORANGE, EPHEMERIS and TIMEDATE. Once the data items have been added to the vehicle, they must be edited to suit the application.

Data item: GPS, MX7140, POSITION

If the MX7140 is configured to output an internally calculated DGPS position to WinFrog then this data item can be used.

The Position data item must be edited once it is added to a vehicle's device list. Highlight the POSITION 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 position data from the device in the final solution of the vehicles' position.

Note: In the case of Primary device failure, WinFrog will not automatically use the Secondary devices for the vessel's position computation. Instead, the vehicle's positioning will go to dead reckoning (if dead reckoning is turned on). You must manually change a Secondary device to Primary in order for the data to be utilized.

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. The vessel's heading will be derived by the inverse of the GPS antenna coordinates.

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, however, changes should be made with caution 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.

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 items: GPS, MX7140, PSEUDORANGE

GPS, MX7140, EPHEMERIS

For use with WinFrog, the MX7140 is set to output raw Pseudorange and Ephemeris data. WinFrog’s optional GPS Calculations Extension Module can utilize raw GPS Pseudorange and Ephemeris data. With this extension module, WinFrog is able to combine the raw data with RTCM format differential corrections from up to 5 different base stations to calculate 5 independent antenna positions. These 5 positions are then combined in a weighted mean solution to result a single Multi-Ref antenna position. See Chapter 14 of the WinFrog User’s Guide for more details on using the WinFrog GPS Calculations Extension Module. A Calculations window can be configured, in WinFrog, allowing you to monitor the status of the Multi-Ref solution and make appropriate adjustments. See the section later in this document entitled *Configure Calculations Window* for more details on setting up and using the Calculations window.

Although the EPHEMERIS data item is essential and must be added to the vehicle's device list, no configuration is required for this device. All position calculation configuration is accomplished by highlighting the PSEUDORANGE data item in the Configure Vehicle-Devices window and clicking the Edit button. The Pseudorange Calculation window appears as seen below.

Calculation:

Select either Primary or Secondary radio button. Devices set to Primary calculation are used to produce a vehicle position. If more than one positioning device added to the vehicle's device list is deemed as primary, WinFrog will weight them based on the accuracy value entered. Devices with a higher accuracy value (i.e. lower entered value) will be weighted higher.

If a positioning device's calculation is set to Secondary, WinFrog will not use the position data in the calculation of the vehicles' position solution; that device's position will simply be received and monitored. Note that in the case of Primary device failure, WinFrog will not automatically use the Secondary devices for the vehicle position computation. Instead, it will start dead reckoning (if dead reckoning is turned on). You must manually change a secondary device to primary status if you want to utilize the data coming from that device.

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 referencing the GPS (WGS84) Ellipsoid. Do not enable this option unless you are utilizing high accuracy (centimeter level) RTK type GPS positioning.

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. However, 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.

Antenna Height:

Set the Antenna Height using the radio buttons and the (input) Ellipsoid Height box. 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** entry box. 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 entry window (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:

If On is selected, a labeled square will be made visible in the Graphics and Bird's Eye windows, 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 Calculation window (when the GPS Pseudorange device is turned on for display in that window). Select from the 3 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).

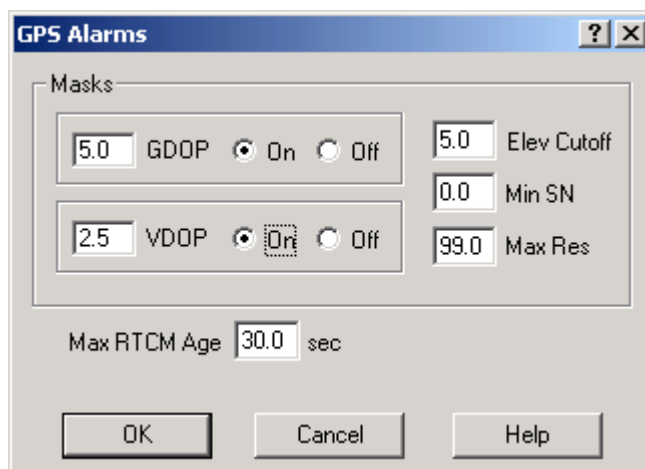
Statistics - The Calculations window will show the results of the GPS Calculations, including the Multi-Ref position and statistical data related to each individual solution.

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 inverts the individual sensors' raw positions to derive the bearing between them.

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 box. 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.

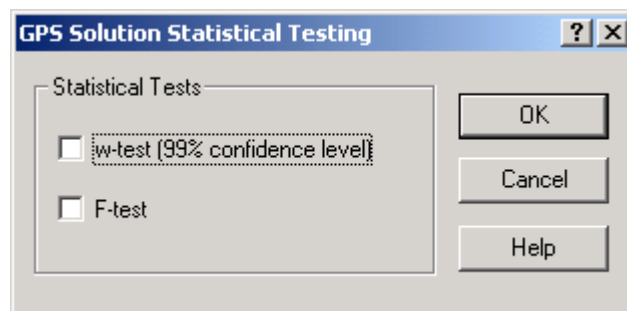
Max Res - Maximum Measurement Residual. WinFrog will not use any satellite measurement with a residual greater than the Maximum Measurement Residual in its pseudorange position computations. Satellites not used in the position

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 the **ACK** button to acknowledge this alarm.

Test:

Click this button to bring up 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 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.

Ref-Stns:

Click the RefStns button in the Pseudorange Calculation window to bring up the Select DGPS Reference Stations display, as seen below.

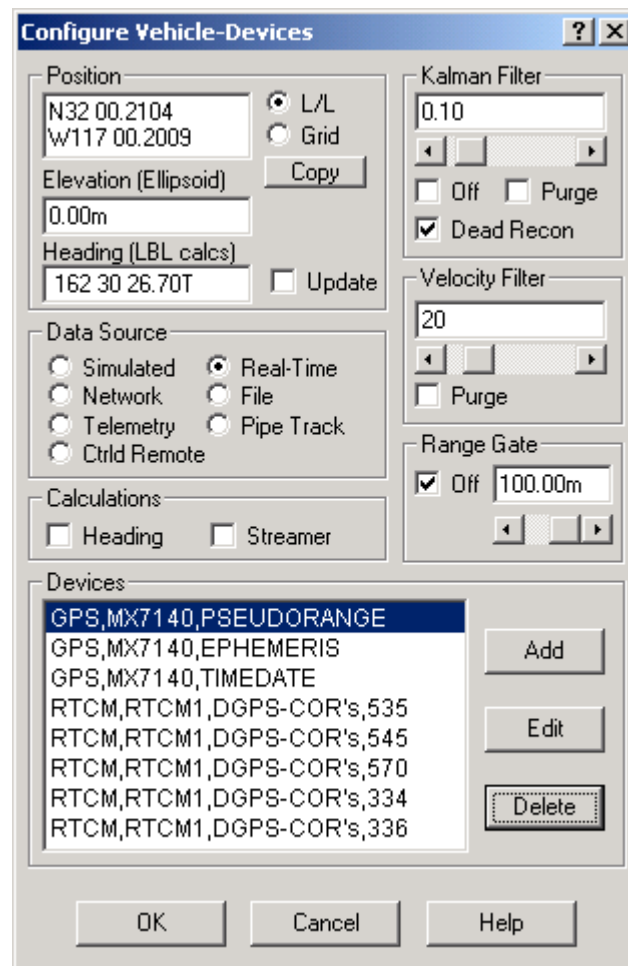
ID	Off	Use	Monitor	Relative Std. Dev.
535	☐	☒	☐	1
545	☐	☒	☐	2
570	☐	☒	☐	3
334	☐	☐	☒	1
336	☐	☒	☐	8

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. Note that regardless of the RTCM source, each base station should only be used once in each Multi-Ref solution.

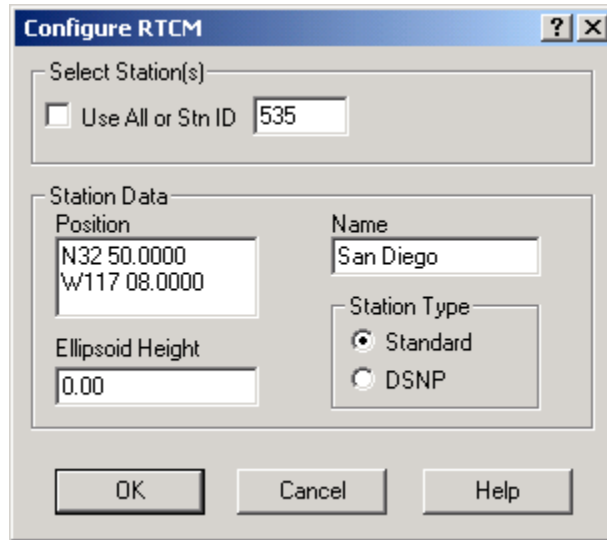
To use all received DGPS corrections, select the Use all Available Stations checkbox at the top left-hand corner of the dialog. When this checkbox is selected,

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 5 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 5 times as seen below.



From the Configure Vehicle-devices dialog, highlight and edit each RTCM data item to indicate a unique Code, as seen below.



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 will appear in red text in WinFrog's Calculation window and not update.

Use – Reference Station is used in the Multi-Ref position solution, and will appear in the Calculation 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.

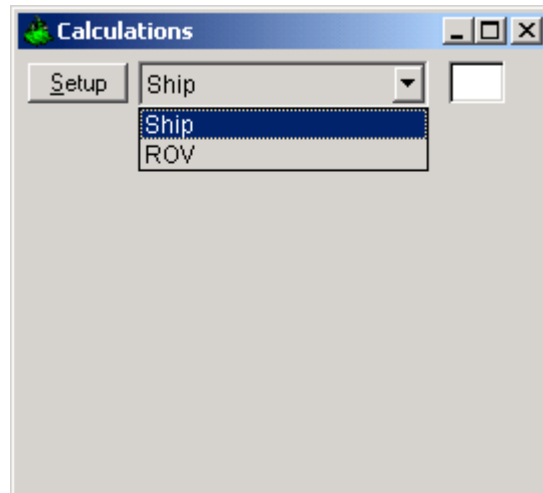
Monitor – Reference Station is simply monitored by WinFrog, and is not used in the Multi-Ref position. This solution will appear in yellow text in WinFrog's Calculation window.

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

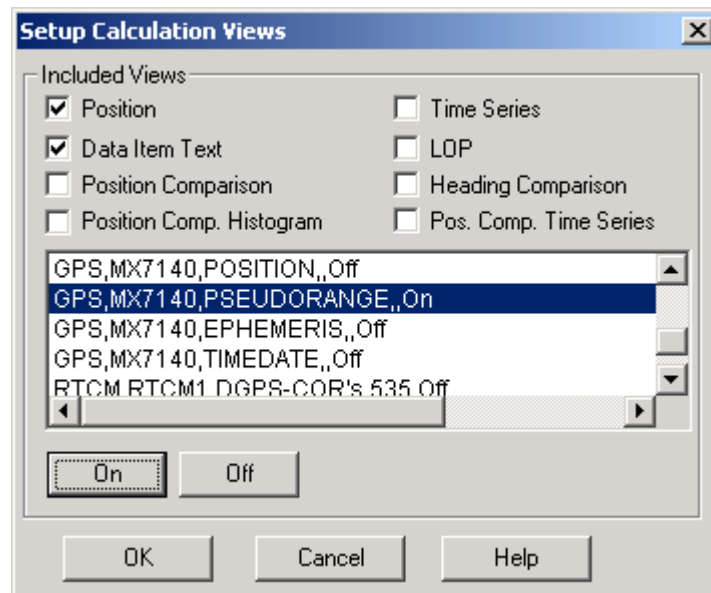
Multi-Ref solution. Entering a higher Rel. Std. Dev value will de-weight an individual solution compared to the others in the Multi-Ref solution.

CONFIGURE CALCULATIONS WINDOW:

As previously mentioned, a Calculations window can be configured in WinFrog, allowing you to monitor the status of the Multi-Ref solution and make appropriate adjustments. To open the Calculations window select **View > Calculations** from the main menu. From the dropdown list, select the appropriate vehicle as seen below.



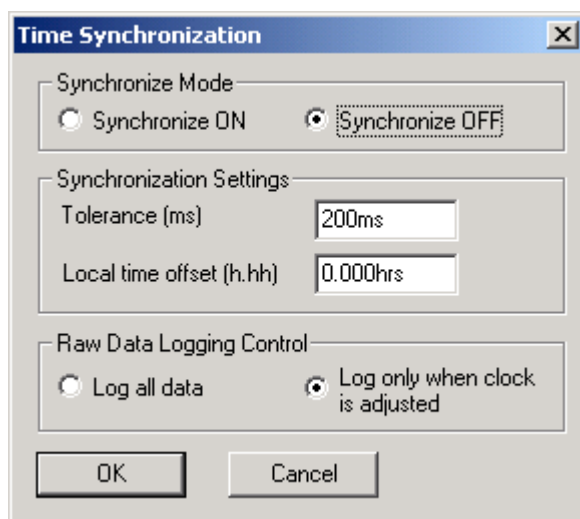
Click the **Setup** button and select the **Position** and **Data Item Text** checkboxes.



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 this calculation window.

Data item: GPS, MX7140, TIMEDATE

The MX7140 TIMEDATE data item may be edited once it is added to a vehicle's device list. Highlight the GPS, MX7140, TIMEDATE data item in the vehicle's device list and click the Edit button. The Time Synchronization dialog box appears as seen below.



Select the Synchronization On option to enable WinFrog to synchronize its virtual time with the GPS time output by the MX7140 receiver.

In the Synchronization Settings section, the Tolerance, entered in milliseconds, defines the maximum limit of the difference between WinFrog's virtual time and the GPS time before WinFrog's time is reset. In the above example, if WinFrog's time goes ahead or falls behind the incoming GPS time by more than 200 milliseconds, WinFrog's time will be reset to the GPS time.

The Local Time Offset value is added to the incoming GPS time to correct it to the local time. Note that the offset value entered can be a positive or negative number.

NOTE: The computer's system clock is not reset to the GPS time – only WinFrog's time is affected by enabling the synchronizing option.