Dynamic Calibration

Work Instruction | NL-MAI-TCH-WI-037 | Issue 06

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1. Purpose

The purpose of this document is to detail the steps to be taken to process in office the data of a Dynamic Calibration performed on a vessel. This processing consists of five steps. First the raw data needs to be converted, (Section 2) and then processed to precise-point-positions (Section 3). Once this has been done, it can be processed in GravNav (Section 4) and consecutively in the Dynamic Calibrations Sheet (Section 5). Then the final results can be created (Section 6).

1.1 Abbreviations

1.2 Related documents

The following documents may also need to be referred to:

Title	Document No.

2. Raw Data

2.1 Converting Raw GNSS Data to Trimble / NovAtel Format

Raw data received from the vessel will consist of something similar to the folders in Figure 2.1.

SPK_Primary_PORT	07/12/2016 10:32	File folder	
SPK_Primary_STB	07/12/2016 11:55	File folder	
SPK_Secondary_FWD	07/12/2016 10:32	File folder	
SPL Data	07/12/2016 10:32	File folder	
20161204-Log Book Scan.pdf	06/12/2016 09:18	Adobe Acrobat D...	524 KB
20161205-Log Book Scan.pdf	06/12/2016 09:17	Adobe Acrobat D...	444 KB
AD492_Side.gif	21/09/2016 19:59	GIF Image	2,631 KB
AD492_Top.gif	21/09/2016 20:03	GIF Image	2,806 KB
CN103 Dynamic Cal Dat_20161204.zip	06/12/2016 09:15	zip Archive	272,249 KB
CN103 Dynamic Calibration - Field Data _...	06/12/2016 10:30	Microsoft Word 9...	5,150 KB
CN103-DOR 080_05122016.pdf	06/12/2016 09:19	Adobe Acrobat D...	537 KB
Copy Of BE801_FSBV.svs	04/12/2016 13:32	SVS File	11 KB

Figure 2.1: Dynamic calibration data received from vessel

The "Dynamic Calibration – Field Data" sheet (Figure 2.2) details aspects of the data logging for the dynamic calibration, including specification of the types of GNSS receivers used.

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GNSS Receiver	Card Type	Dyn Cal Antenna	Coordinates (Vessel Coordinates Frame)		
			X [m]	Y [m]	Z [m]
SPK Primary STB (Serial No: 01326)	Trimble BD982	AD492	10.055	90.651	21.707
SPK Secondary FWD (Serial No: 00522)	NovAtel OEMV3G	AD492	0.039	103.937	21.729
SPK Primary PORT (Serial No: 00591)	NovAtel OEMV3G	AD492	-9.715	90.648	21.772

Figure 2.2: Example of Dynamic Calibration – Field Data Sheet

This information should be used to determine which executable file is required to convert the raw data in its native 'rinex' format, to Trimble / NovAtel format.

The executable files can be found in the following location - P:\03.04 SUPPORT\03 Equipment\01 Positioning and Attitude Solutions\01 GNSS\Fugro - Starpack\04 Software\SPEXPORT

Extract the relevant .zip file, containing the executable file and the .ini file, and paste this into the raw data folder containing the .spm data. Amend the .ini file as per the information in pages 4 and 5 of "Extracting raw GNSS observations from SPM files.pdf", defining the settings for NovAtel and Trimble GNSS cards. Ensure to only edit the relevant parameters in this file.

Once the .ini file has been amended, select the executable file to run. Upon completion, the window will close, and a file matching the name of the "output=" entry in the .ini file will be in the same folder. In this case, "out.raw" for NovAtel data.

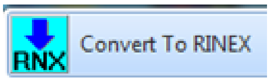
out.raw	07/12/2016 13:51	Headerless RAW ...	63,277 KB
spexport.exe	09/01/2013 15:28	Application	18 KB
spexport.ini	07/12/2016 11:55	Configuration sett...	1 KB
spmc0418.spm	05/12/2016 14:59	SPM File	19,854 KB
spmc0419.spm	05/12/2016 14:59	SPM File	19,276 KB
spmc0420.spm	05/12/2016 14:59	SPM File	19,265 KB
spmc0421.spm	05/12/2016 14:59	SPM File	20,422 KB
spmc0422.spm	05/12/2016 14:59	SPM File	18,002 KB
spmc0423.spm	05/12/2016 14:59	SPM File	19,286 KB
spmc0500.spm	05/12/2016 14:59	SPM File	18,053 KB
spmc0501.spm	05/12/2016 14:59	SPM File	17,867 KB
spmc0502.spm	05/12/2016 14:59	SPM File	19,891 KB
spmc0503.spm	05/12/2016 14:59	SPM File	20,612 KB
spmc0504.spm	05/12/2016 14:59	SPM File	18,115 KB
spmc0505.spm	05/12/2016 14:58	SPM File	17,756 KB

Figure 2.3: Output file after running "spexport.exe"

Repeat this process for the remaining GPS antennas, paying attention to the type of card used.

2.2 Converting Raw GNSS Data to RINEX Format

Once the files have been converted using SPEXPORT.exe, it is necessary to convert this raw data to RINEX format, in order that GrafNav can convert the data in the next step. Again, using the "Dynamic Calibration – Field Data" sheet, determine which of the following converters should be applied:

- Convert to RINEX 

(for the Trimble data)
- NovAtel Convert4 

(for the NovAtel data)

2.2.1 Convert to RINEX

Install the software, if is not already available on the user's workstation, and open:

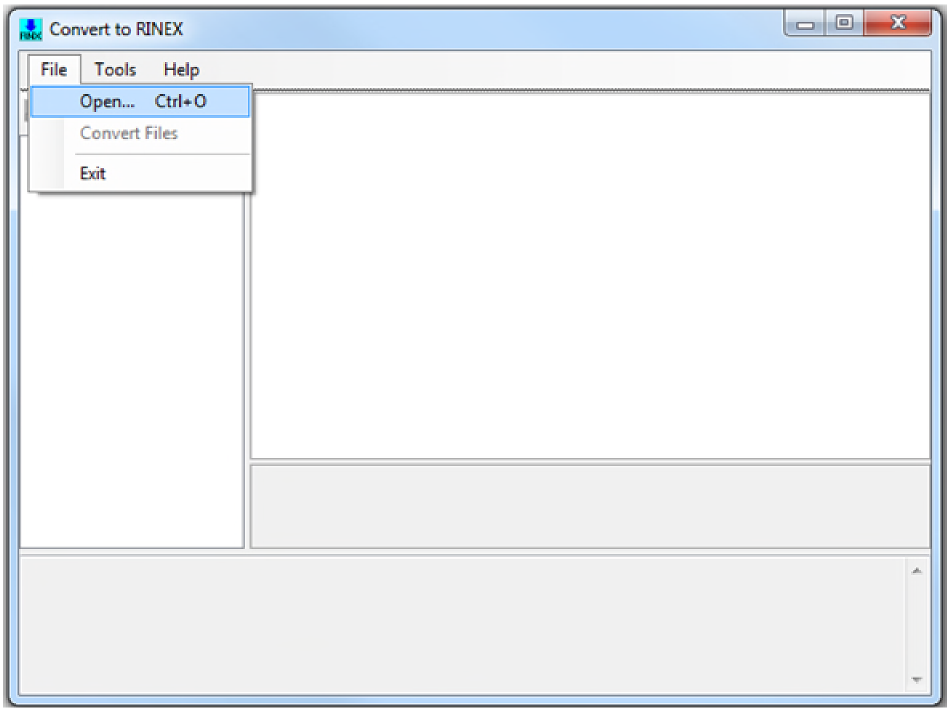


Figure 2.4: Convert to RINEX File > Open...

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Browse to the location of the "*.rt27" file required. It may be necessary to broaden the file selection to include all files:

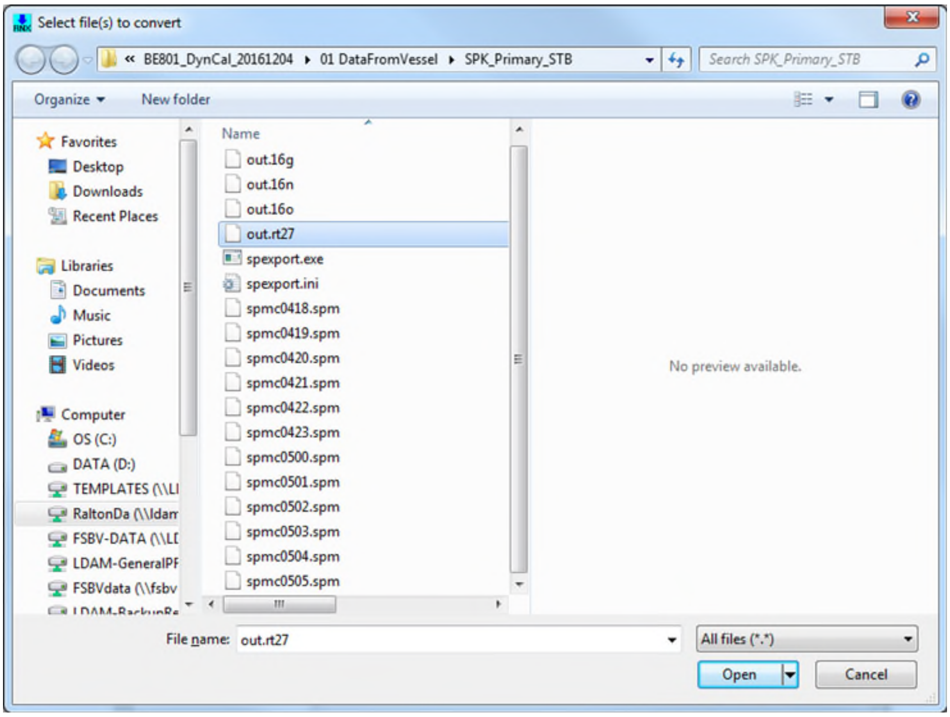

Figure 2.5: Select file(s) to convert (All files)

A message will appear at the bottom of the software window saying "Scanning out", which will add the message "Complete!" when the scanning has finalised. Additionally, the window will populate with the required RINEX data and associated metadata from the logging file. Select **File > Convert Files**.

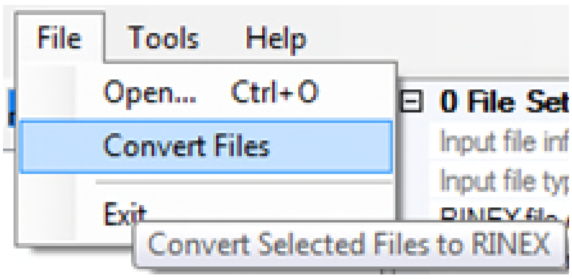

Figure 2.6: File > Convert Files

The user will then receive a message that the software is "Converting out" the file, and a further message of "Success" will appear when this has been completed. Browse to the source file location to find three files with the following extensions:

- *.16g (xxx data;
- *.16n (xxx data);
- *.16o (xxx data).

(Note : the prefix 16 in the file extension relates to the year of processing, i.e. in 2018 the prefix should be 18: .18o, .18n, .18g)

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2.2.2 NovAtel Convert4

Install the software, (currently version 1.8 or 2.1.1 of the software appears to work (version 2.0 does not)) if is not already available on the user's workstation, and open. Ensure the settings are as below before opening any files:

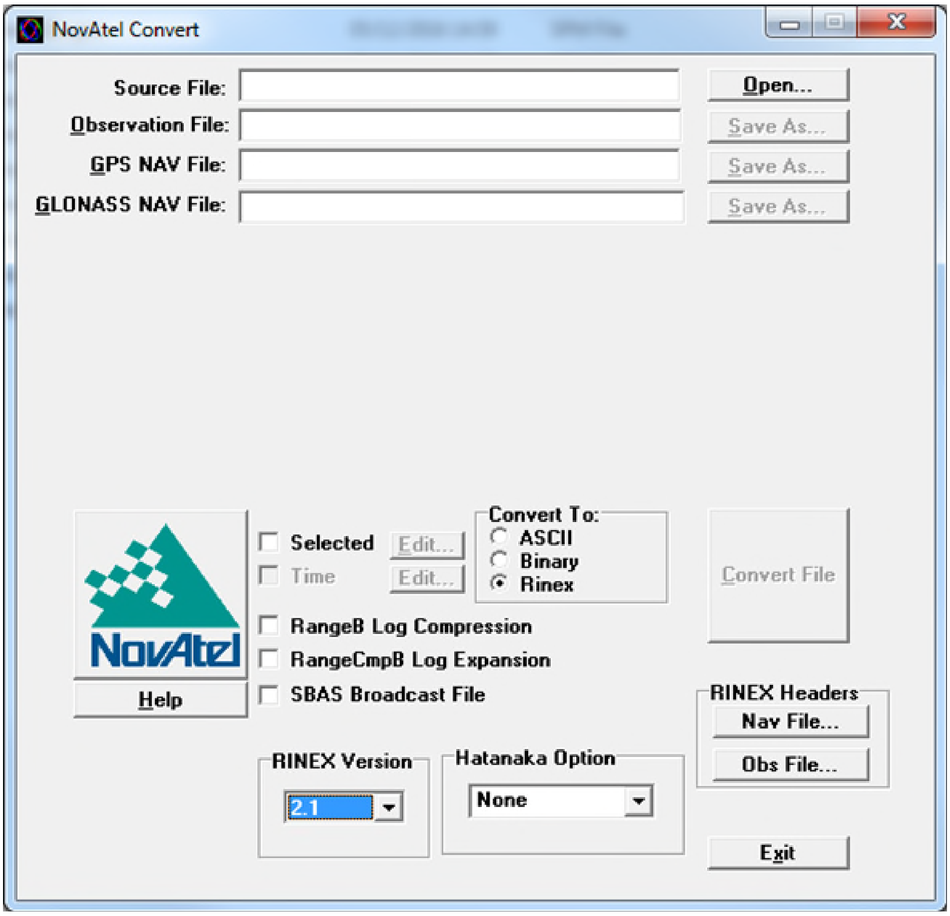

Figure 2.7: NovAtel Convert File > Source File Open

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Browse to the location of the "*.raw" file required. It may be necessary to broaden the file selection to include all files:

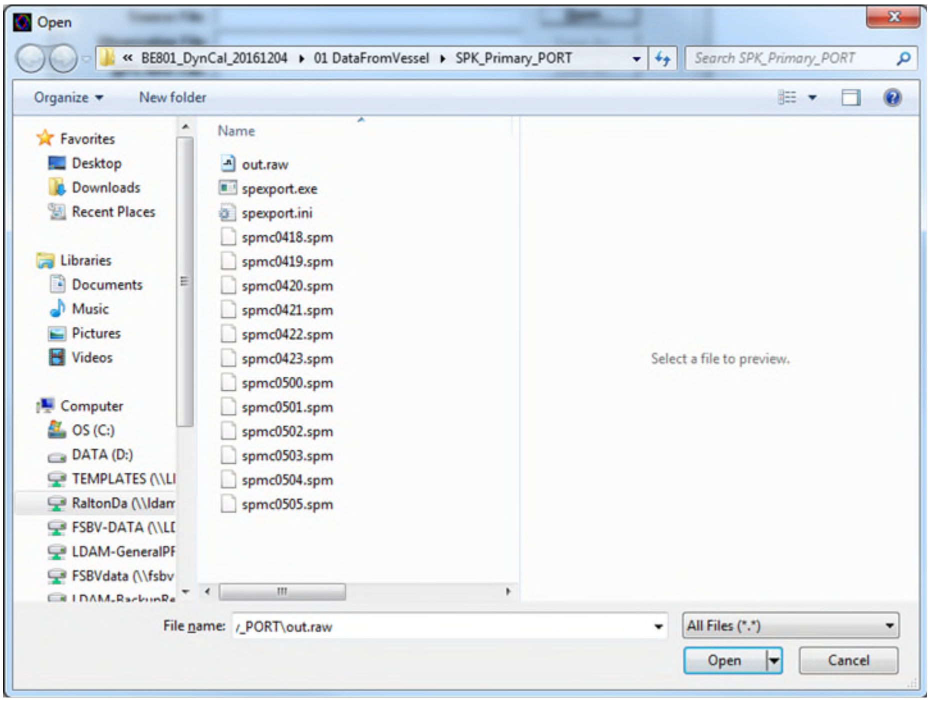

Figure 2.8: Open (All Files)

The following file paths will populate:

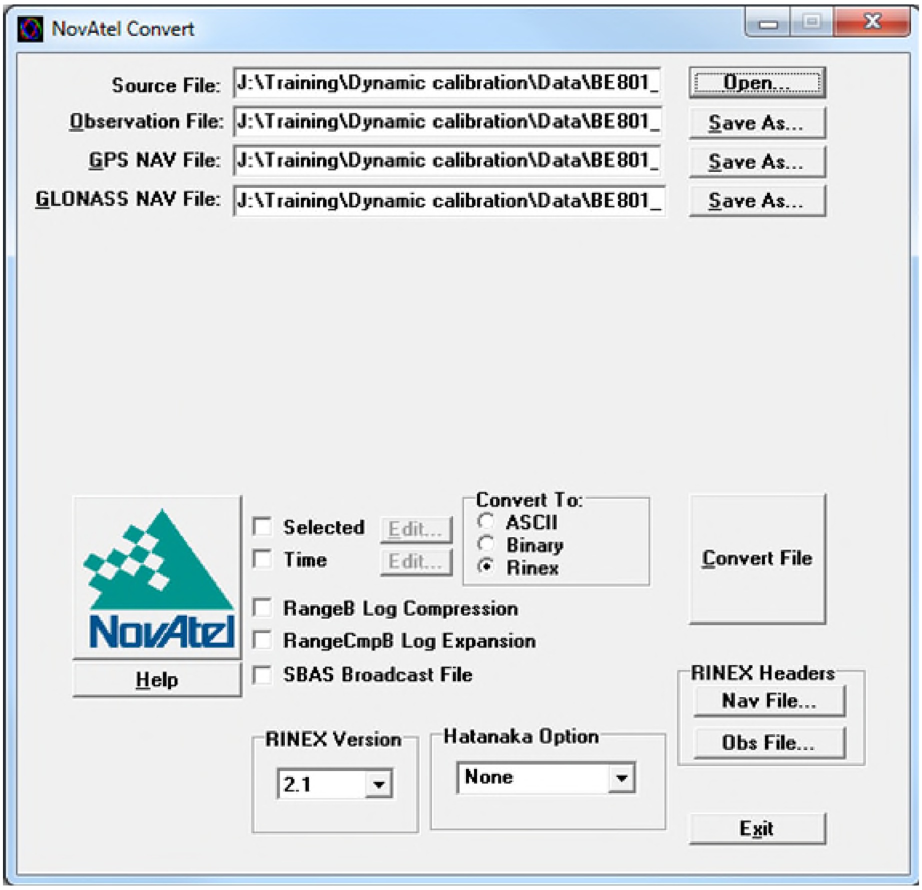

Figure 2.9: Populated source file and destination file paths

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Select Convert File and wait till the following Conversion Progress window shows the process to be completed, then select **OK**:

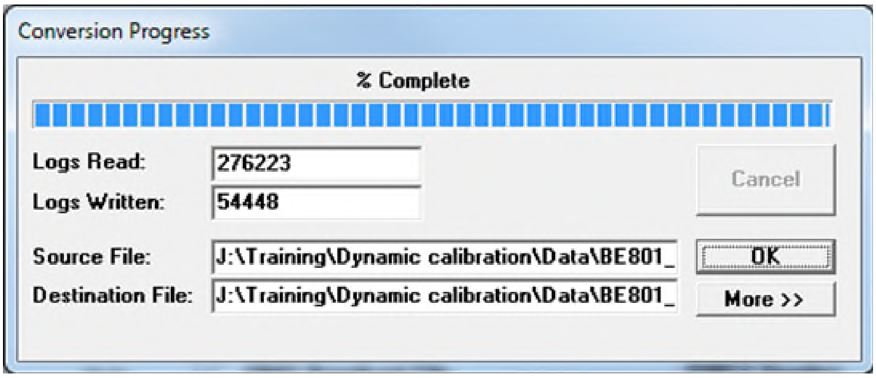

Figure 2.10: Conversion Progress > OK

Browse to the source file location to find three files with the following extensions:

- *.16G (xxx data;
- *.16N (xxx data);
- *.16O (xxx data).

Some points to note:

- If the *.16N file is only 1kb then the conversion hasn't worked. This may be because the version of the software is not functioning correctly (e.g. NovAtel Convert 4 version2.0);
- If one antenna has an extra *.spm logging session then don't use it. Adjust the ini files such that each antenna data covers the same time period;
- If may prove useful to rename the *.16G, N & O files as per the antenna in question so that PPP reports from NRCAN will be easily identifiable.

3. Processing for Precise Point Positioning

It is necessary to obtain Precise Point Positioning (PPP) from the logged GNSS data, in order to define the master station when creating a moving baseline solution in GrafNav. The preferred method to obtain this data is detailed in Section 3.1, with an alternative method detailed in Section 3.2.

Note: Make sure that the data sets for all antennas are the same length, or choose a data set (files) that coincides with all locations.

3.1 Natural Resources Canada Site

To define the PPP for the dynamic calibration, access to the Natural Resources Canada site is necessary (create an account before first use):

https://webapp.geod.nrcan.gc.ca/geod/tools-outils/ppp.php?locale=en

The following settings should be utilised with the exception of the Processing Mode. This should be set to Static or Kinematic, depending on the type of calibrations done (whether alongside or in-field).

Once all settings are configured, browse to the location of the *.16O file(s) and select **Submit to PPP:**

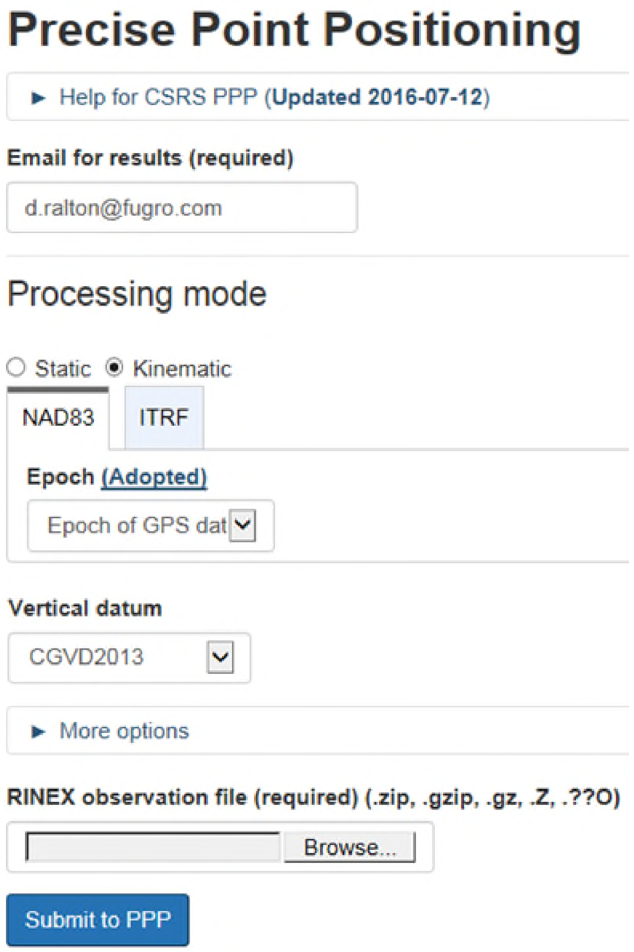

Figure 3.1: NRCan upload window

When this process is successful, the website will advise that the uploaded file was successfully submitted for processing, and that the results will be emailed to the specified address. Note that this process can take some time, and it is not unusual to receive an error upon apparent completion of the process. Repeat this method until the process is successful.

Once the data has been received by email, download and save the .zip file. It should contain the following file types:

- *.pos;
- *.mtm;
- *.sum;
- *.csv;
- *.pdf;
- errors.txt.

If a static solution is chosen, the required position will be detailed in the *.pdf file. If a kinematic solution is chosen, the average of the latitude and longitude values should be taken from the .*csv file.

To convert decimal degrees to degrees, minutes, and seconds in Excel, use the following formula (where the latitude or longitude value is in A1):

=TEXT(TRUNC(A1), "0" & CHAR(176) & " ") & TEXT(INT((ABS(A1)- INT(ABS(A1)))*60), "0' ") & TEXT(((((ABS(A1)-INT(ABS(A1)))*60)- INT((ABS(A1) - INT(ABS(A1)))*60))*60), " 0''")

3.2 Obtaining PPP from *.gpb Files

If, for any reason, it is not possible to utilise the web-based solution to provide PPP, the latitude and longitude for the master station can be obtained during the steps to Section 4: **GrafNav – Convert Raw GNSS Data to GPB.**

After creating the project and defining the Master, Remote (Section 4.3.2) , etc, the following window will appear:

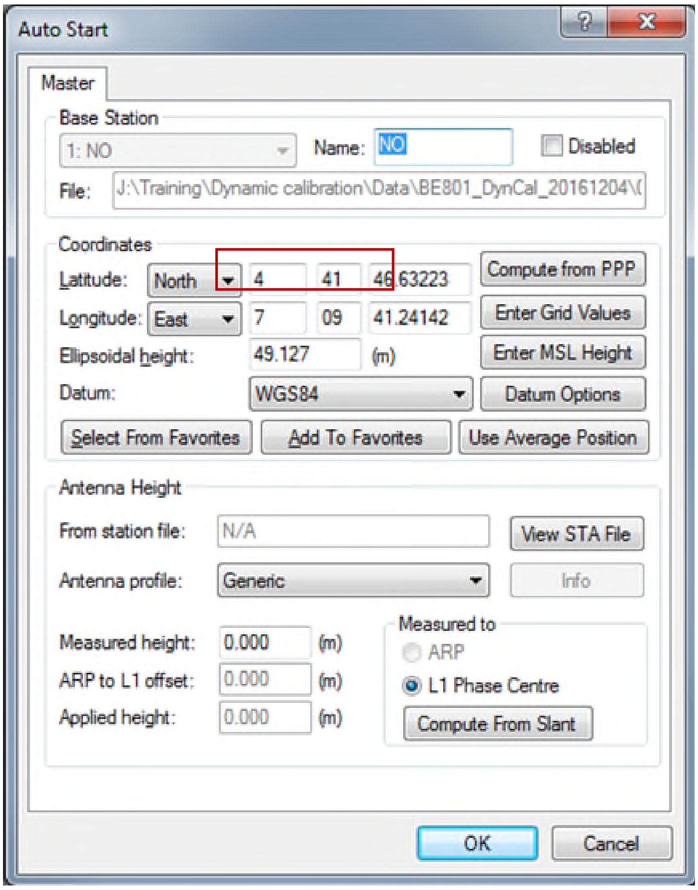

Figure 3.2: Master > Compute from PPP

Select Compute from PPP. The following message will appear once this computation is completed. The latitude and longitude displayed will automatically migrate to the Master station parameters once **Close** is selected:

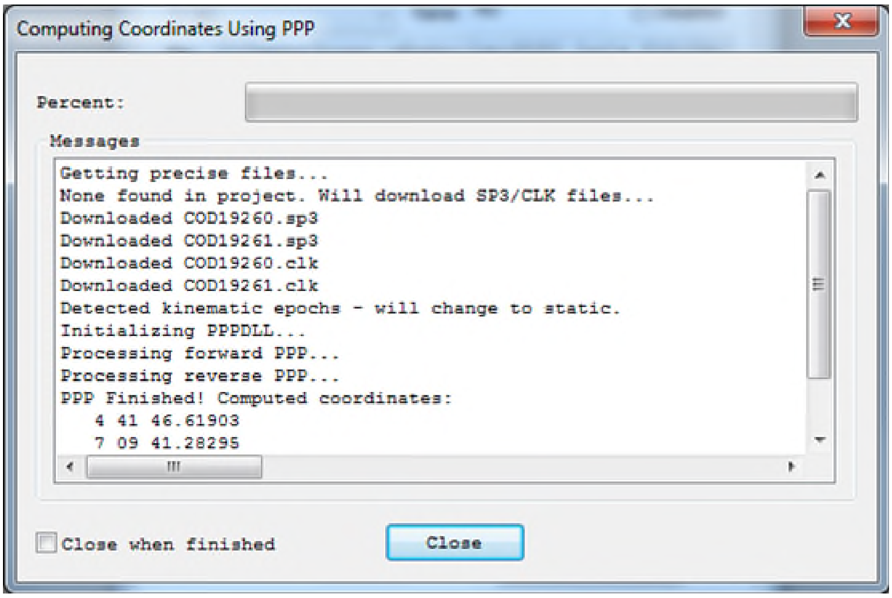

Figure 3.3: Computing Coordinates using PPP

The amended latitude and longitude in the following image should match those stipulated in the preceding image. It is important to note that using this method will return the data to Static mode. Once the PPP is obtained from the *.gpb files, the steps in Section 3 should be repeated to return these to Kinematic mode before continuing.

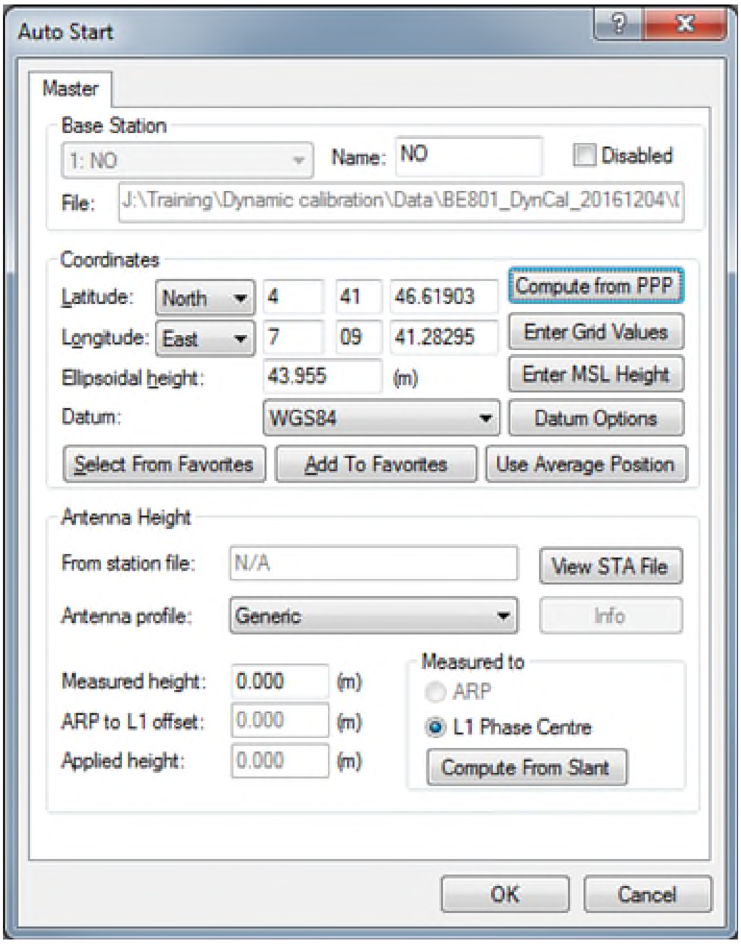

Figure 3.4: Amended latitude and longitude from computed PPP

4. Processing using GrafNav

4.1 GrafNav – Setup

Prior to using this software, install the software following this link:

P:\03.04 SUPPORT\05 Software\06 GNSS\Novatel\Novatel Waypoint GrafNav-GrafNet\SetupNav8504320.exe

The following *.prf files should be copied from P:\03.04 SUPPORT\05 Software\06 GNSS\Novatel\GrafNav Profiles, and pasted to the C: drive of the workstation under *C:\Users\[Name]\AppData\Roaming\NovAtel\Waypoint_8_50\User*:

- Fugro_DnCal HPR-Epochs.prf
- Fugro_PosVerf_PPP-RTK-Epochs.prf
- Fugro_RefSta_PPP-RTK-Static.prf

The following *.atx files should be copied from P:\03.04 SUPPORT\05 Software\06 GNSS\Novatel\Antex files and pasted to the C: drive of the workstation under *C:\Users\[Name]\AppData\Roaming\NovAtel\Waypoint_8_50\Manufact*:

- Fugro_AD49x.atx
- Fugro_AD49xmod.atx
- ngs08.atx
- ngs08_new.atx
- ngs08_new_ADx.atx
- ngs08mod.atx

4.2 GrafNav – Convert Raw GNSS Data to GPB

Open the software and select File > Convert > Raw GNSS to GPB:

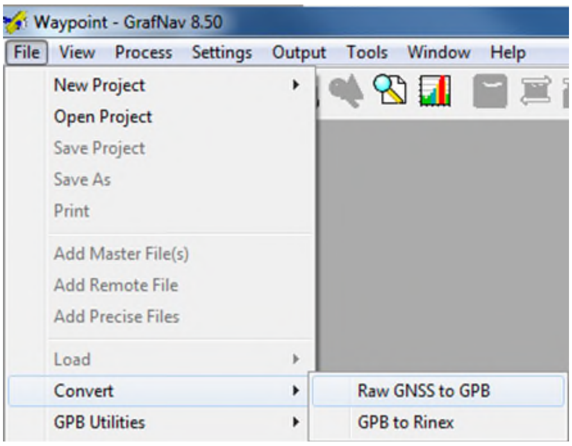

Figure 4.1: GrafNav File > Convert > Raw GNSS to GPB

The following window will appear:

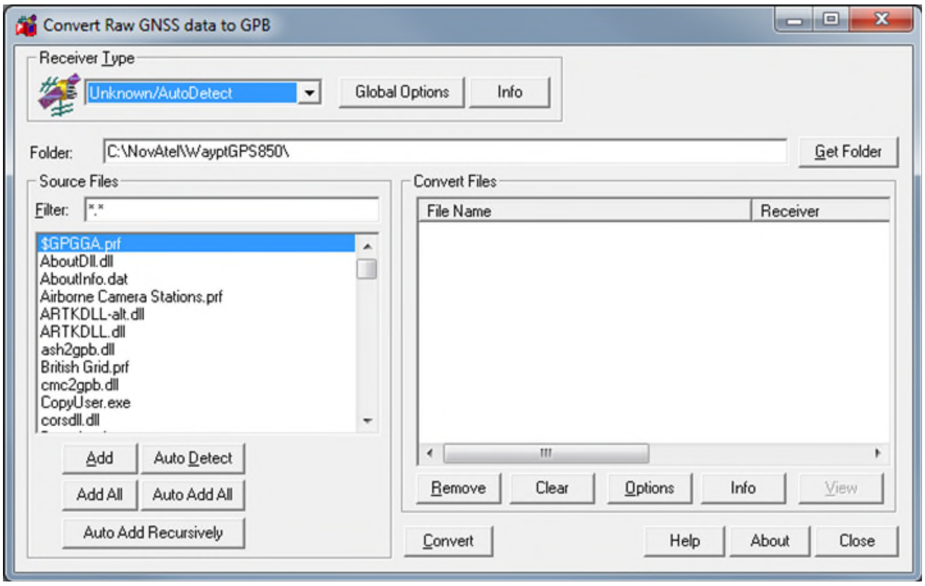

Figure 4.2: Convert Raw GNSS data to GPB

Browse to the first source folder and select the file ending in “*.16O”, and select **Auto Detect.** Select **Yes** when they following message appears:

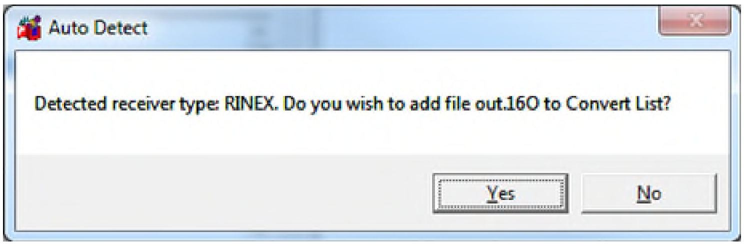

Figure 4.3: Auto Detect > Yes

The file will now appear in the Convert Files list on the right side of the software window:

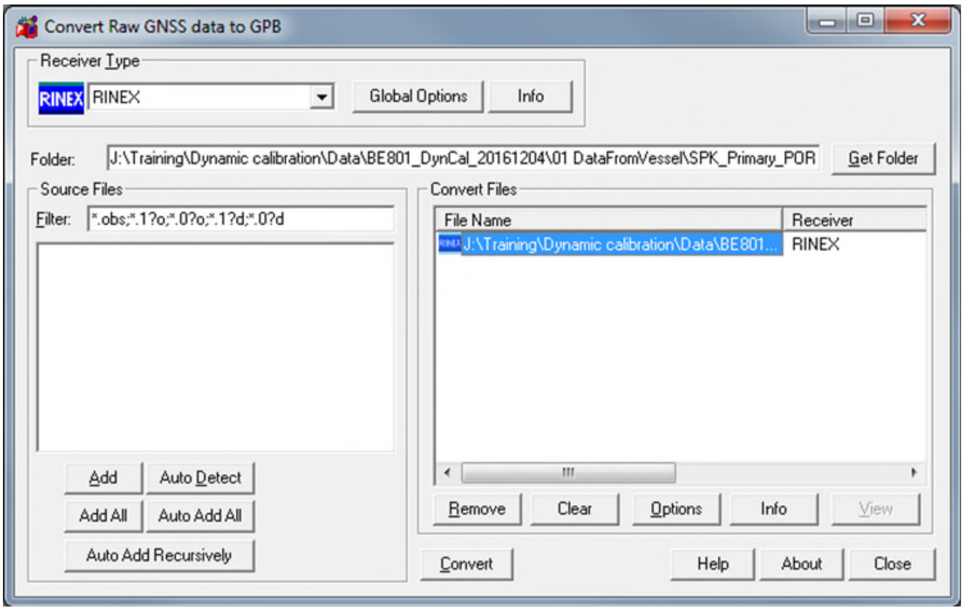

Figure 4.4: Convert Files

Select **Convert:**

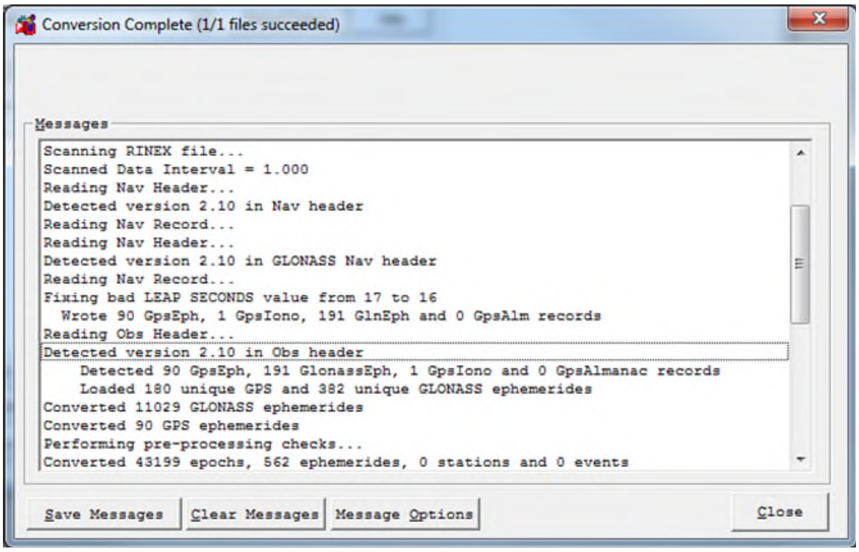

Figure 4.5: Conversion Complete window

Repeat this for each source folder. Browse to the source folder to find the converted output files with the extension "*.gpb". These are required for the next step.

4.3 GrafNav – Moving Baseline Solution

4.3.1 View Raw GNSS Data

As per the instructions in section 5 of Work Instruction GNSS Data Processing using NovAtel Waypoint GrafNav, first view the raw GNSS data in the newly-created *.gpb files by **selecting File > GPB Utilities > View Raw GNSS Data:**

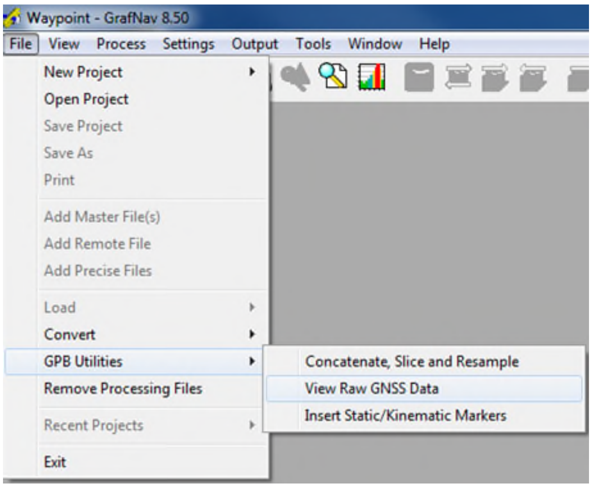

Figure 4.6: GrafNav File > GPB Utilities > View Raw GNSS Data

Review the Position Information section to determine whether the Mode is set to Static or Kinematic.

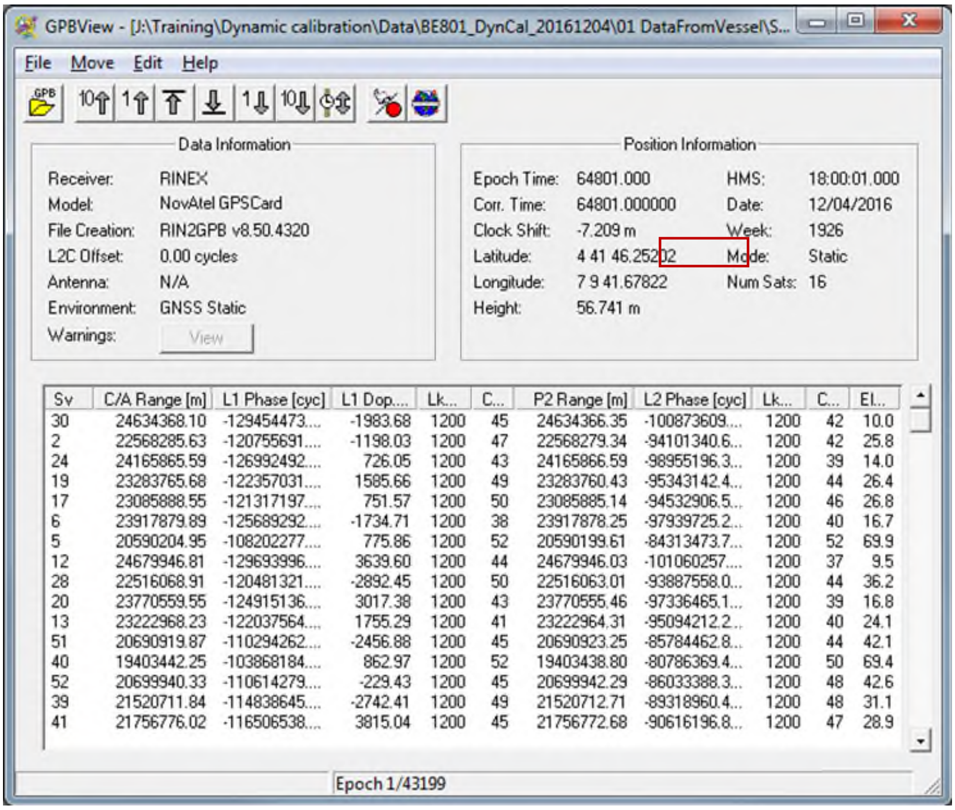

Figure 4.7: Raw GNSS data viewed in Graf Nav

Review the data under Position Information to ascertain whether the Mode is currently set to Static or Kinematic. If the former, it is necessary to amend this to Kinematic using the following utility:

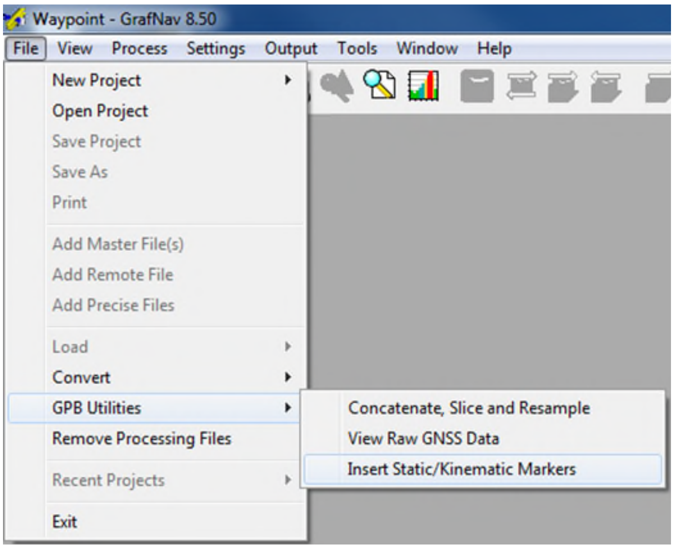

Figure 4.8: GrafNav File > GPB Utilities > Insert Static/Kinematic Markers

Browse to the source folder containing the relevant *.gpb files. To convert all epochs from static to kinematic, ensure "Make all epochs kinematic" is selected, and select **Process:**

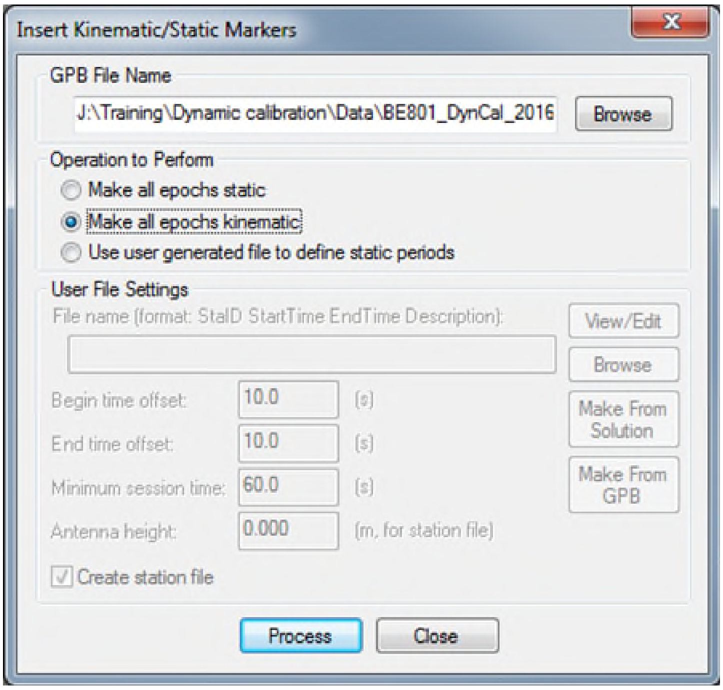

Figure 4.9: Insert Static/Kinematic Markers > Process

The software will present a further prompt. If the user is unsure about permanently changing the *.gpb file, make a copy of this file before selecting **Yes**:

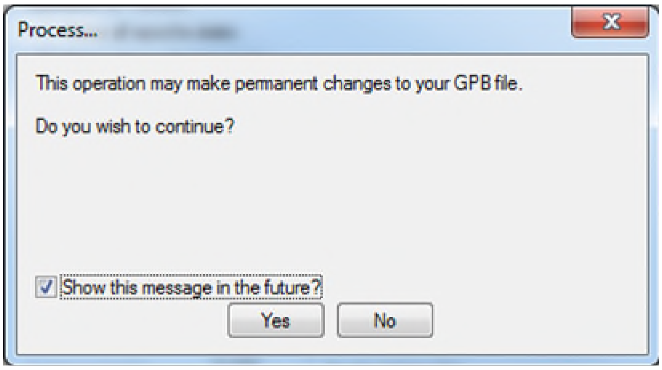

Figure 4.10: Process... > OK

Upon completion, the following prompt will appear. Select **OK** to continue:

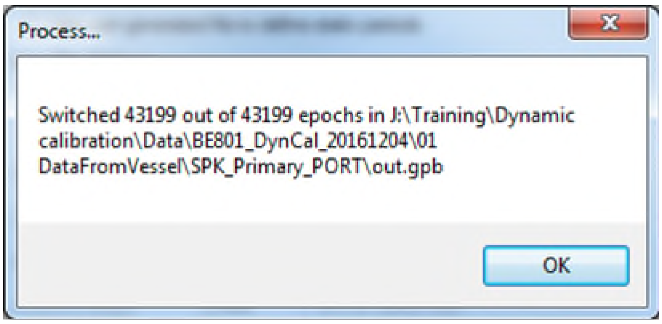

Figure 4.11: *.gpb file conversion completed

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4.3.2 Creating A New Project and Adding Data

Upon successful review of the raw GNSS data to verify that the Mode is now set to Kinematic, select **File** > **New Project** > **Auto Start**:

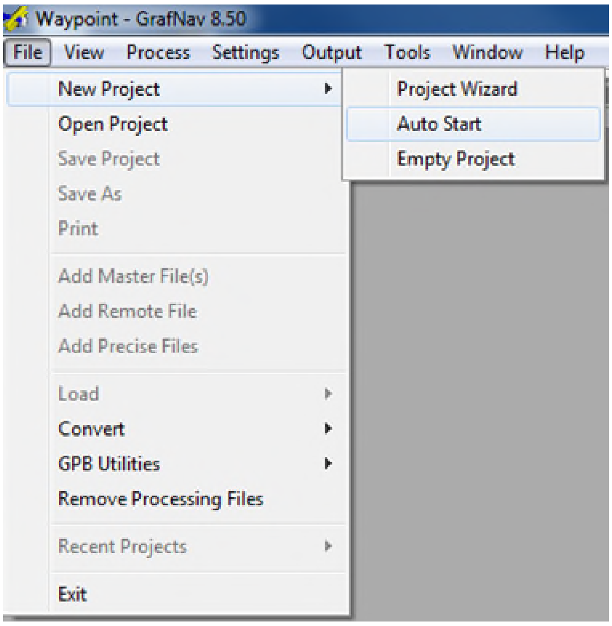

Figure 4.12: *GrafNav File > New Project > Auto Start

Populate the Auto Start window with the following items, and select **OK.** Note that this process should be repeated for each baseline. In this worked example, there are three stations (FWD, PORT, STBD) which means there will be three baselines between them to be measured to form part of the dynamic calibration:

Table 4.1: GrafNav Auto Start Moving Baseline Solution Settings

Parameter	Value
Path	Browse to the intended location of the working directory here
Name	Add a suitable project name for the working directory
Master	Add the Master base station file here (usually the results from the FWD antenna)
Remote	Add the remote file here
Settings	In the case of a dynamic calibration at sea, select GNSS Marine here

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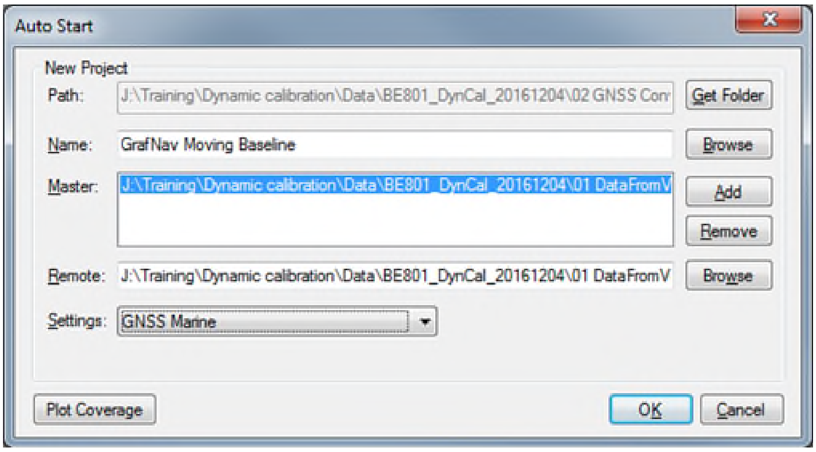

Figure 4.13: Graf Nav New Project Master and Remote settings

The software will then prompt the user to define the parameters for the Master base station. Add the base station name, and amend the latitude and longitude to match the PPP report values, if these are available. If not, follow the process for Section 3.2, ensuring to amend the *.gpb settings to kinematic before continuing. Also add the antenna height information from the PPP report (if done in Static mode).

Note - If using the NRCAN PPP report on a transiting vessel, use the average Lat/Long/height from the csv file sent as part of the NRCAN PPP email delivery.

After input of the Master base station information, select **OK:**

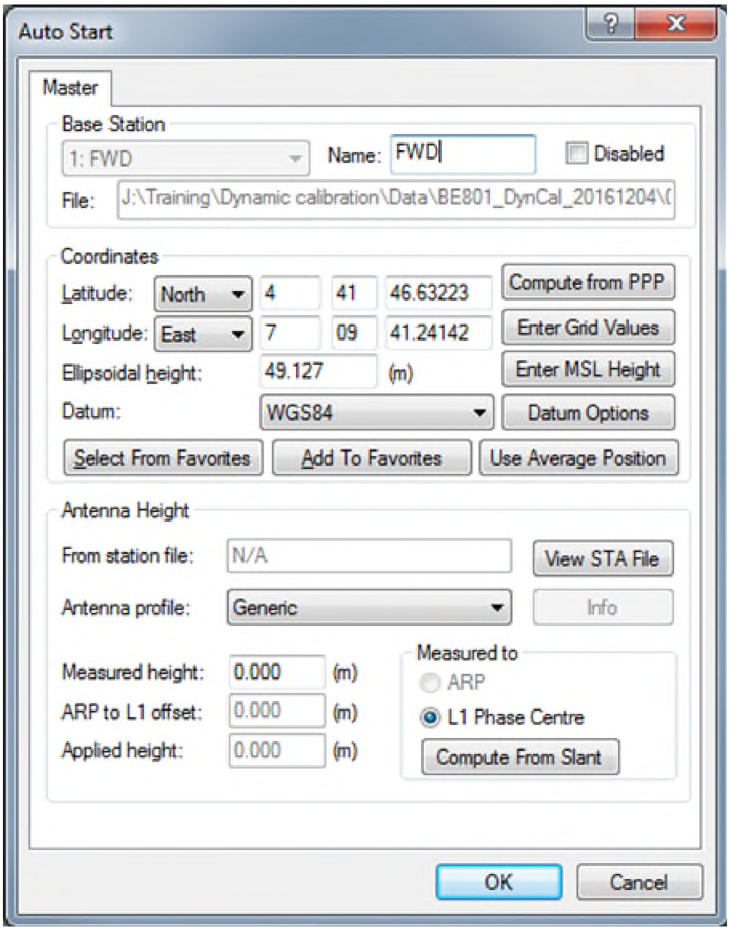

Figure 4.14: GrafNav Master Base Station parameters – note, beware of the North/South latitude

The next window details the Remote base station parameters. All settings here can be accepted by selecting **OK**:

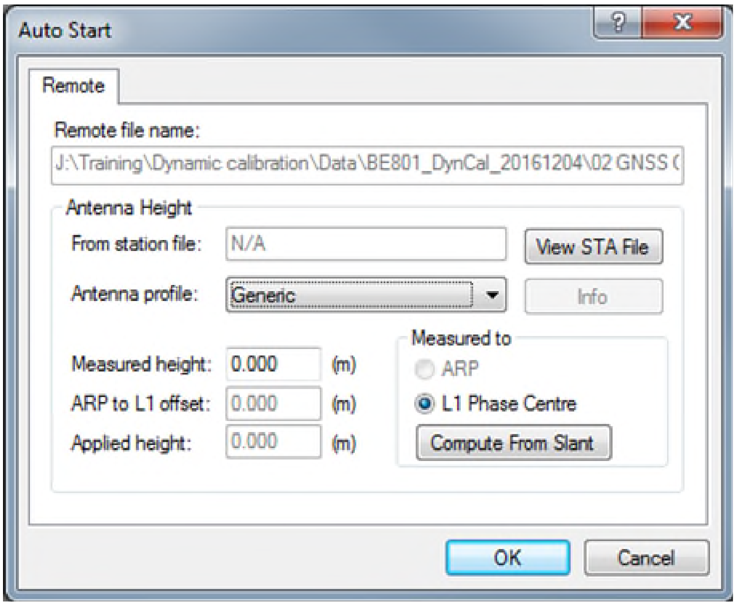

Figure 4.15: GrafNav Master Remote Station parameters

The unprocessed GNSS data will be displayed as per the following window:

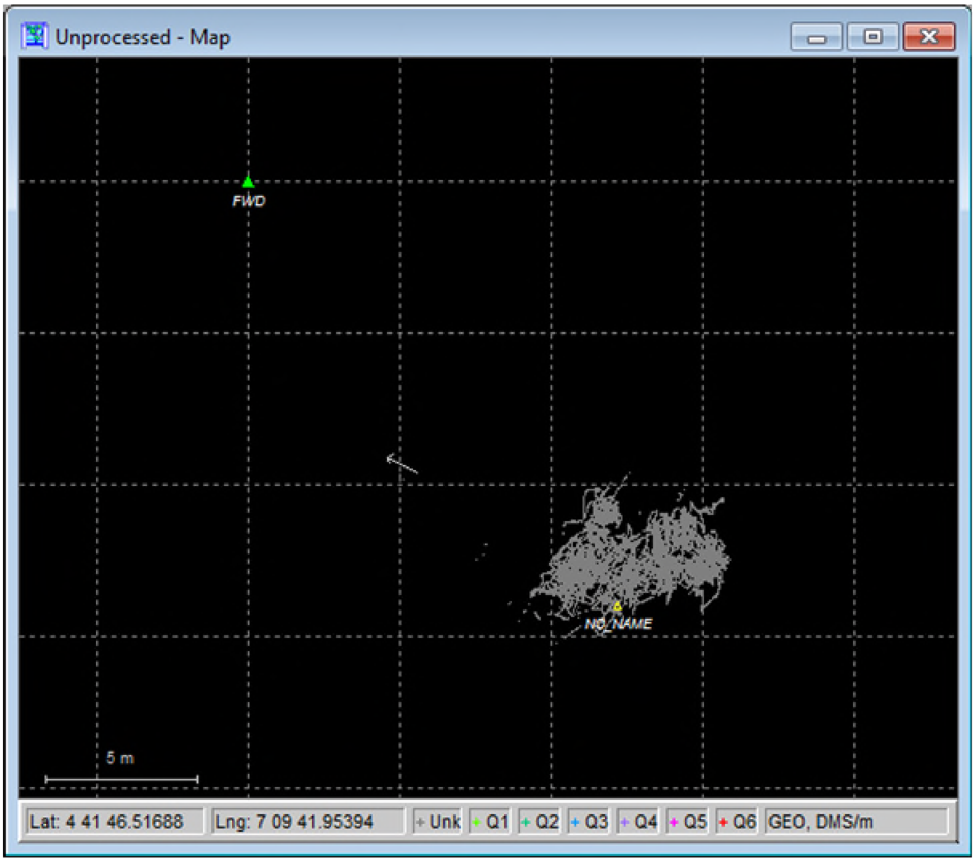

Figure 4.16: GrafNav Master Remote Station parameters

4.3.3 Define the Datum and Grid

Select **Settings** > **Datum** to ensure the correct datum is applied to the project as per the project procedure (or mobilisation and calibration report if the dynamic calibration is not done locally to the offshore worksite):

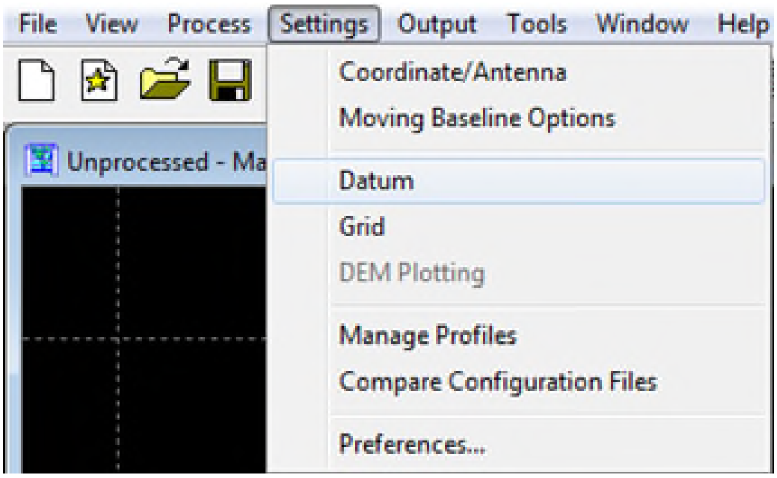

Figure 4.17: Settings > Datum

The Datum Options window will appear. Make any necessary changes under the Project Options tab, and select **OK** when completed.

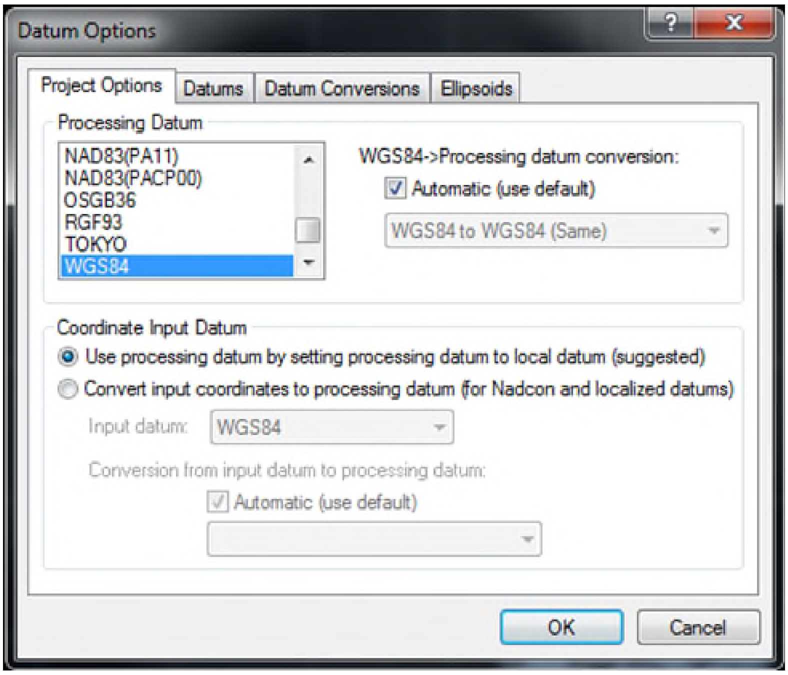

Figure 4.18: Datum Options

Now select **Settings** > **Grid** to define the grid settings:

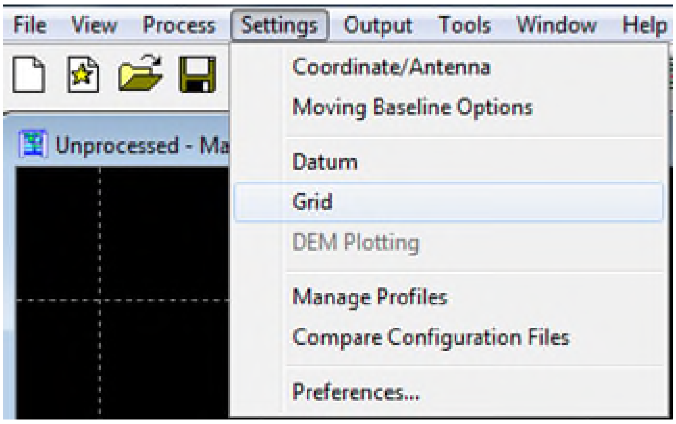

Figure 4.19: Settings > Grid

Ensure the content of the Grid Settings for Coordinate Input window is correct for the project and location. Amend where required, and select **OK:**

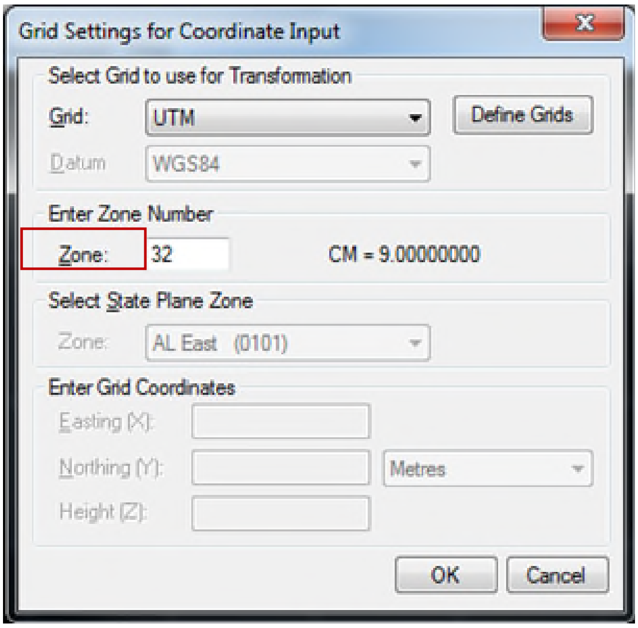

Figure 4.20: Grid Settings for Coordinate Input

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4.3.4 Moving Baseline Options

Prior to processing the GNSS data, set the parameters for the processing under **Settings > Moving Baseline Options:**

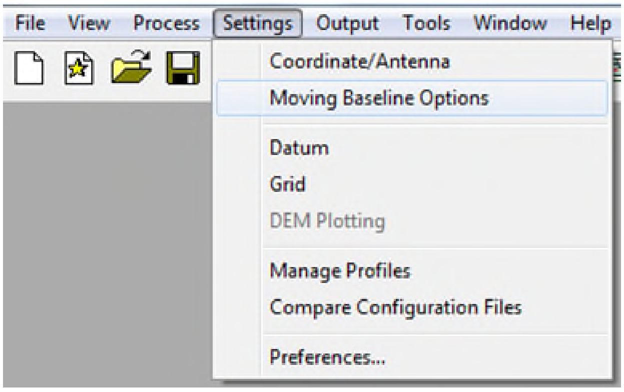

Figure 4.21: Settings > Moving Baseline Options

The Moving Baselines Options window will appear. Select the second setting under Azimuth Determination.

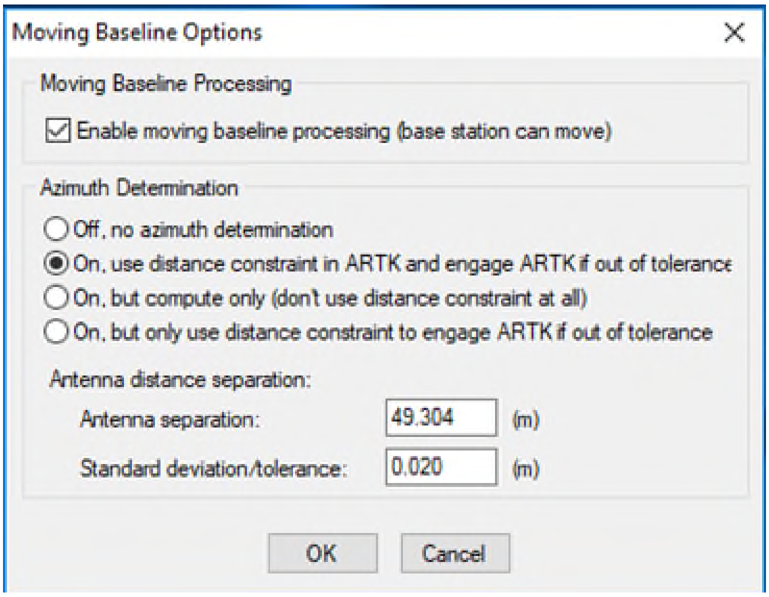

Figure 4.22: Moving Baseline Options

The antenna separation should also be calculated and added. This can be calculated using the Easting and Northing values from the PPP reports (if available, else the offsets can be inserted into the Dynamic Calibration spreadsheet I.1 and Slant range results obtained from II.1). Select **OK** to apply these settings and close this window.

Note: – if the vessel is transiting it is important to check the "Enable moving baseline..." checkbox in Figure 4.22.

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4.3.5 Process the Gnss Data

The next step is to process the GNSS data in the GrafNav. Select **Process** > **Process GNSS** from the top toolbar

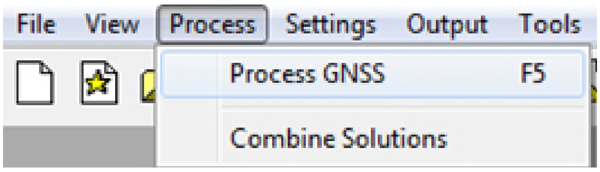

Figure 4.23: Process > Process GNSS

Ensure the Process GNSS settings are as per the following figure, setting the Processing Settings to **GNSS Marine**, Advanced settings – Set Elevation mask to 10* on General tab (Figure 4.25), Tick options under General Options in the Fixed Static tab (Figure 4.26) and select **Process**:

*- On reviewing the results in Section 4.3.6, if data is poor due to number of satellites or masking, the Elevation masking can be adjusted up or down (preferably not below 10°).

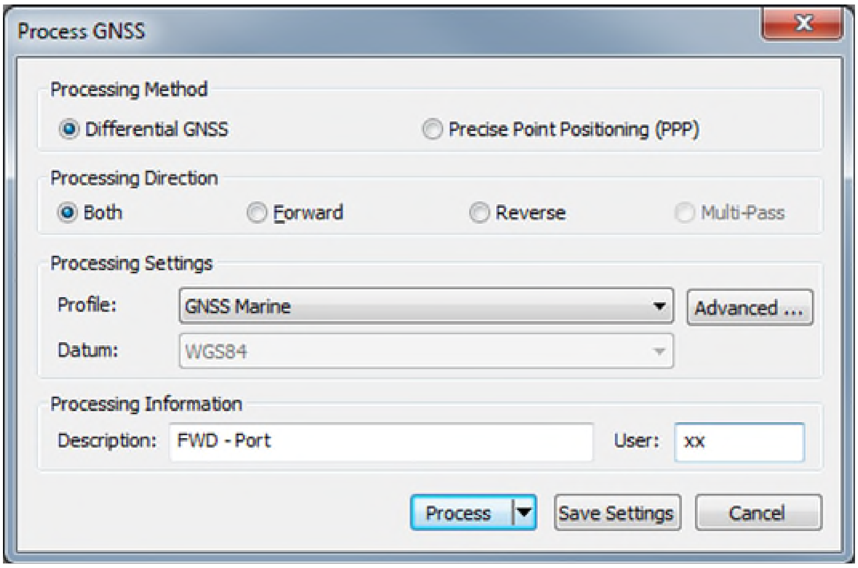

Figure 4.24: Process GNSS

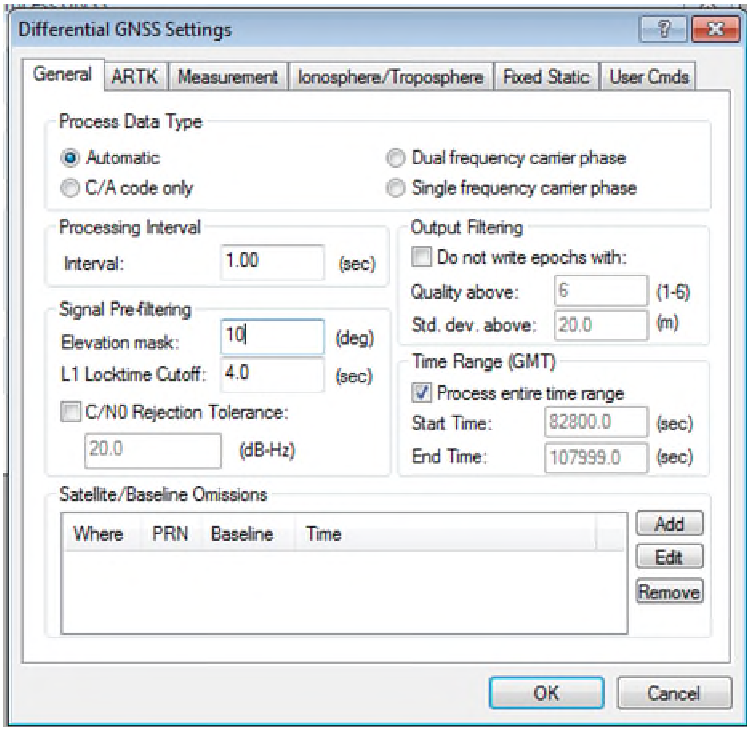

Figure 4.25: Advanced setting – Elevation Mask

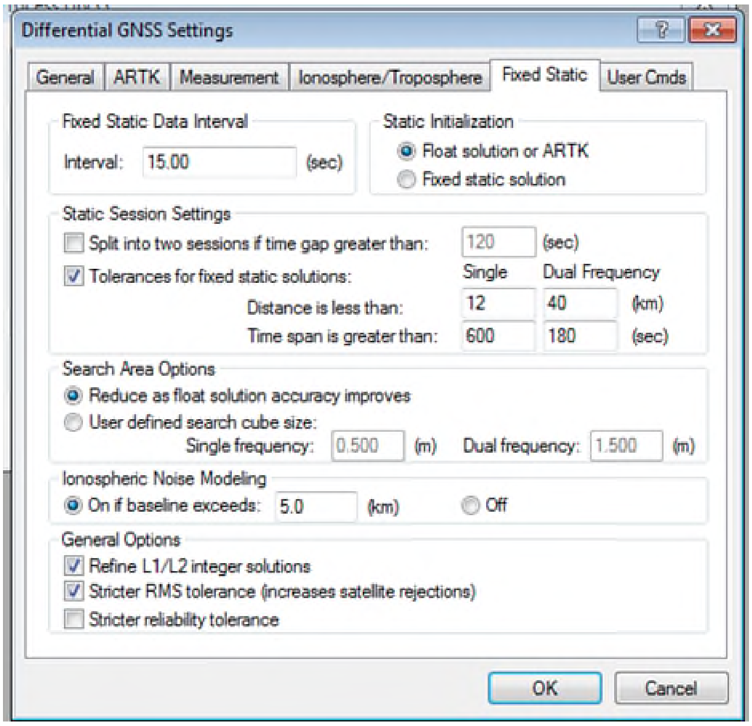

Figure 4.26: Differential GNSS Settings – Advanced – Fixed Static

Two processing windows will appear whilst the data is processing. Allow this processing to run to completion for both windows. Once the GNSS processing is complete, the processed data will be shown:

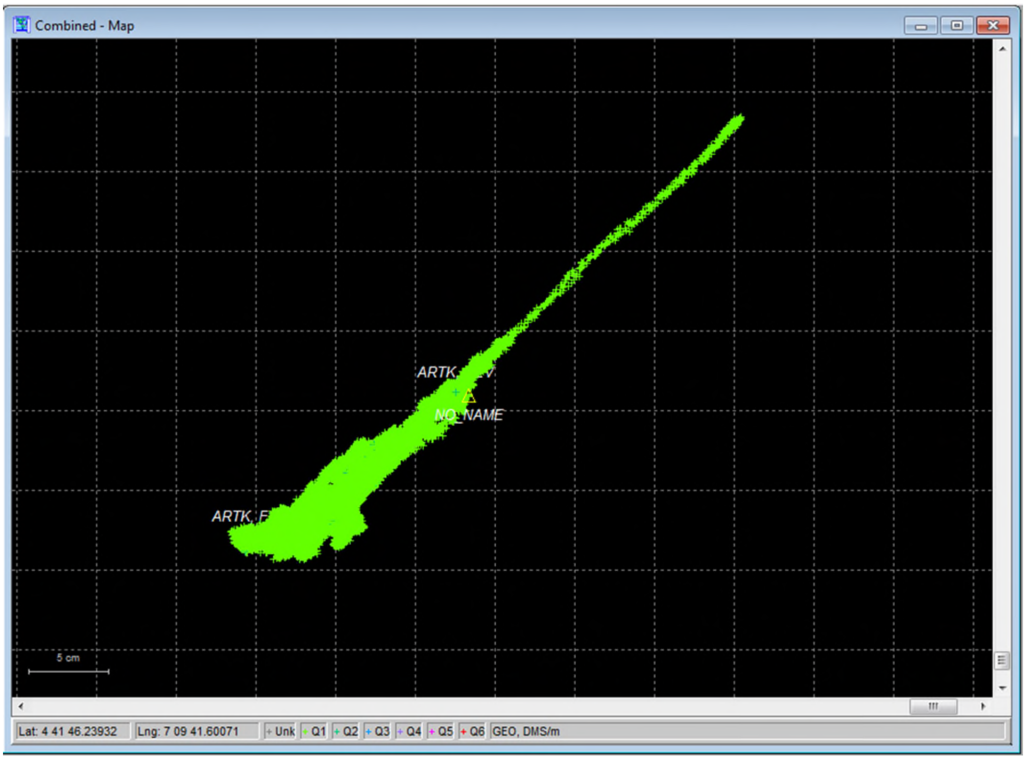

Figure 4.27: Combined - Map window showing processed GNSS data (static position)

Repeat this process for the remaining baselines.

A moving (transiting vessel) should look similar to that in Figure 4.28.

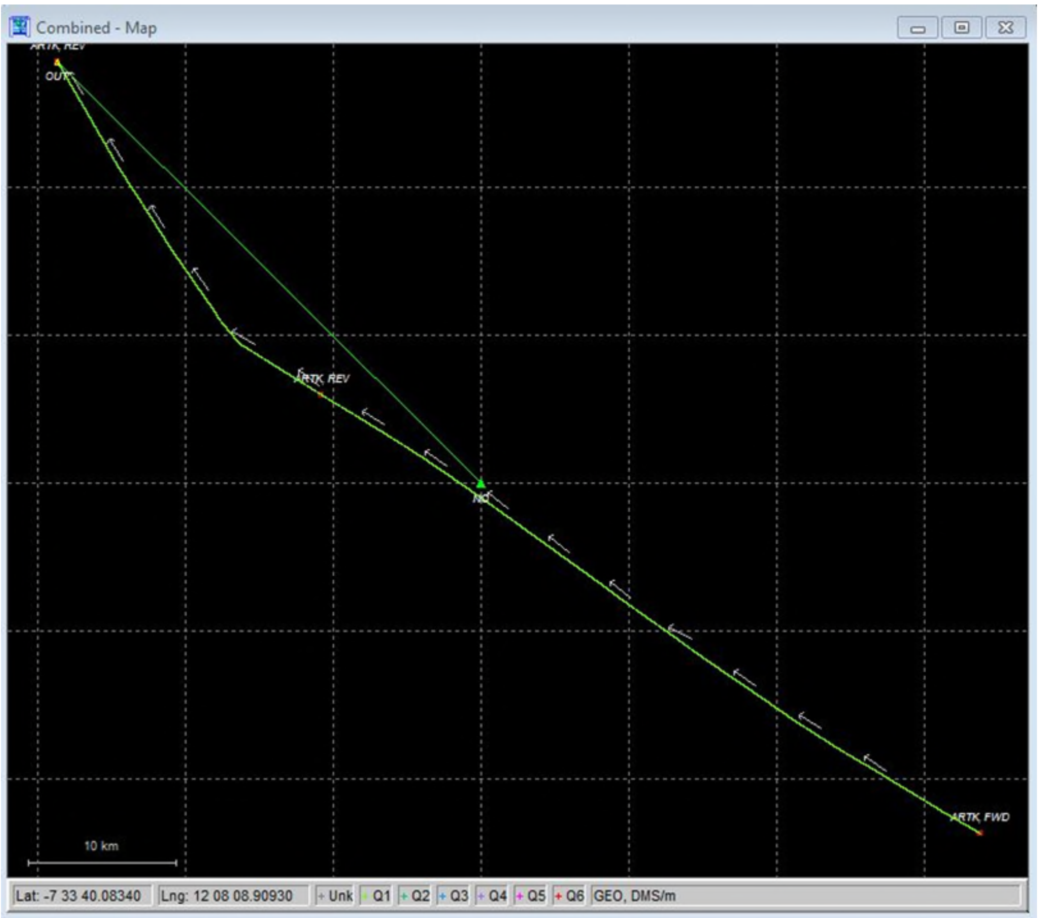

Figure 4.28: Combined - Map window showing processed GNSS data (transiting vessel)

4.3.6 Plotting the Processed Data

Before exporting the data, select **Output** > **Plot Results**:

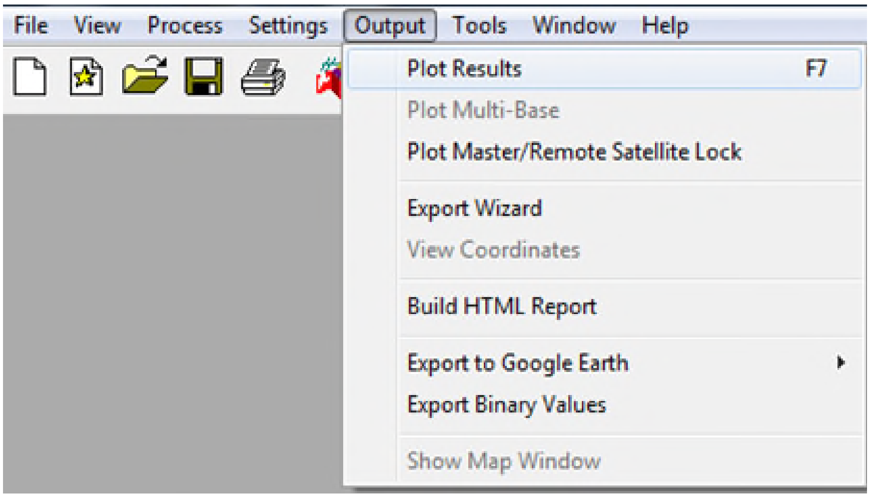

Figure 4.29: Output > Plot Results

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The Plot Results window details the different plot types available:

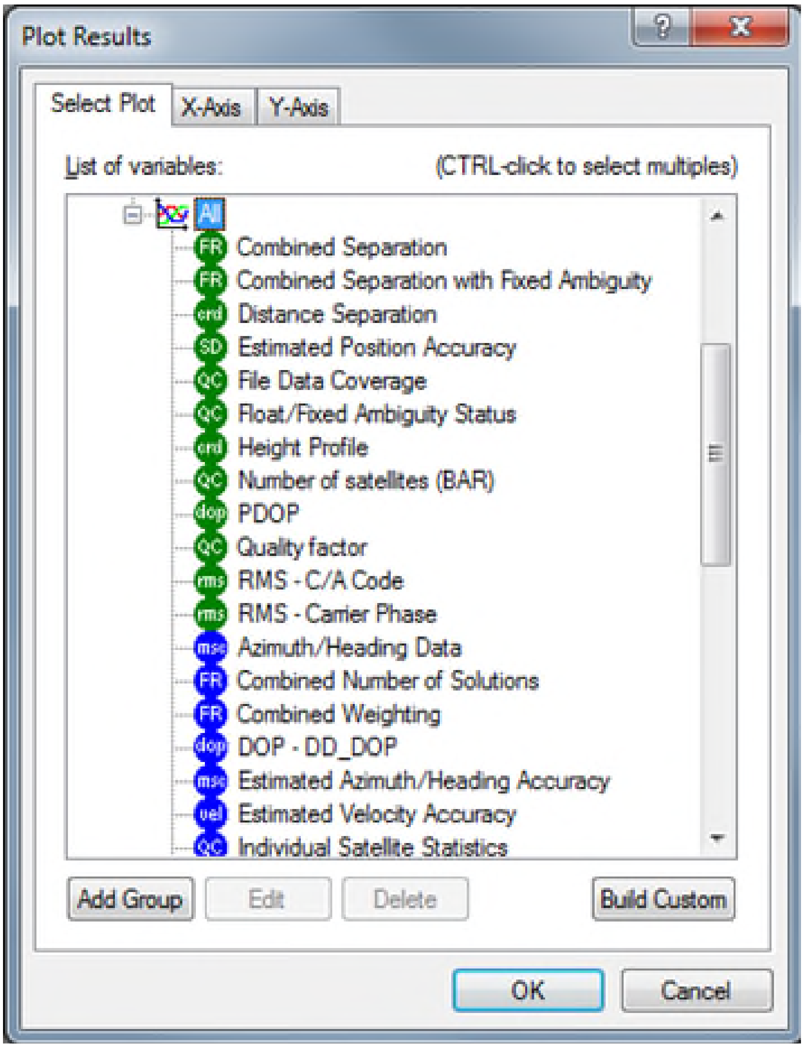

Figure 4.30: Plot Results variables

Further details on these plot types are available on p19 of Work Instruction GNSS Data Processing using NovAtel Waypoint GrafNav but the main ones to select are:

- **Combined Separation**, showing the Northing, Easting, and height position differences between the two solutions loaded into the project, usually including both the forward and reverse processing results. Closely correlating plots are desired to give confidence in the acquired data. Greater differences can occur in the instance of a kinematic solution. This is not necessarily incorrect and can be remedied in VBAProc if the data is otherwise reliable;
- **PDOP**, where a PDOP value of below 4 is usually acceptable;
- **Quality Factor**, which is assigned by GrafNav to give an overall quality rating. A smaller quality number denotes a better quality rating. For a static solution, quality values of 2 or lower are satisfactory. For a kinematic solution, quality values above 2 may be observed.

4.3.6.1 Combined Separation

The Combined Separation plot displays the Easting, Northing, and height (Up), with a key at the bottom of the window to differentiate between these. Generally, a separation of ±0.4 m is acceptable. As per the following example, a data spike can be acquired at the beginning or end of a data set which is otherwise satisfactory. This can be remedied in subsequent processing stages by selecting a date and time range for processing that will eliminate this errant data.

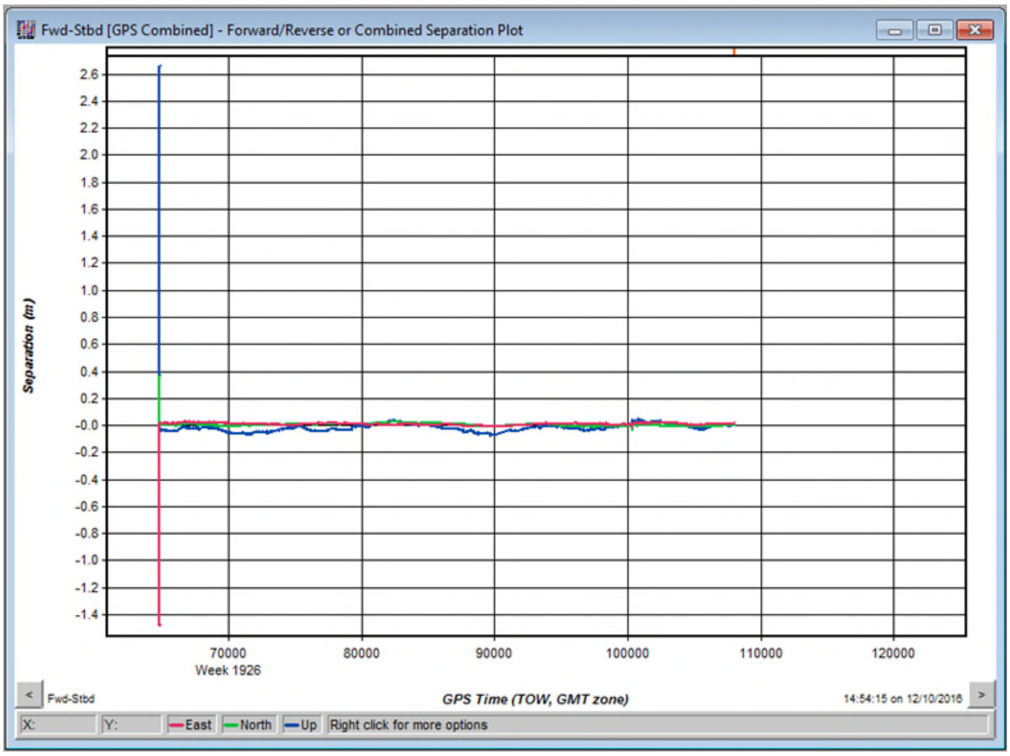

Figure 4.31: Combined Separation plot, data overview

After a review of the data in its entirety it is possible to zoom to specific areas using the mouse. It is also possible to right-click the mouse anywhere in the window to manually adjust the axes minimum and maximum values to hone in on specific areas, or increase the vertical exaggeration.

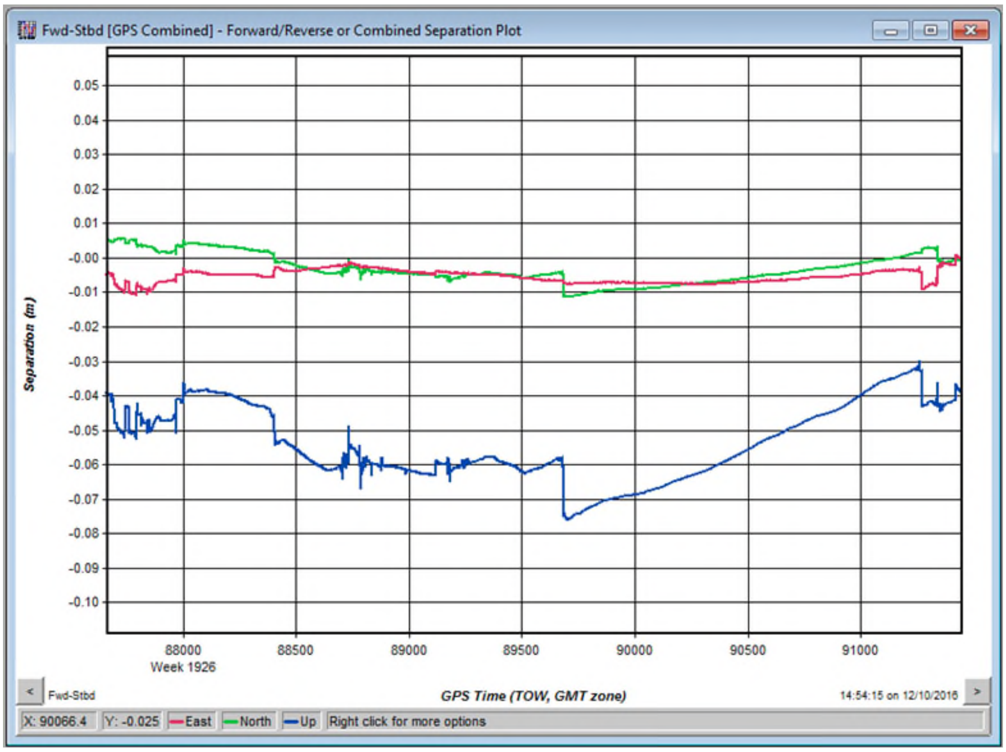

Figure 4.32: Combined Separation plot, closer inspection

4.3.6.2 Pdop

A PDOP value of 3 or lower is usually acceptable:

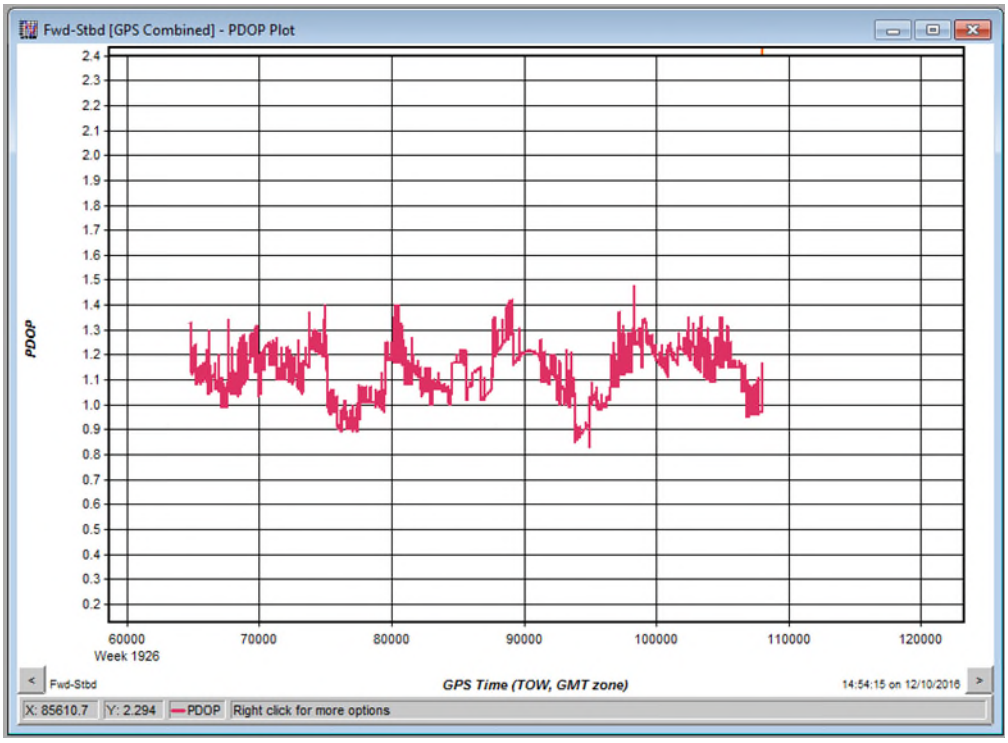

Figure 4.33: PDOP plot

4.3.6.3 Quality Factor

The quality number is assigned by the GrafNav software to indicate an overall quality rating. A smaller quality number denotes a better quality rating. For a static solution, quality values of 2 or lower are satisfactory. For a kinematic solution, quality values above 2 may be observed. To adjust the horizontal or vertical range or scale, right click in the Quality Factor Plot window and adjust the settings to suit:

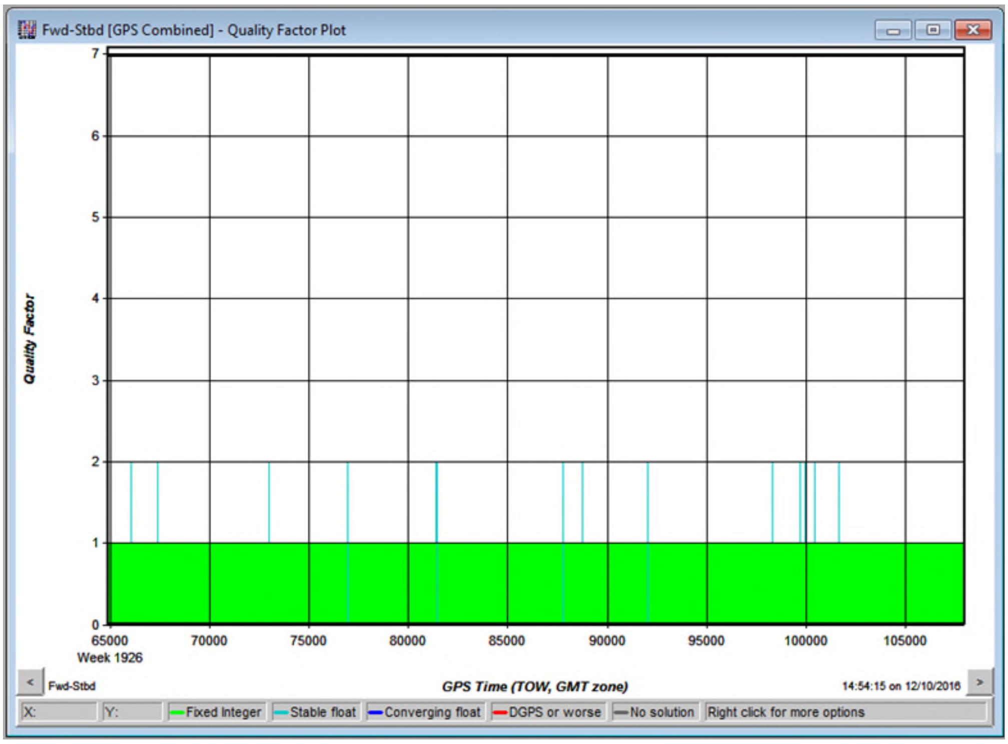

Figure 4.34: Quality factor

4.3.7 Processed Data Output

To export the processed GNSS data, select Output > Export Wizard:

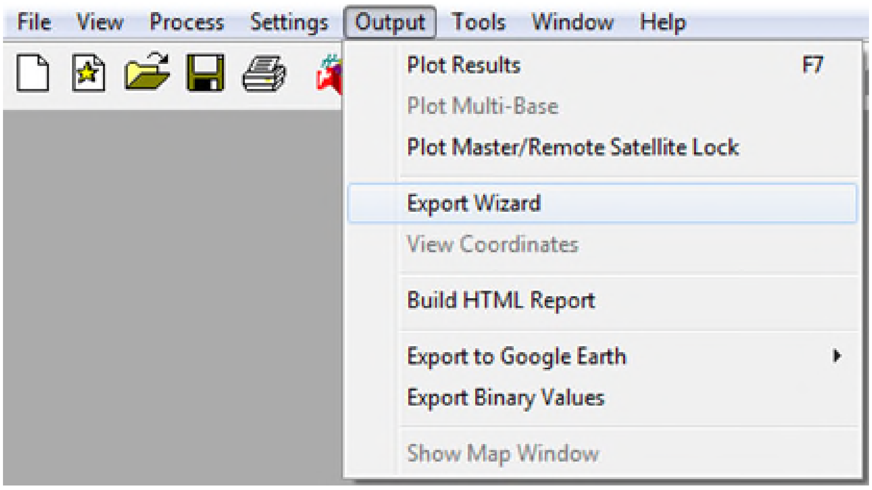

Figure 4.35: Output > Export Wizard

Define the profile type for the Export Coordinate Wizard as **Fugro_DNCal_HPR-Epochs**, and select **Next:**

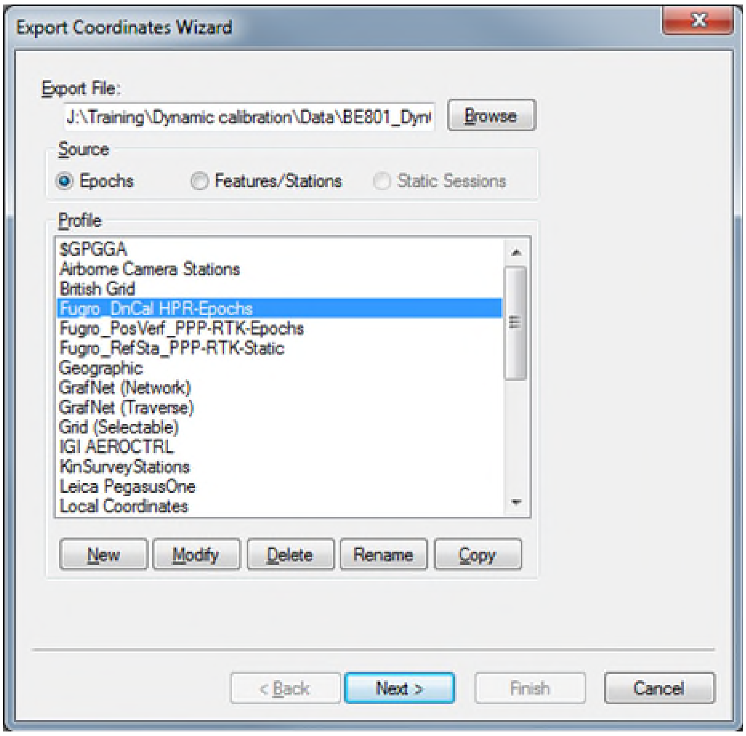

Figure 4.36: Export Coordinates Wizard

In the next window, Select Output Coordinate Datum, select the option to **Use processing datum**, and select **Next:**

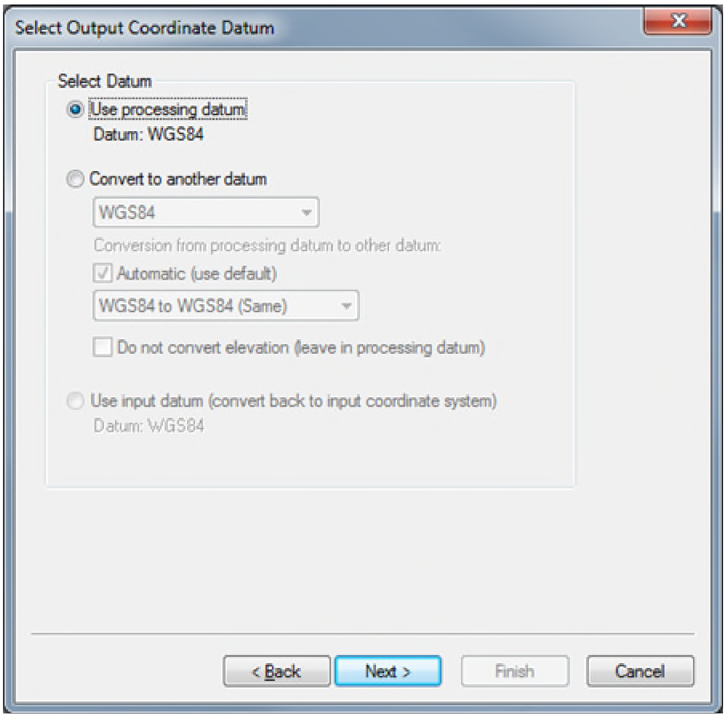

Figure 4.37: Select Output Coordinate Datum

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Enter the UTM Zone Number in the next window (referring to the project mobilisation and calibration procedure), and select **Next:**

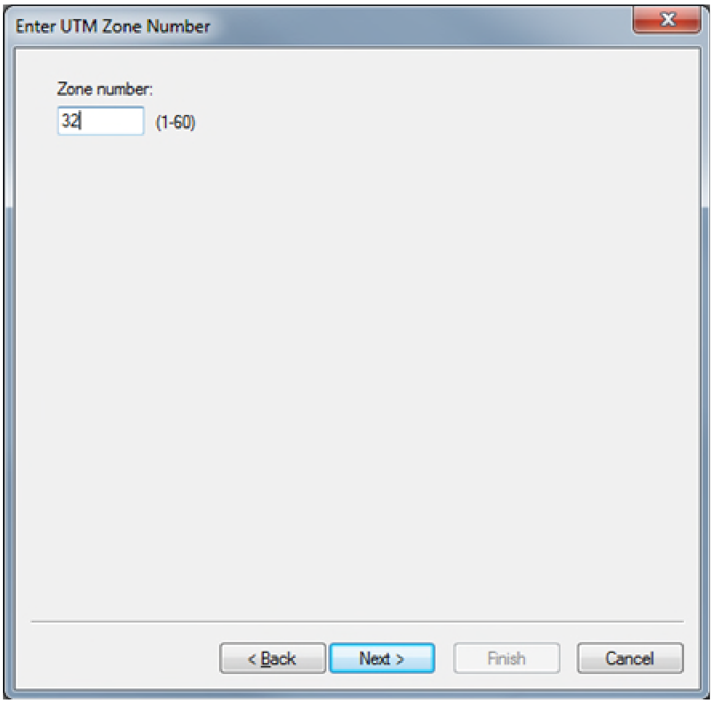


Figure 4.38: Enter UTM Zone Number

Ensure the following parameters in the Filter Output / Estimated Accuracy Scaling window are configured as per the following figure, and select **Next**:

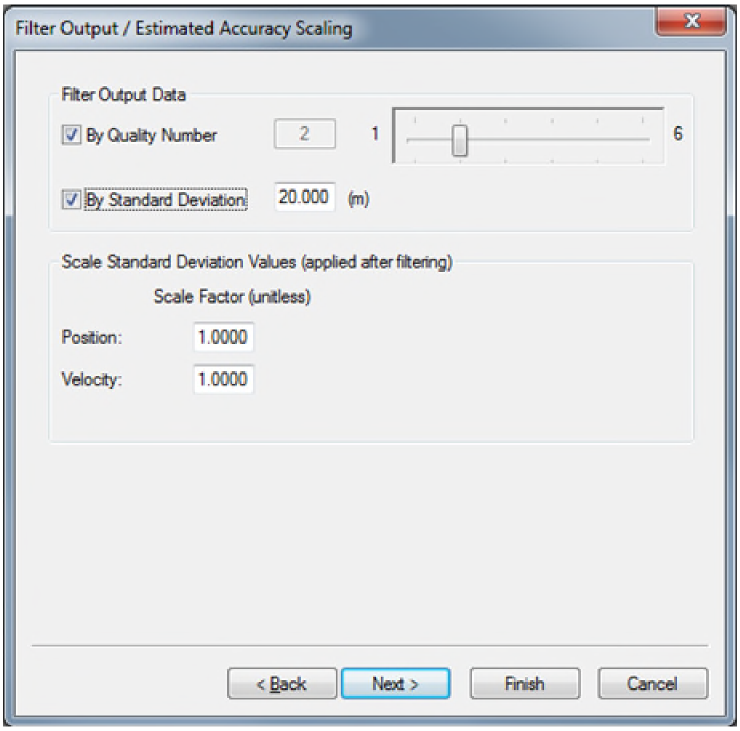


Figure 4.39: Filter output / Estimated Accuracy Scaling settings

In the Select Epoch Sampling Mode, ensure **Export every epoch** is selected, and select **Next**:

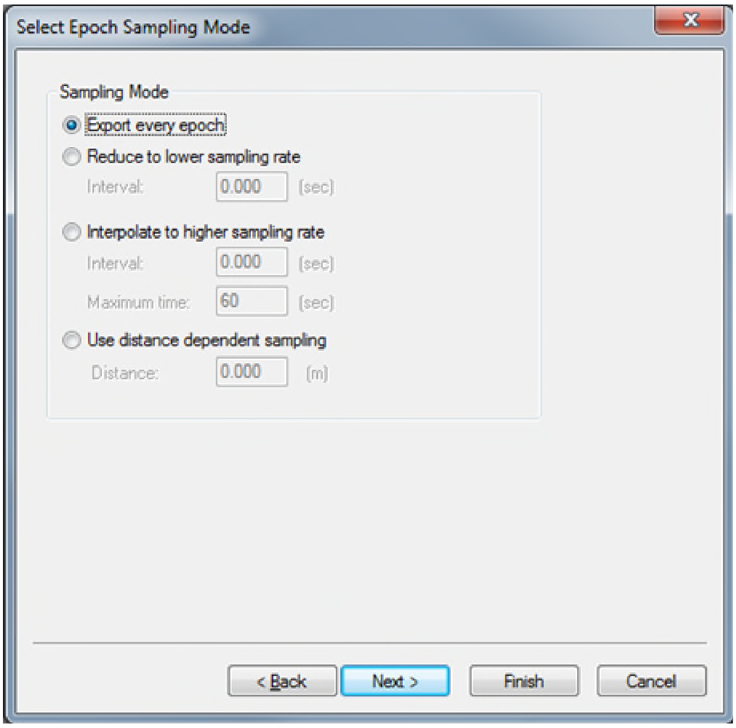


Figure 4.40: Select Epoch Sampling

Under Enter Time Options, ensure that the correct UTC offset is set here. Note that the value entered here is dependent on when the data was acquired. From http://tycho.usno.navy.mil/leapsec.html:

Before the 2016 leap second, GPS is ahead of UTC by seventeen (17) seconds. After the 2016 leap second, GPS is ahead of UTC by eighteen (18) seconds.

As of June 30 2015, and until the leap second of December 31 2016:

- TAI is ahead of UTC by 36 seconds;
- TAI is ahead of GPS by 19 seconds;
- **GPS is ahead of UTC by 17 seconds**.

After December 2016:

- TAI is ahead of UTC by 37 seconds;
- TAI is ahead of GPS by 19 seconds;
- **GPS is ahead of UTC by 18 seconds**.

Based on this information, enter the correct UTC time offset and select **Next**:

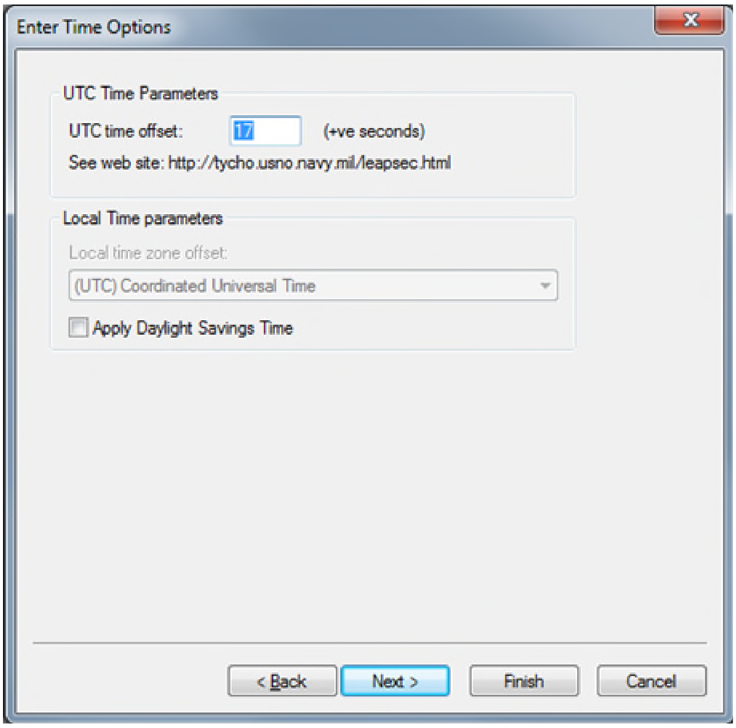


Figure 4.41: Enter Time Options

To complete the steps in the Export Wizard, select the "UTC Date (Day/Month/Year)" option under Export Fields in the Export Definition Complete window, and select **Finish:**

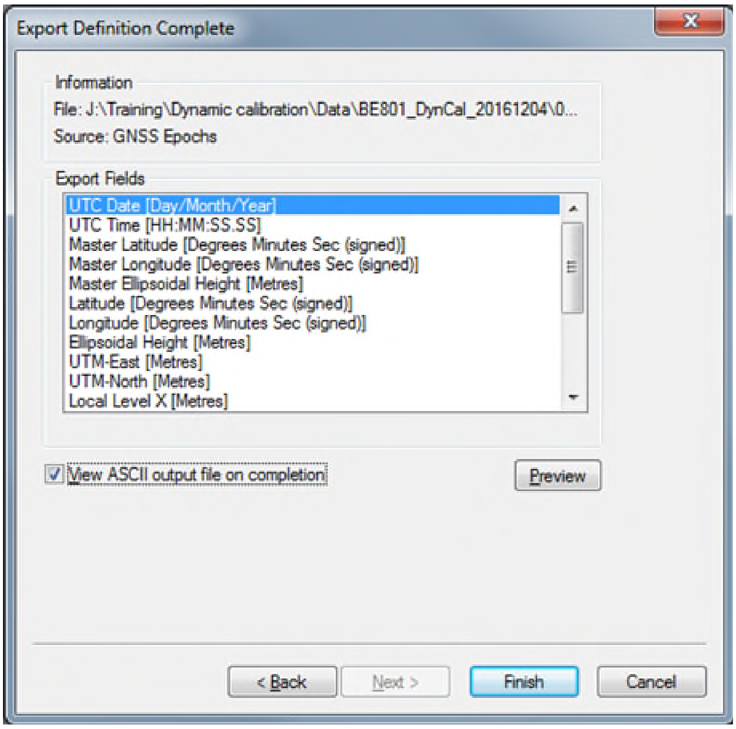


Figure 4.42: Export Definition Complete

Ensure this process is repeated for all baselines, before progressing to the next section.

5. Dynamic Calibrations Sheet

The Dynamic Calibration spreadsheet template "**F - Dynamic Calibration Template**" is in the following location. Select the latest revision:

P:\03.04 SUPPORT\02 Documentation\01 FSBV Survey Guides\14 Dynamic calibrations\Template directory\04 Dynamic calibrations sheet

Copy this template to the relevant project folder, and save the file with the correct project prefix. Note that this spreadsheet can take a moment or two to open.

5.1 Tab I – Import Data from GrafNav

5.1.1 I.1 Import Offsets

The first step in this first tab is to add the antenna offsets into the yellow cells as they are defined in the calibration field data document, under the **Vessel Coordinates Frame** table header in section I.1:

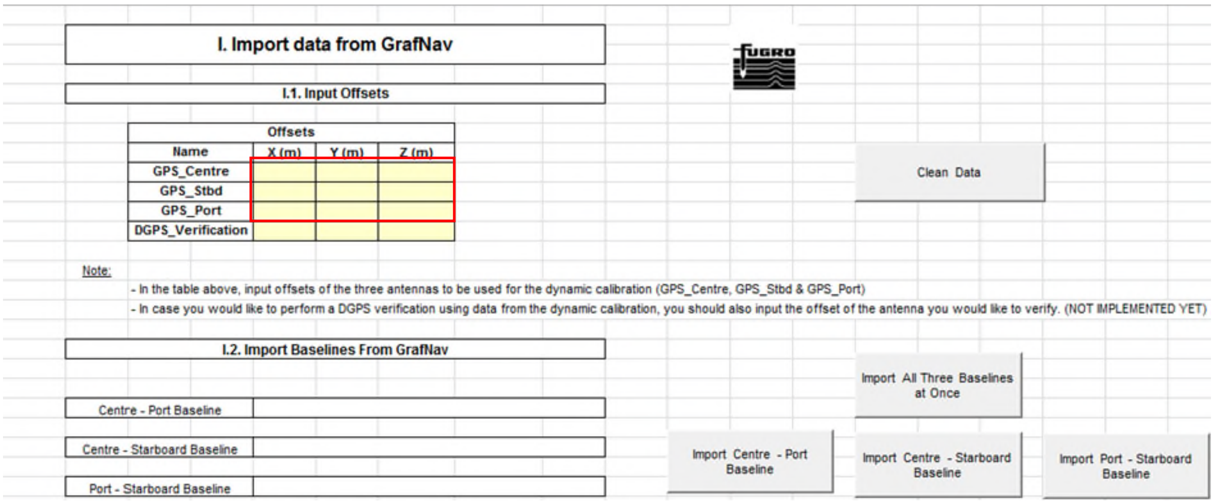


Figure 5.1: I. Import data from GrafNav, add offsets

Presently there is no requirement to input data to the DGPS Verification cells.

Once the offsets are entered, import the baselines from GrafNav under section I.2.

5.1.2 I.2 Import Baselines from GrafNav

Import the baselines from GrafNav, either individually using each individual button, or all at once:

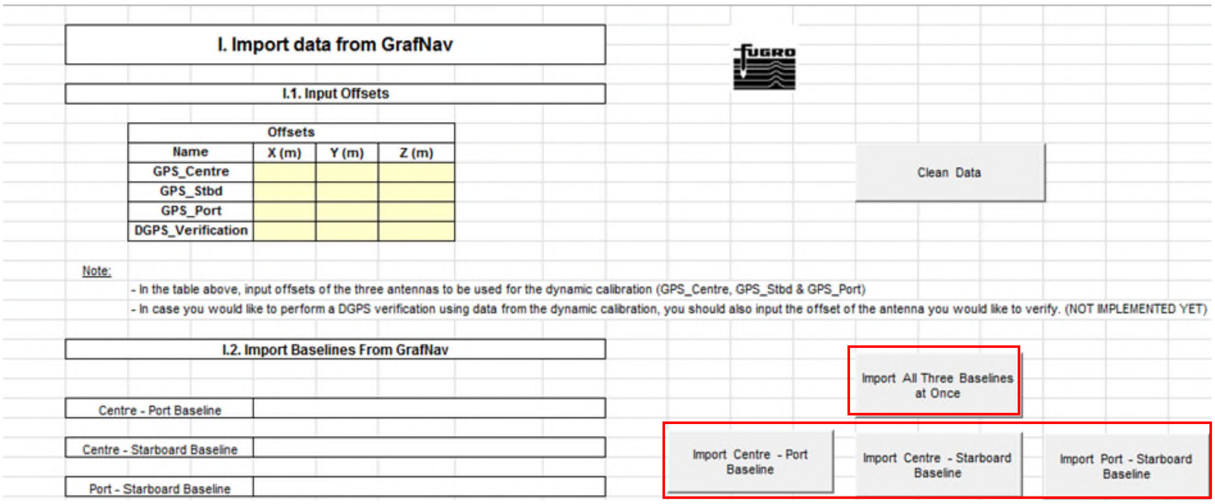


Figure 5.2: I. Import data from GrafNav, import baselines

Wait for the status window too say that all data have been imported successfully.

Once all baselines have been added, the cells from row 41 onwards on his tab will be populated with the headers and subsequent baseline data from *.txt files:

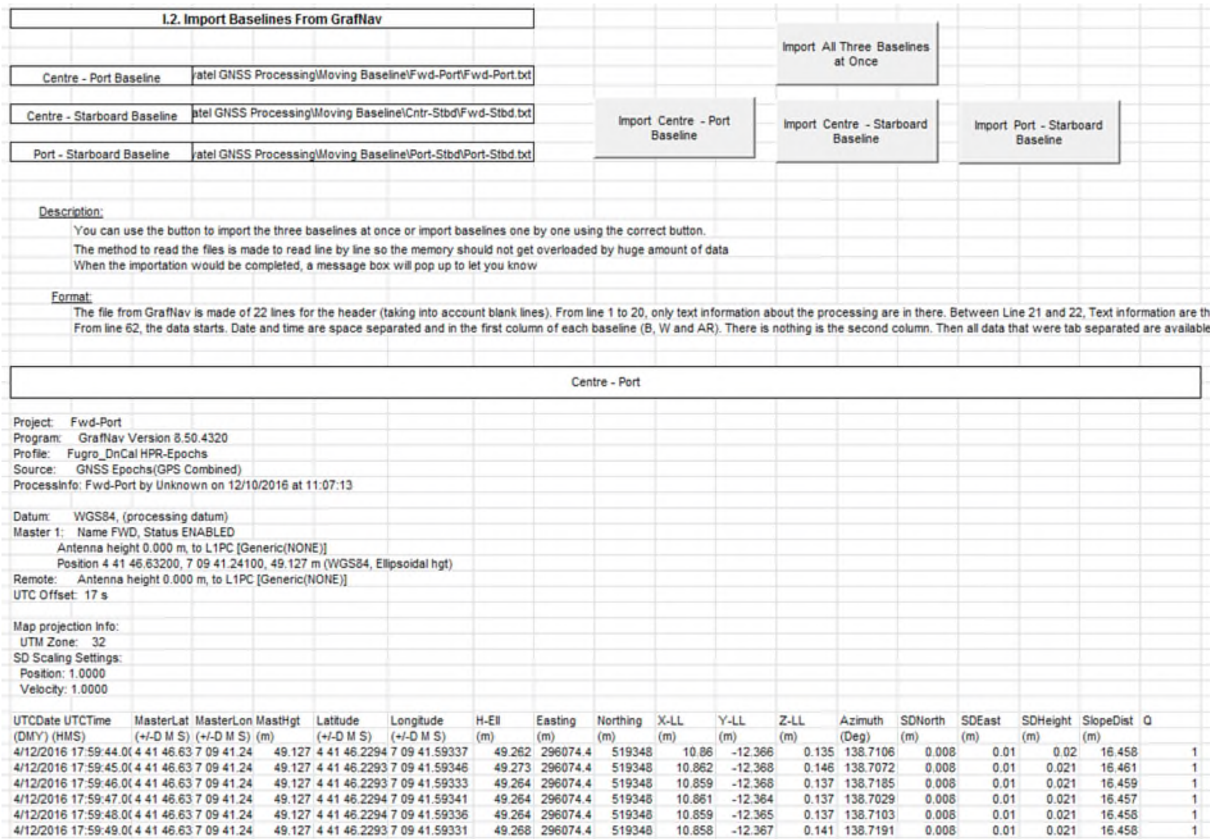
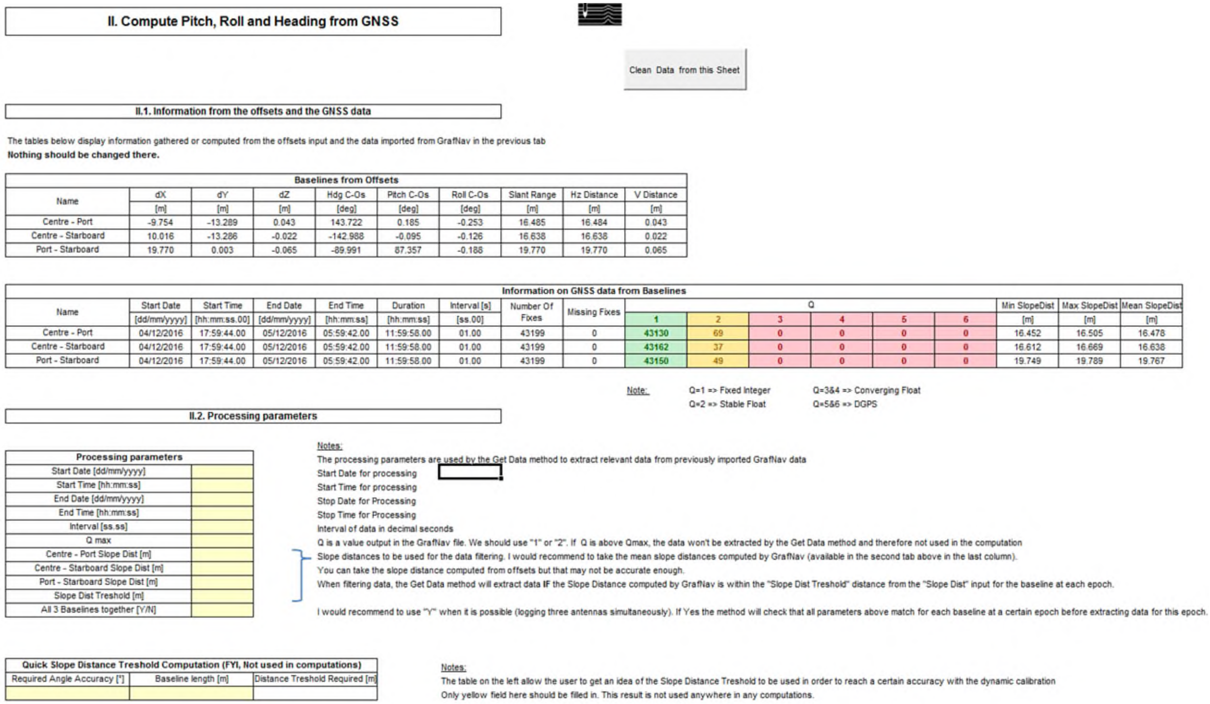


Figure 5.3: I. Import data from GrafNav, baseline data imported

5.2 Tab II – Calculate Pitch, Roll, Heading from GNSS

5.2.1 II.1. Information from the Offsets and the GNSS Data

Once the GNSS data has been imported in tab one, save the spreadsheet and continue to the second tab.



II. Compute Pitch, Roll and Heading from GNSS

Clean Data from this Sheet

II.1. Information from the offsets and the GNSS data

The tables below display information gathered or computed from the offsets input and the data imported from GrafNav in the previous tab
Nothing should be changed there.

Baselines from Offsets									
Name	dX	dY	dZ	Hdg C-Os	Pitch C-Os	Roll C-Os	Slant Range	Hz Distance	V Distance
	[m]	[m]	[m]	[deg]	[deg]	[deg]	[m]	[m]	[m]
Centre - Port	-9.754	-13.289	0.043	143.722	0.185	-0.253	16.485	16.484	0.043
Centre - Starboard	10.016	-13.286	-0.022	-142.988	-0.095	-0.126	16.638	16.638	0.022
Port - Starboard	19.770	0.003	-0.065	-89.991	87.357	-0.188	19.770	19.770	0.065

Information on GNSS data from Baselines																	
Name	Start Date	Start Time	End Date	End Time	Duration	Interval [s]	Number Of Fixes	Missing Fixes	Q						Min SlopeDist	Max SlopeDist	Mean SlopeDist
	[dd/mm/yyyy]	[hh:mm:ss.00]	[dd/mm/yyyy]	[hh:mm:ss]	[hh:mm:ss]	[ss.00]			1	2	3	4	5	6	[m]	[m]	[m]
Centre - Port	04/12/2016	17:59:44.00	05/12/2016	05:59:42.00	11:59:58.00	01.00	43199	0	43130	69	0	0	0	0	16.452	16.505	16.478
Centre - Starboard	04/12/2016	17:59:44.00	05/12/2016	05:59:42.00	11:59:58.00	01.00	43199	0	43162	37	0	0	0	0	16.612	16.669	16.638
Port - Starboard	04/12/2016	17:59:44.00	05/12/2016	05:59:42.00	11:59:58.00	01.00	43199	0	43150	49	0	0	0	0	19.749	19.789	19.767

Note: Q=1 => Fixed Integer Q=3&4 => Converging Float
Q=2 => Stable Float Q=5&6 => DGPS

II.2. Processing parameters

Processing parameters	
Start Date [dd/mm/yyyy]	
Start Time [hh:mm:ss]	
End Date [dd/mm/yyyy]	
End Time [hh:mm:ss]	
Interval [ss.ss]	
Q max	
Centre - Port Slope Dist [m]	
Centre - Starboard Slope Dist [m]	
Port - Starboard Slope Dist [m]	
Slope Dist Treshold [m]	
All 3 Baselines together [Y/N]	

Notes:
The processing parameters are used by the Get Data method to extract relevant data from previously imported GrafNav data
Start Date for processing
Start Time for processing
Stop Date for Processing
Stop Time for Processing
Interval of data in decimal seconds
Q is a value output in the GrafNav file. We should use "1" or "2". If Q is above Qmax, the data won't be extracted by the Get Data method and therefore not used in the computation
Slope distances to be used for the data filtering. I would recommend to take the mean slope distances computed by GrafNav (available in the second tab above in the last column).
You can take the slope distance computed from offsets but that may not be accurate enough.
When filtering data, the Get Data method will extract data **IF** the Slope Distance computed by GrafNav is within the "Slope Dist Treshold" distance from the "Slope Dist" input for the baseline at each epoch.

I would recommend to use "Y" when it is possible (logging three antennas simultaneously). If Yes the method will check that all parameters above match for each baseline at a certain epoch before extracting data for this epoch.

Quick Slope Distance Treshold Computation (FYI, Not used in computations)		
Required Angle Accuracy [°]	Baseline length [m]	Distance Treshold Required [m]

Notes:
The table on the left allow the user to get an idea of the Slope Distance Treshold to be used in order to reach a certain accuracy with the dynamic calibration
Only yellow field here should be filled in. This result is not used anywhere in any computations.

Figure 5.4: II. Compute PRH from GNSS, baseline data imported

Under II.1, the "Baselines from Offsets" and "Information on GNSS data from Baselines" tables will be populated with data input or uploaded in the previous tab.

5.2.2 II.2. Processing Parameters

Set the processing parameters under II.2:

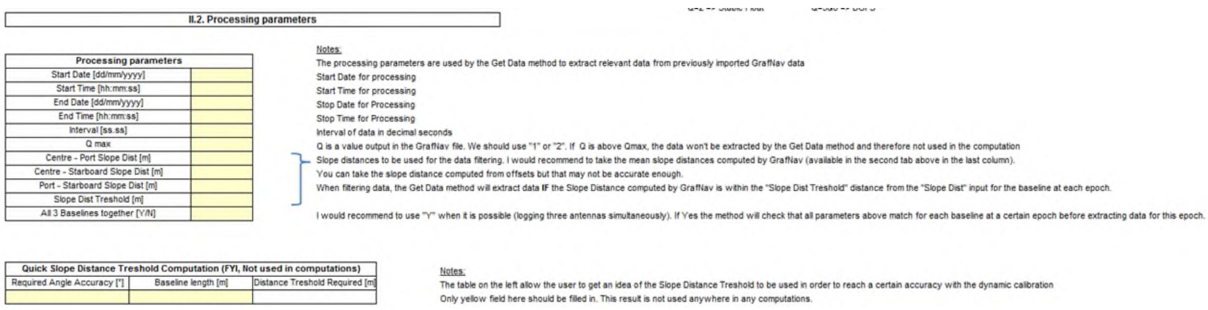


Figure 5.5: II. Compute PRH from GNSS, baseline data imported

For each parameter, follow these criteria:

Table 5.1: II.2 Processing Parameters Criteria

Parameter	Criteria
Start Date [dd/mm/yyyy]	It is usual that the start date will be the same for all the datasets, but in case not, select a start date that will encompass all required datasets.
Start Time [hh:mm:ss]	As per the start date, select a start time that will encompass all required datasets.
End Date [dd/mm/yyyy]	Select an end date that encompasses all datasets.
End Time [hh:mm:ss]	Select an end time that encompasses all data sets.
Interval [ss.ss]	Check the interval in the "Information on GNSS data from Baselines" table in section II.1, which is usually 01.00.
Q max	It is usual to set the quality value here to 2, to capture all fixes assigned quality values 1 and 2.
Centre - Port Slope Dist [m]	Take this value from the relevant row in the last column in the the "Information on GNSS data from Baselines" table in section II.1.
Centre - Starboard Slope Dist [m]	Take this value from the relevant row in the last column in the the "Information on GNSS data from Baselines" table in section II.1.
Port - Starboard Slope Dist [m]	Take this value from the relevant row in the last column in the the "Information on GNSS data from Baselines" table in section II.1.
Slope Dist Threshold [m]	Calculate from "Quick Slope Distance Threshold Computation" table.
All 3 Baselines together [Y/N]	Enter "Y" here.

For the Slope Dist Threshold [m] entry, the table below the processing parameters in the spreadsheet should be used to calculate the slope distance threshold. Enter the data required for the first two columns, and the result will be populated in the third column:

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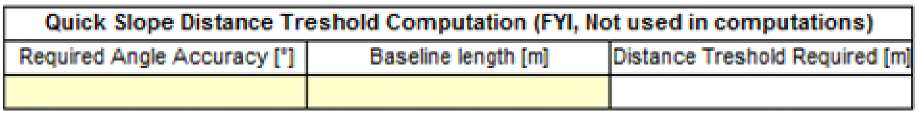

Quick Slope Distance Treshold Computation (FYI, Not used in computations)		
Required Angle Accuracy [°]	Baseline length [m]	Distance Treshold Required [m]

Figure 5.6: II.2 Quick slope distance threshold computation

Table 5.2: II.2 Quick Slope Distance Threshold Computation criteria

Parameter	Criteria
Required Angle Accuracy [°]	Enter 0.1.
Baseline length [m]	Select the longest baseline of the last column in "Information on GNSS data from Baselines" in section II.1.

5.2.3 II.3. Extracting the Data and Computing Pitch, Roll, and Heading

Once all the parameters have been set in the yellow cells in this tab, extract the data from the previous tab using the **Get Data from Previous Tab using Processing Parameters** button under **II.3.1 Extracting the data**:

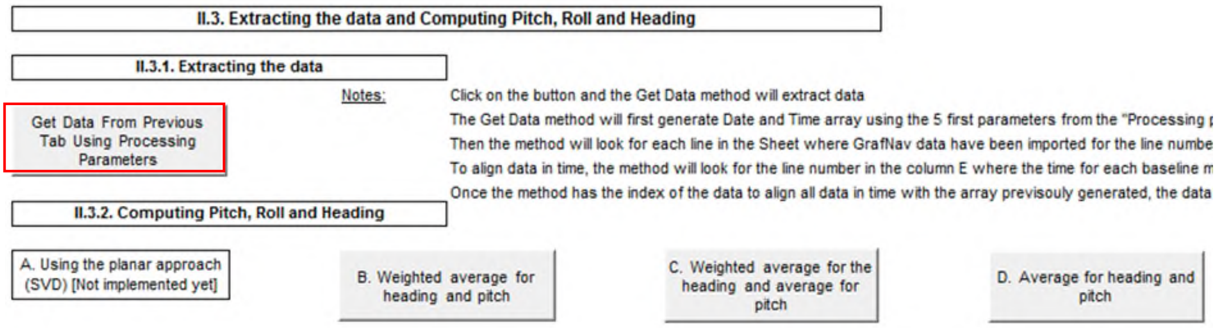

Figure 5.7: II.3.1 Extracting the data

The following message will appear, select Yes:

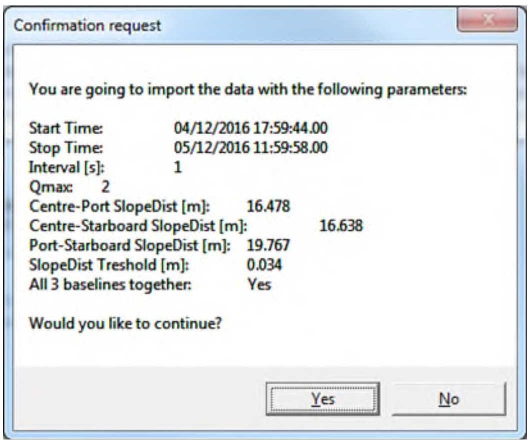

Figure 5.8: II.3.1 Confirmation request

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This may take a moment or two to complete, after which time a window will appear to confirm data importation:

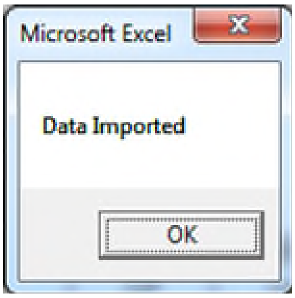

Figure 5.9: Confirmation of data importation

After this, it is necessary to select the appropriate processing method to compute the pitch, roll, and heading data. At present, method B **Weighted average for heading and pitch** is recommended for use:

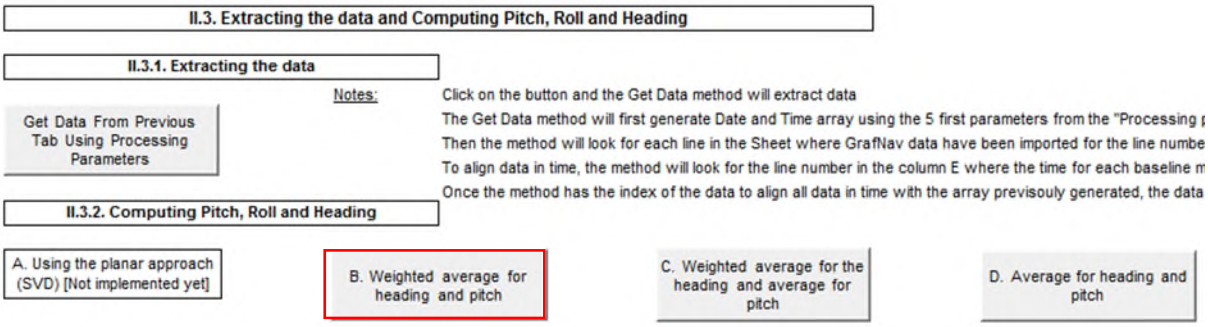

Figure 5.10: II.3.2 Method B. Weighted average for heading and pitch

Select Yes when the Confirmation Request window appears:

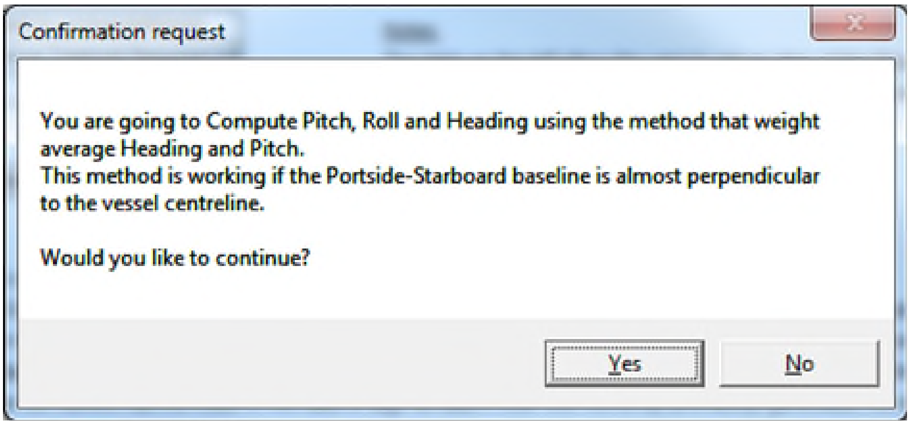

Figure 5.11: Confirmation request to compute pitch, roll, and heading

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Once the computation has been completed, select OK for the following message:

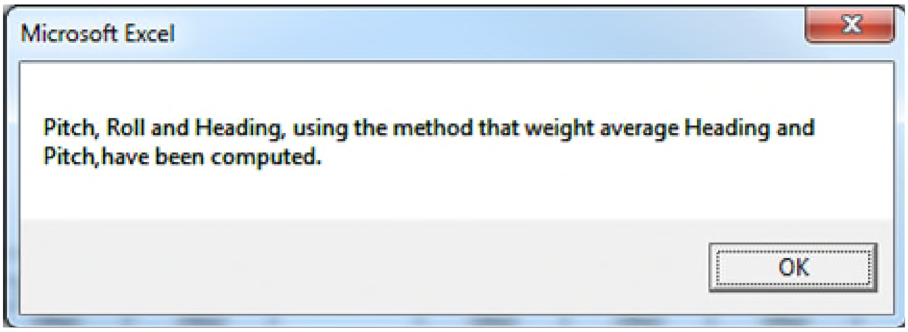

Figure 5.12: Successful computation of heading, pitch, and roll

5.3 Tab III – VBAProc and Mproc

5.3.1 III.1 Export data for VBAProc

Once the heading, pitch, and roll have been computed, the next step for calibration is in the third tab in the spreadsheet. Select the **Export Non-Filtered Data** button under header III.1:

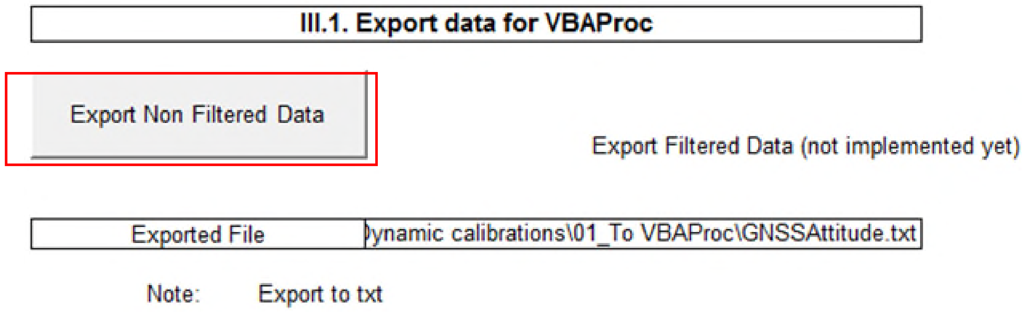

Figure 5.13: Export Non-Filtered Data button

Select the intended output location and file name in the "Save as" window, and select Save:

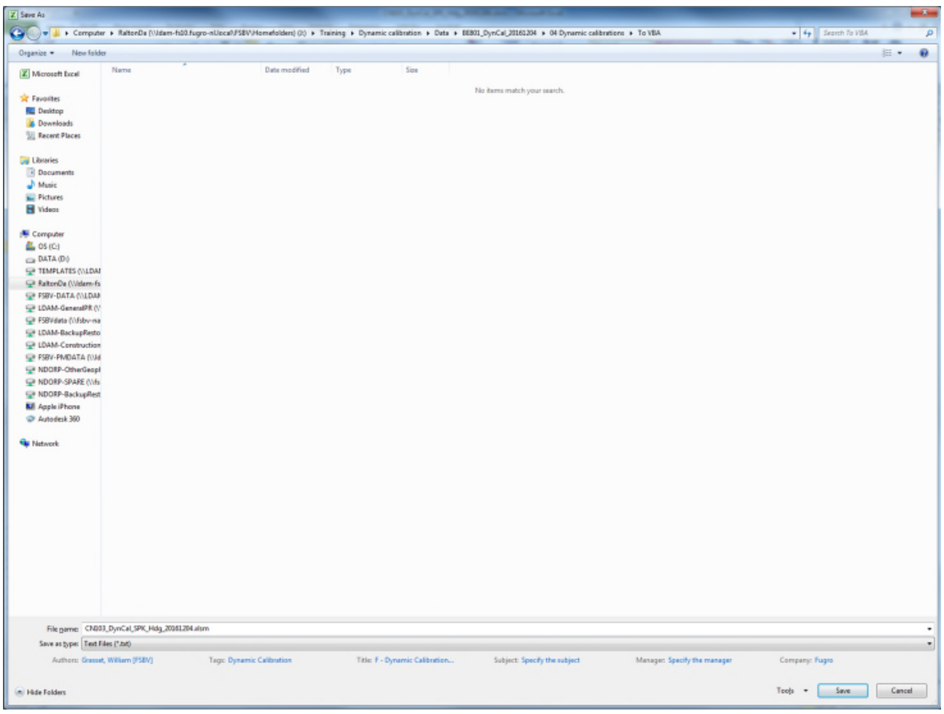

Figure 5.14: Save *.txt file of exported Non-Filtered data

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The spreadsheet will confirm the file path and name before continuing. Verify the information and select OK:

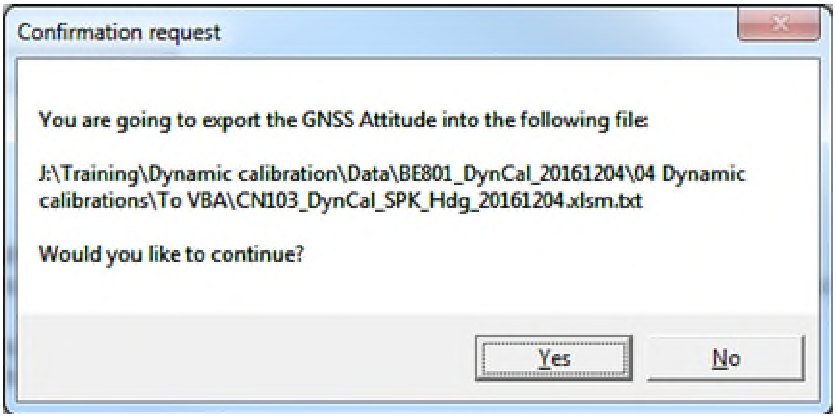

Figure 5.15: Confirmation request to continue export of GNSS attitude data

When the export is completed, the following window will appear. Select OK to continue:

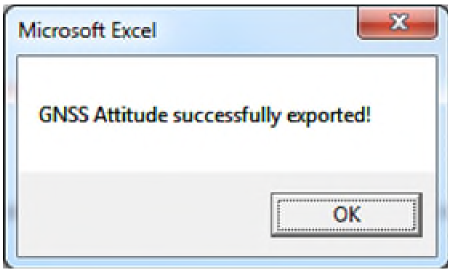

Figure 5.16: GNSS attitude data successfully exported

Browse to the exported file. There are a couple of points to QC, and potentially amend, before continuing. Firstly, the date can export incorrectly in US format (mm/dd/yyyy). Find and replace throughout the document to amend this. Secondly, if the data is acquired over more than one day, the exported data will not include the midnight time entry. Once these edits are complete, save the file before continuing:

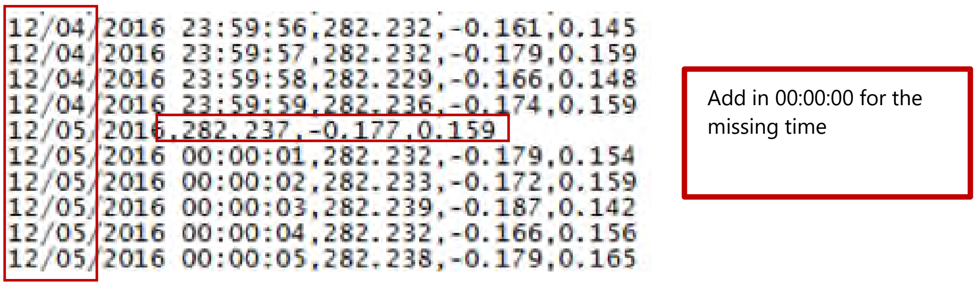

Figure 5.17: Data output format to be amended

Once the GNSS attitude data *.txt file has been verified, and amended where required, proceed to the next step.

5.4 III.2. Import Data in VBAProc

5.4.1 III.2.1 Import SPL Files into VBAProc

Open VBAProc/Starfix Proc. Open the Project Manager:

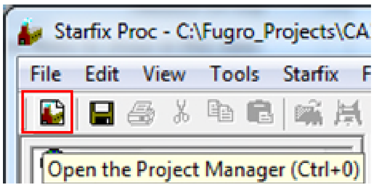

Figure 5.18: Open the Project Manager

The Starfix Project Manager will appear:

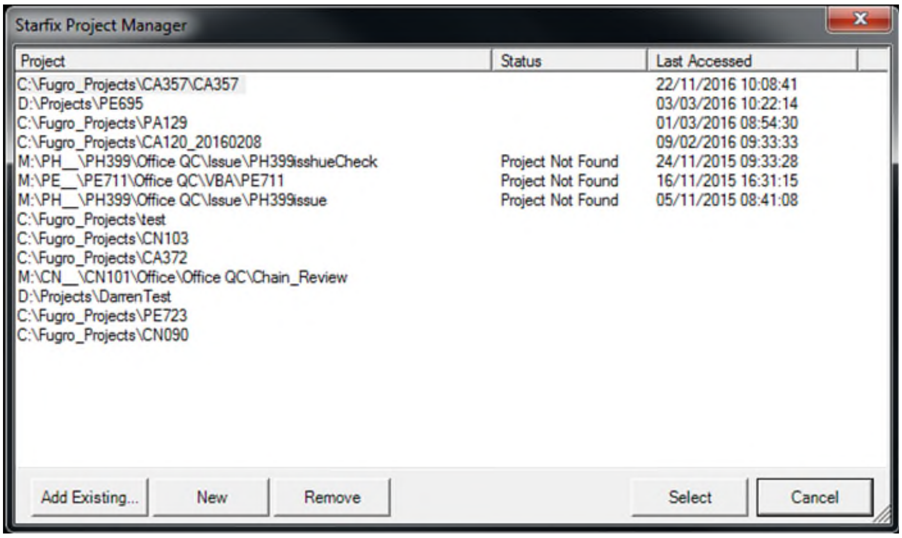

Figure 5.19: Starfix Project Manager

Add a project folder in the C: drive (or appropriate drive).

Create a “Fugro Projects” folder if one does not already exist, and further create a project folder in here. Select OK when this is done:

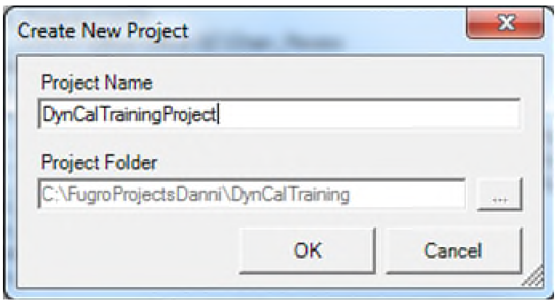

Figure 5.20: Create New Project

Once the project is created, it is necessary to import the data. First, import the Starfix logging data in *.fbf format. If the data was acquired using Starfix Classic, import the *.fbf files through **File** > **Import** > **Starfix Logging Data (.FBF).** If the data was acquired using Starfix NG, import the data through **File** > **Import** > **NG Logging Data (.FBF).**

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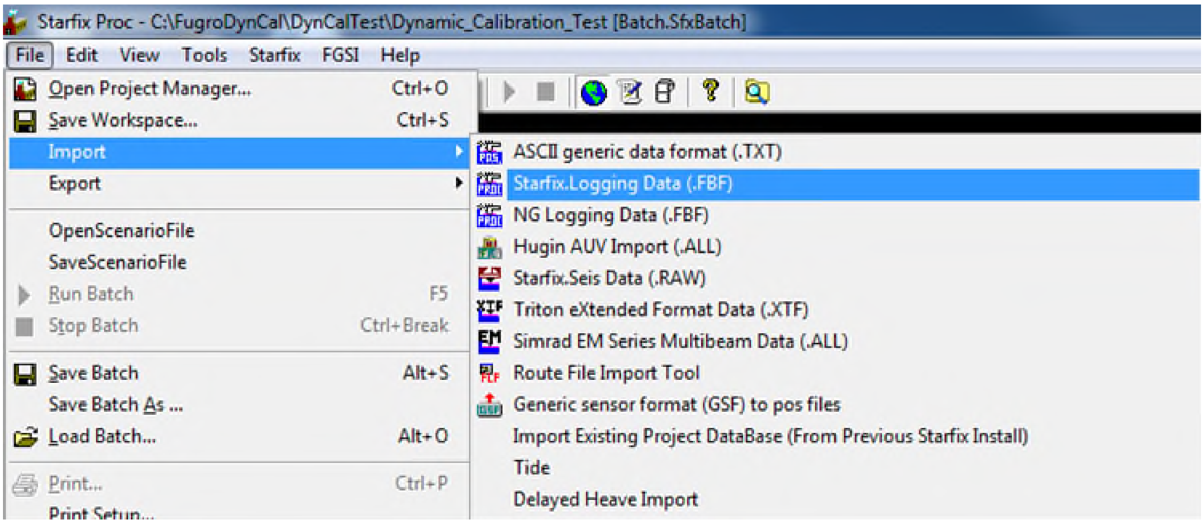

Figure 5.21: File > Import > Select .fbf file import method

Browse to the location of the SPL files, and select the directories to import:

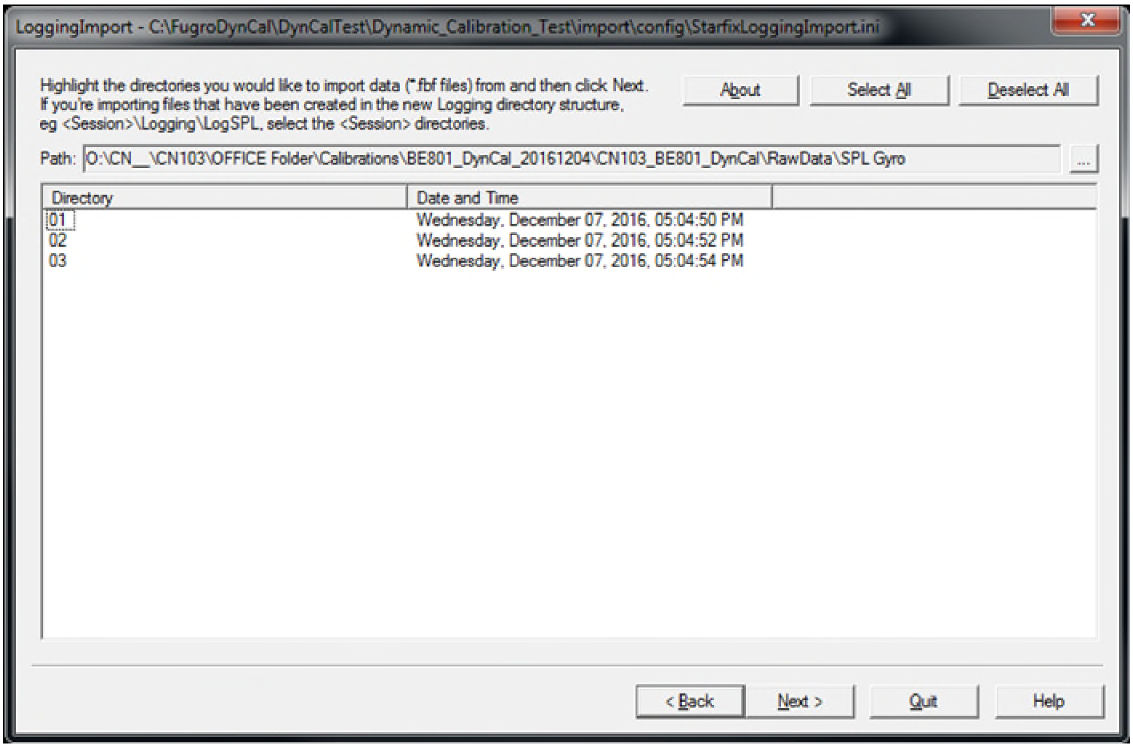

Figure 5.22: Logging Import window

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Select the files to be imported (hold the Shift key to select multiple files). Note that file names containing “PRX” should not be imported as these are not raw and have C-O applied: Select **Next** to continue:

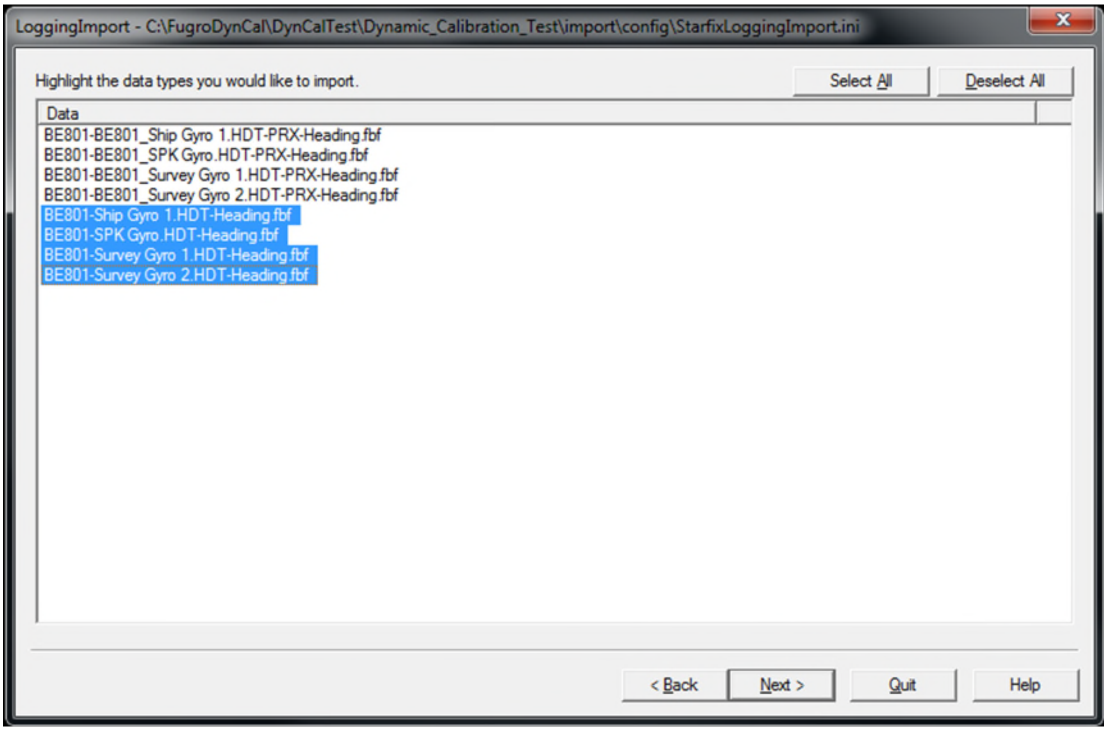

Figure 5.23: Select raw *.fbf files

Select all heading and motion files for which you want to generate C-Os.

Configure the settings as per the following figure, and select **Next** to continue:

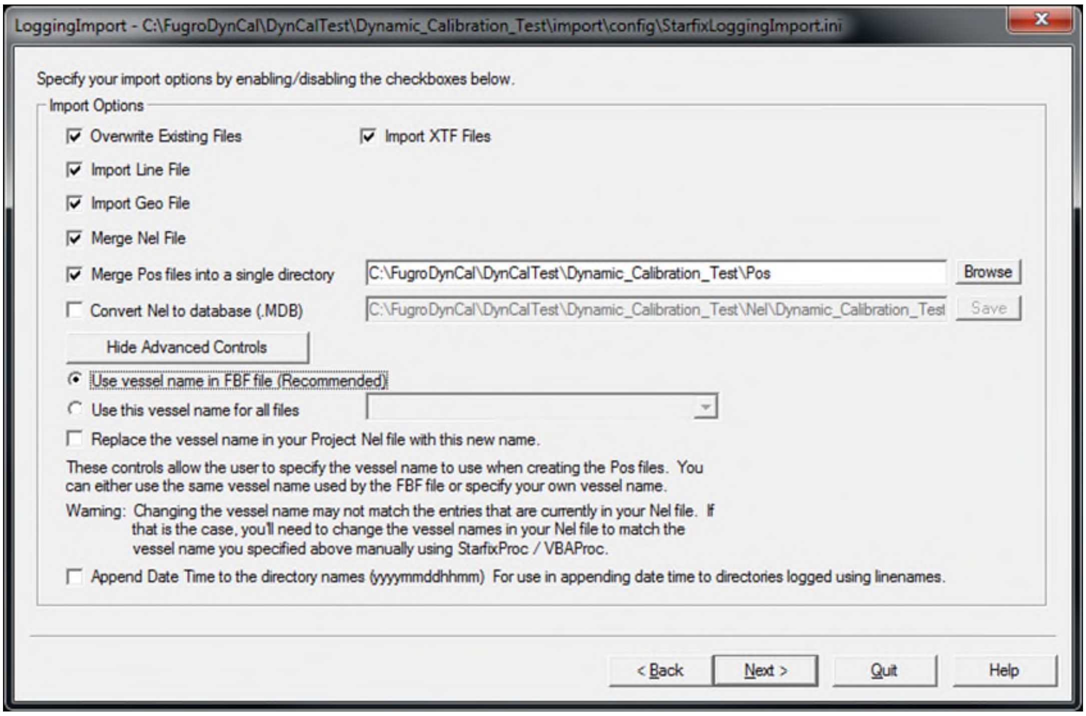

Figure 5.24: Select import options

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Select **Start Import** to commence importing the files. The output window will then populate with the importation activity. When this is complete, the **Start Import** button will be greyed out. Select **Quit** to complete the process.

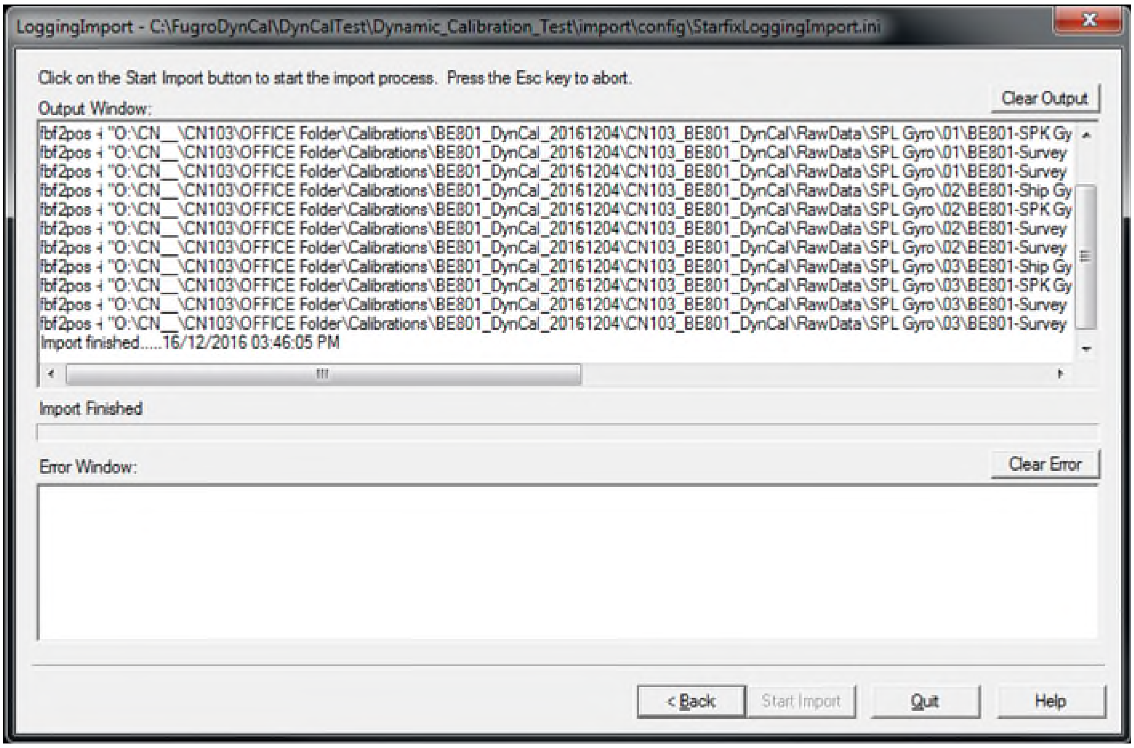

Figure 5.25: Start Import window

5.4.2 III.2.2 Import GNSS Attitude File into VBAProc

Once the SPL files have been imported and converted to *.pos files, the next step is to import the GNSS attitude file in *.txt format to convert into .pos.

Browse to File > Import > ASCII generic data format (*.TXT):

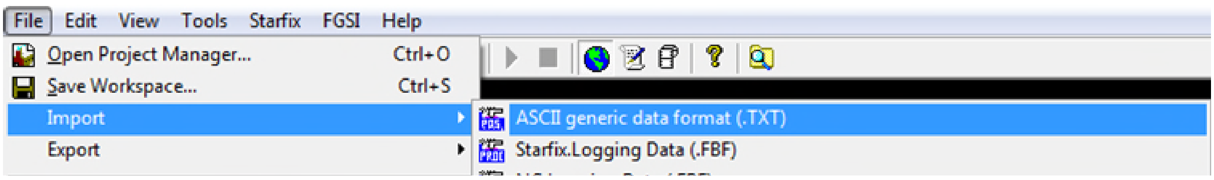

Figure 5.26: Start Import window

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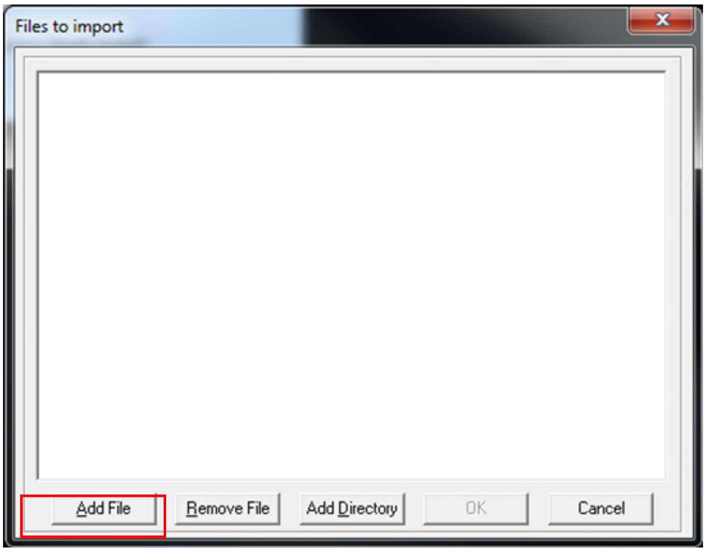

Figure 5.27: Files to import > Add File

Browse to or copy the file path to the *.txt file, and select **Open**:

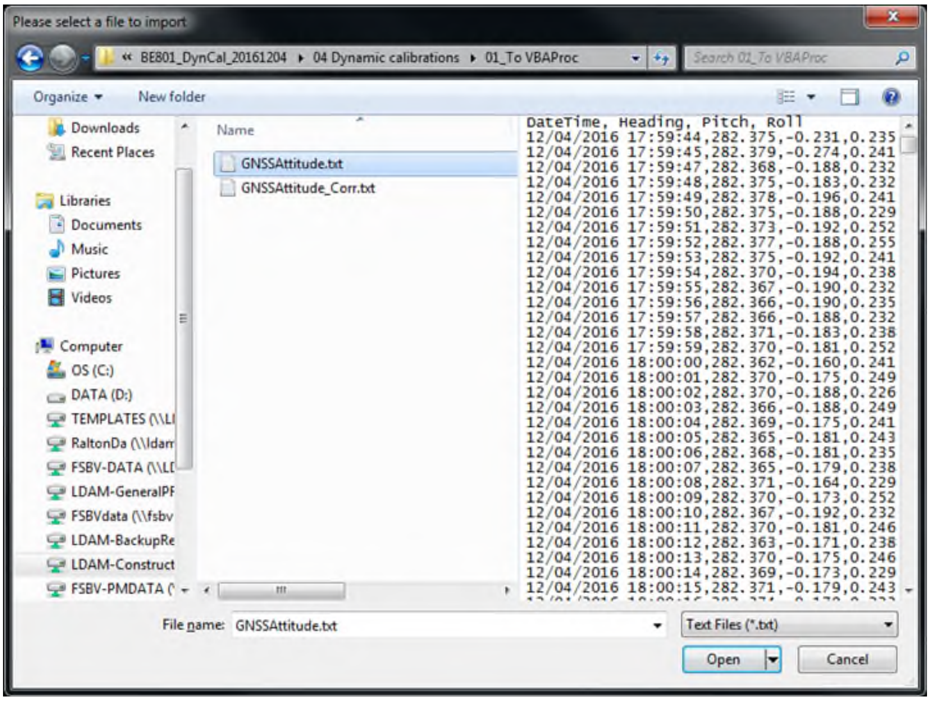

Figure 5.28: Please select a file to import

The Files to import window will now show the file path to the selected *.txt file. Select **OK** to continue:

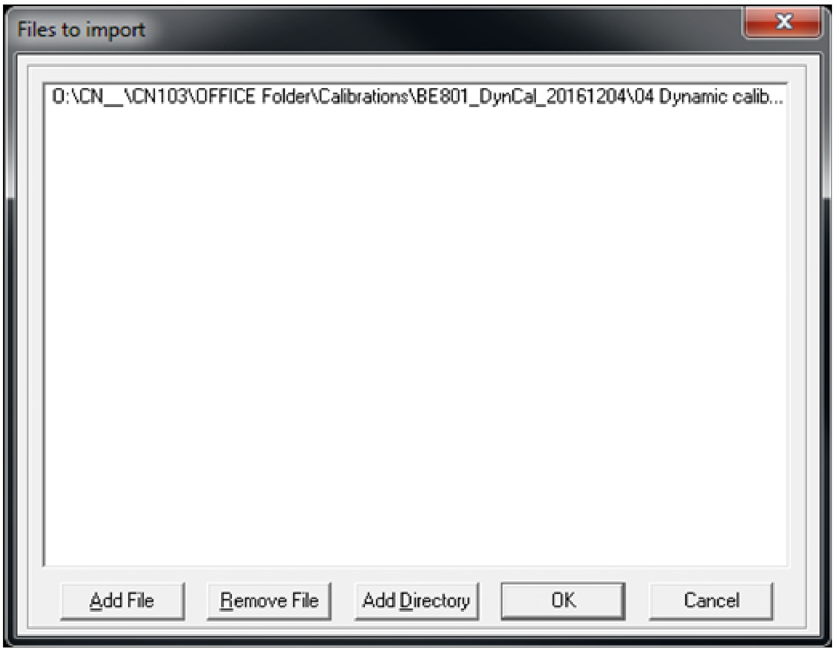

Figure 5.29: Files to import, file selected

In the Import Wizard - Step 1, ensure the settings are as per the following image, setting <u>Number of lines</u> to skip to the relevant value to eliminate header information, and select **Next:**

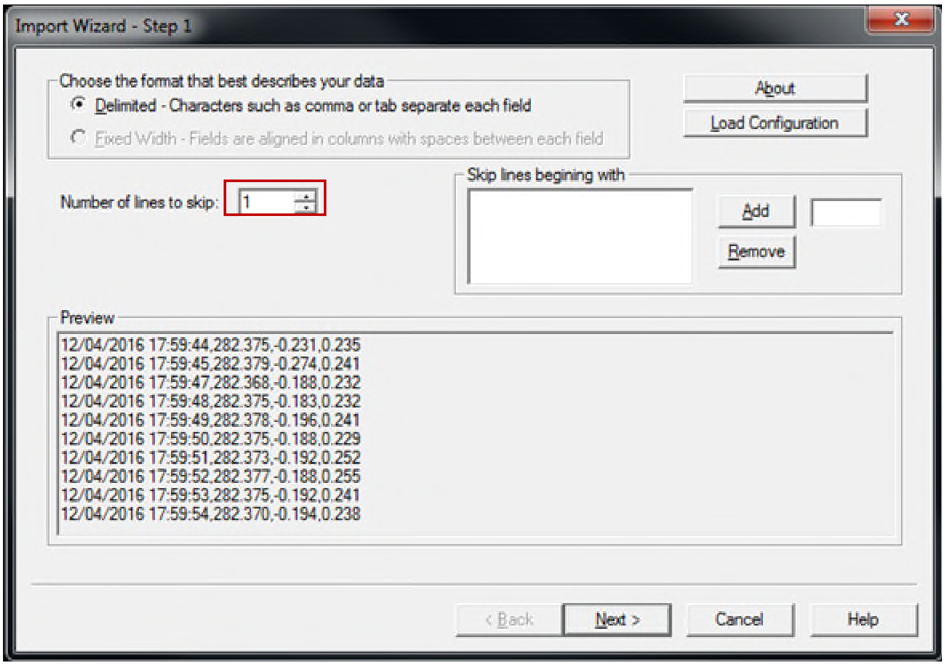

Figure 5.30: Import Wizard - Step 1

In the following window, Import Wizard – Step 2, the type of delimiter should be specified (comma in this case). Select **Next** to continue:

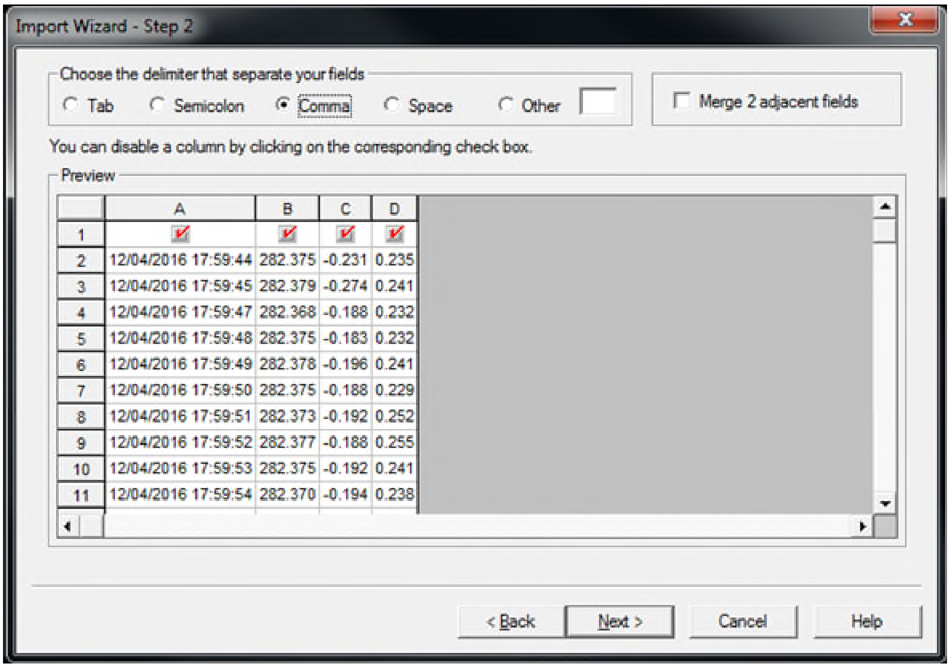

Figure 5.31: Import Wizard -Step 2

In Import Wizard - Step 3, ensure that **User Defined** is set under **Choose Data Fields**, and select **Next** to continue:

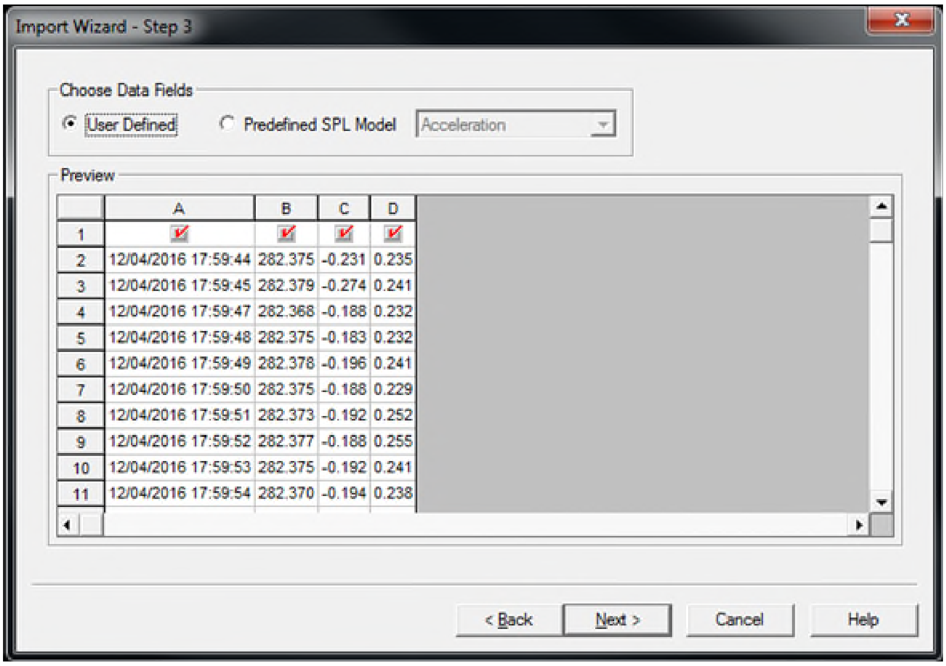

Figure 5.32: Import Wizard -Step 3

In Import Wizard - Step 4, each column requires specific configuration depending on the data type. The first column, the date and time, should be configured as per Figure 5.33. Check **Field is in this format** and select the **Change** button:

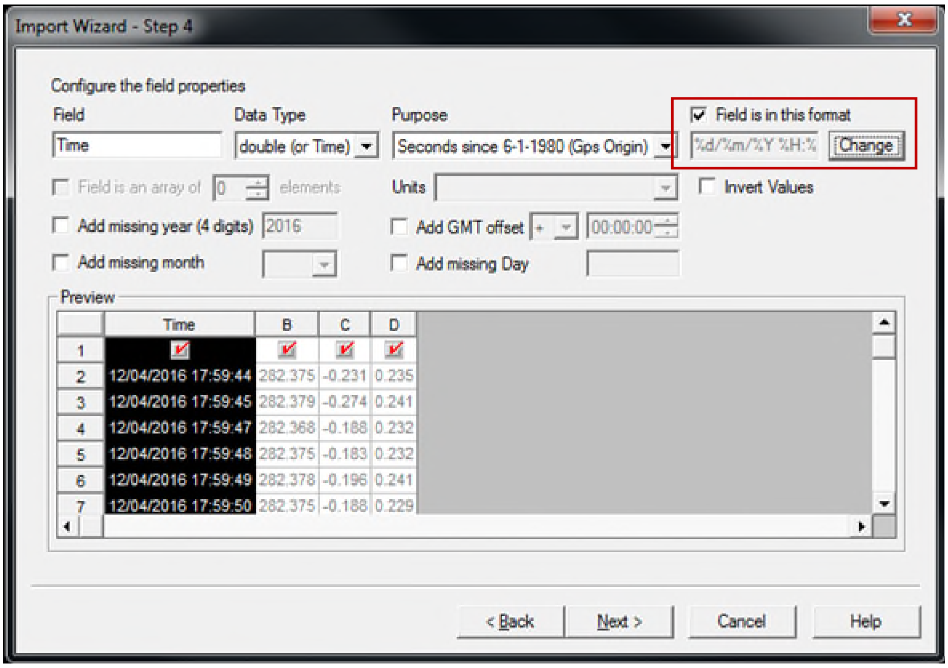

Figure 5.33: Import Wizard -Step 4, time configuration

From the drop down menu, select **dd/mm/yyyy HH:MM:SS.SSS**, and select **Add**. Select **OK**, and in the main wizard window, select the second column:

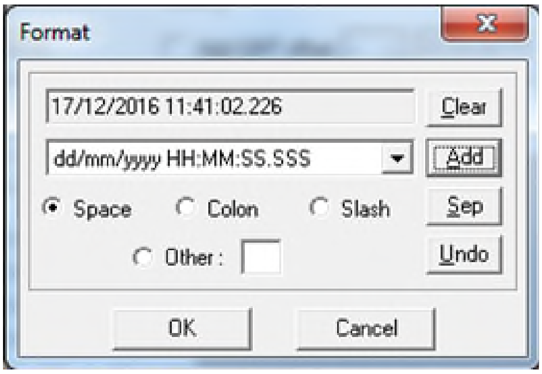

Figure 5.34: Import Wizard -Step 4, field format selection

The second column contains the heading data, and should be configured as such. The following figure shows the settings to be applied. Once all settings have been selected, select the third column:

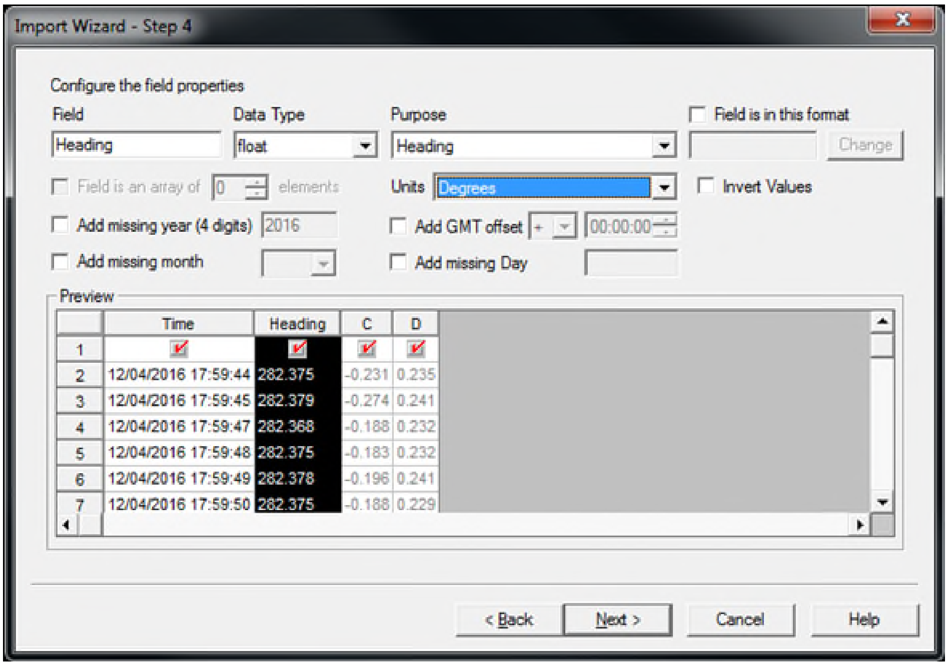

Figure 5.35: Import Wizard -Step 4, heading configuration

The third column contains the sensor pitch data. Ensure the settings are as per the following figure. Once all settings have been selected, select the fourth column:

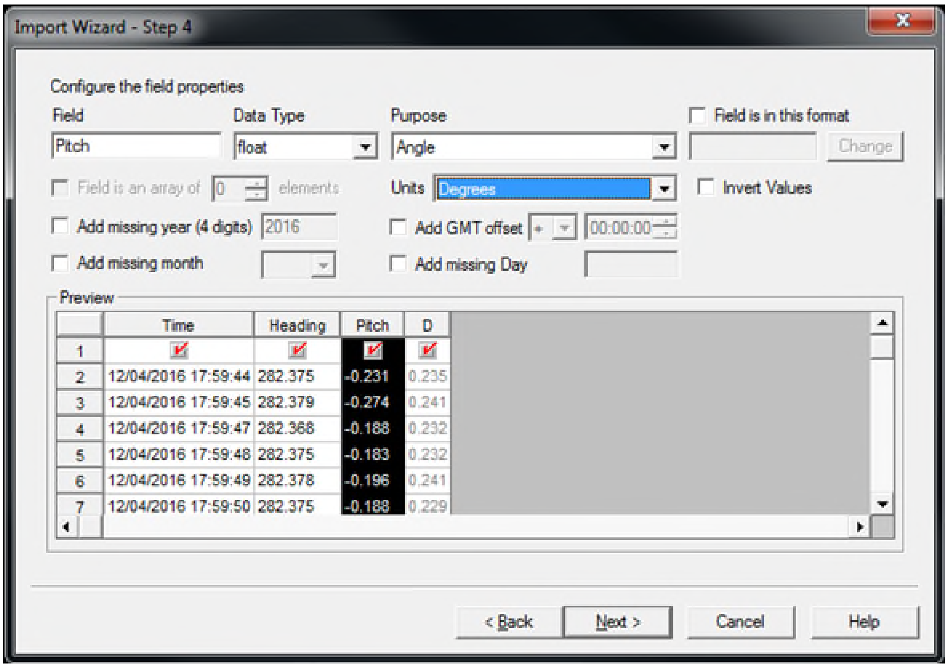

Figure 5.36: Import Wizard -Step 4, pitch configuration

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The fourth and final column, the roll data, should be configured as per the settings in the following figure. Once all settings have been selected, select **Next** to the next step:

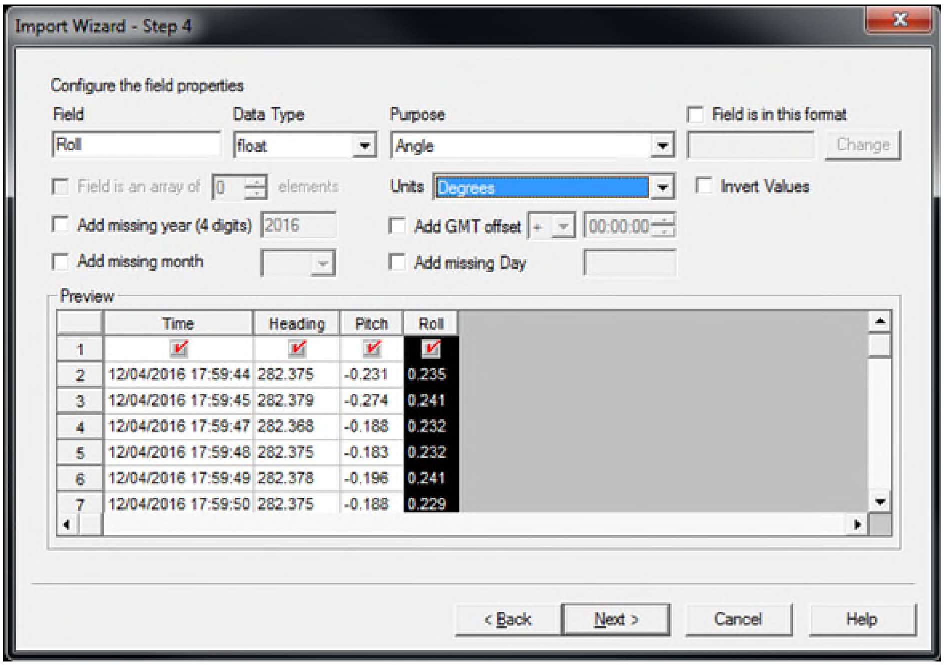

Figure 5.37: Import Wizard -Step 4, roll configuration

An overview of the settings for step 4 is shown in the following table:

Table 5.3: Startfix VBAProc Import Wizard - Step 4 Settings Summary

Column	Field	Data Type	Purpose	Units	Field in this format
Date/time	"Time"	Double (or Time)	Seconds since 6-1-1980 (GPS Origin)	-	Check box, dd/mm/yy HH:MM:SS.SSS
Heading	"Heading"	Float	Heading	Degrees	-
Pitch	"Pitch"	Float	Angle	Degrees	-
Roll	"Roll"	Float	Angle	Degrees	-

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The output file name should be configured in the window Import Wizard - Step 5. Browse to the intended *.pos file save location. The file name format should be [VESSEL NAME]-GNSSAttitude-Model.pos. The vessel name or code here should follow the same format as the other *.fbf files. Ensure the "Add ProcFlags column" setting is selected, and press **Finish**:

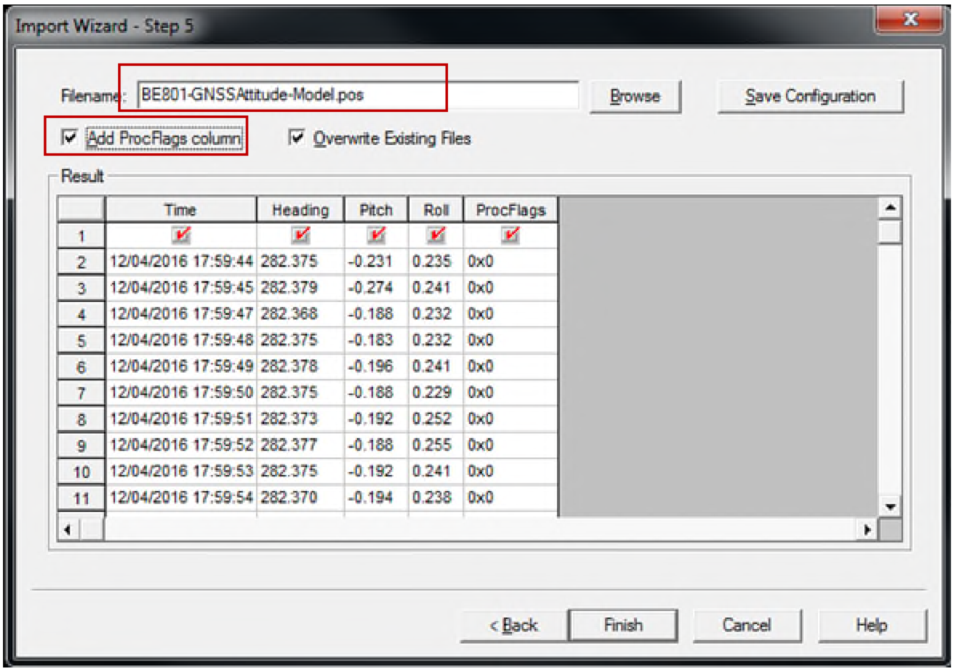

Figure 5.38: Import Wizard –Step 5

Create a folder in the Proc project pos directory and drag all files into it e.g. a folder called 'session1'.

In the VBAProc window, select the refresh button to see the GNSS attitude data displayed under the vessel name in the session. If the data does not appear, browse to the *.pos file location and ensure that the vessel name format exactly matches the others for this same vessel.

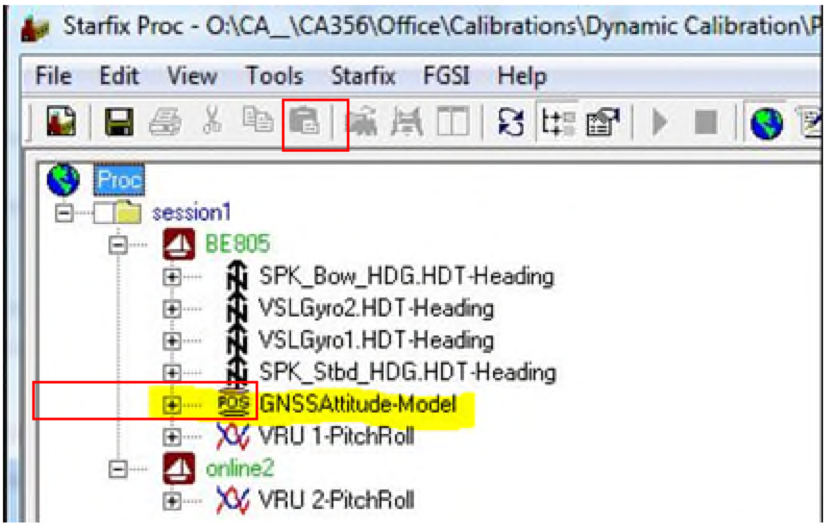

Figure 5.39: VBAProc > Refresh

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5.4.3 III.2.3 Evaluate C-Os in VBAProc

Originally this was used in order to determine the latency of the sensors and thus align the data sets of all the sensors with the calculated latency value. Unfortunately in MProc it is very difficult to determine millisecond latency and thus a threshold value is rather used in the spreadsheet to select data nearest to the GNSS data.

5.5 III.3 Visualise Data in MProc

5.5.1 III.3.1 Bring Data into MProc

In the VBAProc window, right click on the GNSS attitude file and select **Edit**. The MProc window will appear:

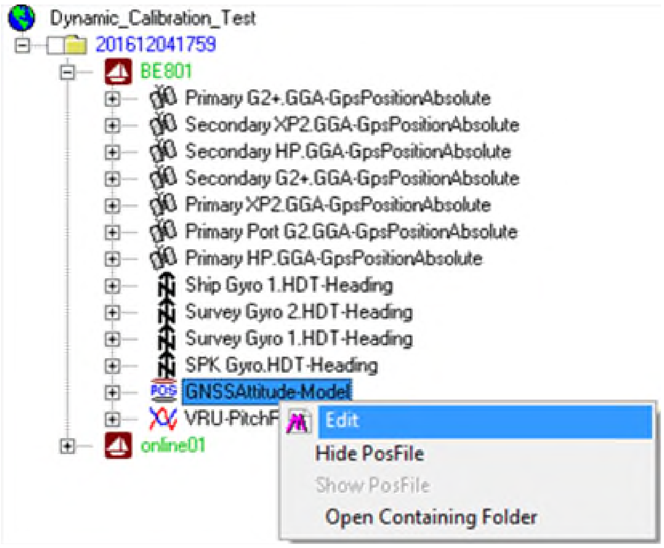

Figure 5.40: GNSS Attitude > Edit

In the MProc window, right click the mouse in the bottom of the window which itemises the data file, and select Add Data File:

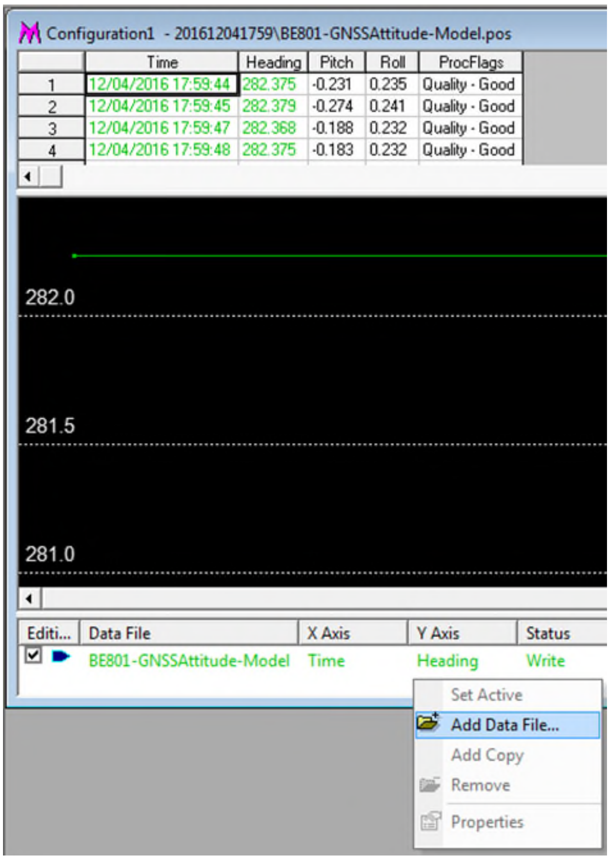

Figure 5.41: Add Data File

The Data File Properties will appear. In the Path window, browse to the data file locations and select the heading data to be imported. The files are compared based on time, and once a file is selected, the Y Axis option should be populated with Heading. For the Offset (shift) Factor Y axis data, the C-O from the estimations in VBAProc should be used here to estimate the latency. (This is not used currently as estimation of latency in the data is very difficult visually. A C-O offset can be inserted to confirm whether the GNSS data corresponds to the sensor data and estimated result of the Dynamic Calibration C-O results. This process can be followed for the motion sensor data as well by adding these files using the MProc Add Data Files).

Select **OK** to continue:

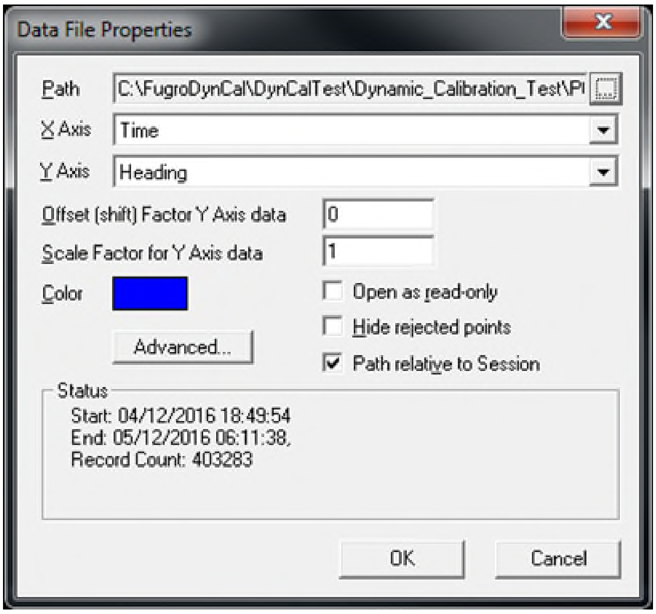

Figure 5.42: Data File Properties configuration

The process should be repeated for the pitch and roll values. Note that the VRU data contains both the pitch and the roll, so this should be added twice, and the Y axis format amended as required. Ensure to select a different colour to display the data each time.

Once the data has been added, the bottom display should show each data source, and the relevant associated information in the colour chosen:

Editi...	Data File	X Axis	Y Axis	Status	Data Points
☑	BE801-GNSSAttitude-Model	Time	Heading	Write	43112
☑	BE801-Survey Gyro 1.HDT...	Time	Heading	Write	403283
☑	BE801-VRU-PitchRoll	Time	Pitch	Write	1313727
☑	BE801-VRU-PitchRoll	Time	Roll	Write	1313727

Figure 5.43: MProc data added for review

If the data is not visible in the display window, right click in the display and select Fit View:

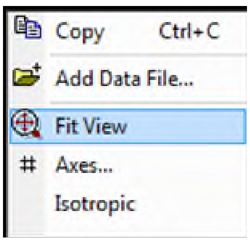

Figure 5.44: Right click > Fit View

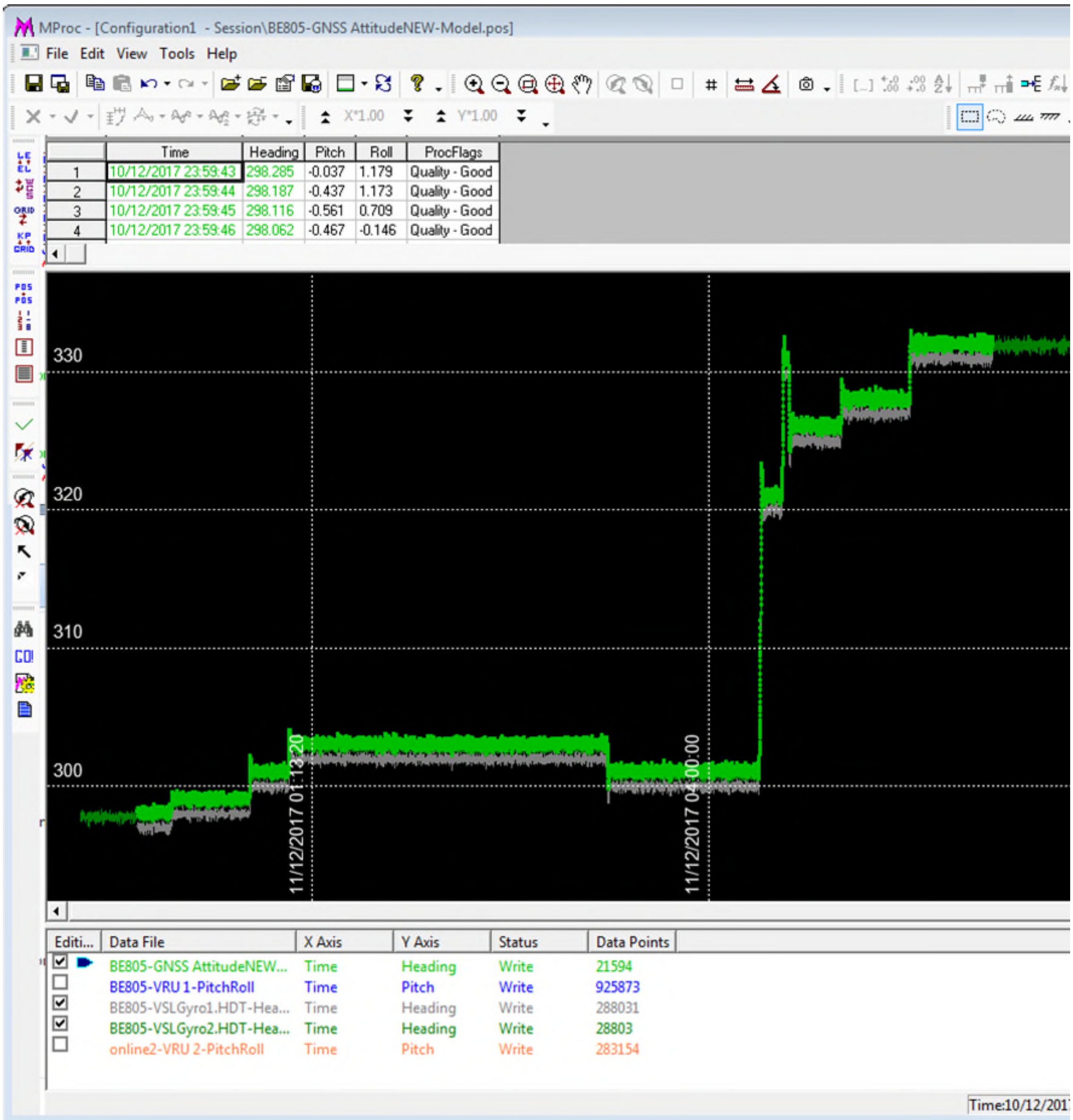

Figure 5.45: Imported data in MProc view (Heading)

At this point it is a good idea to make rough estimates of the C-Os for each sensor (heading, pitch and roll). Compare each sensor against the GNSS data and note these down in a separate spreadsheet or on a piece of paper. This will enable you to gross error check the values generated by the main Dynamic Calibration spreadsheet.

5.5.2 III.3.1 Reject data out of time interval

It is best to use the same time range of data in each data set. This can be best viewed in MProc. The sensor data sets can be clipped to the GNSS Attitude data set extents by rejecting records outside of this data/time range. Alternatively, the GNSS Attitude data can be clipped to the sensor data extents.

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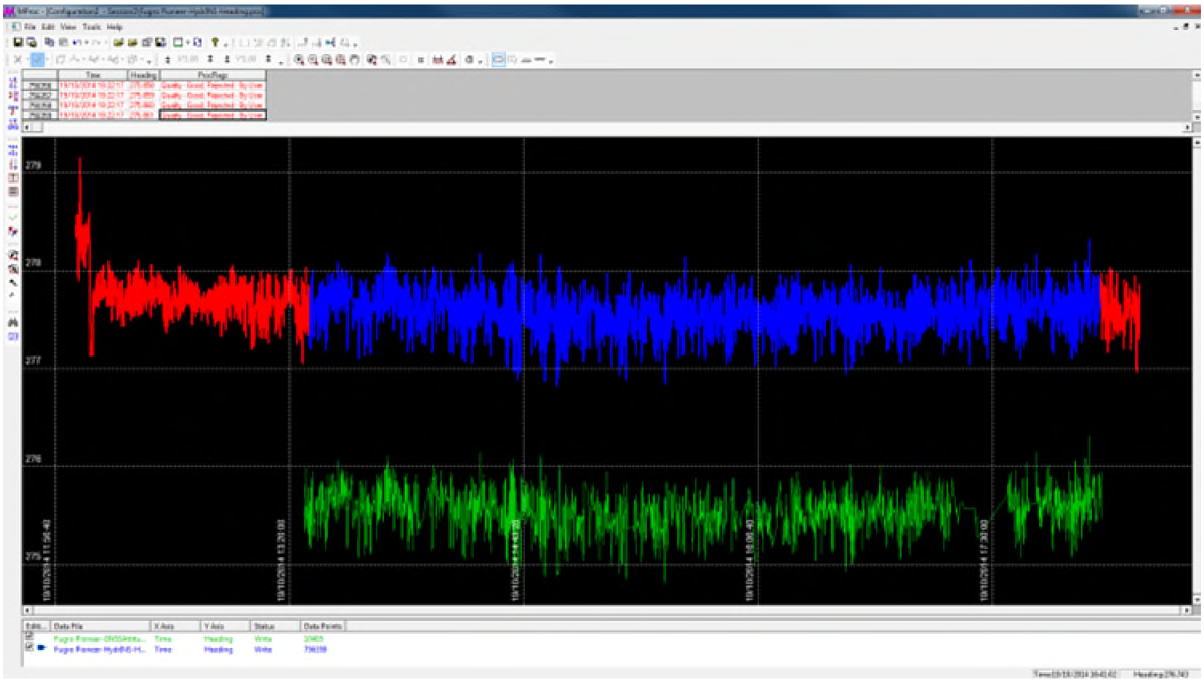


Figure 5.46: Rejected sensor data outside GNSS (green) data set range

All data sets should be reviewed for poor or bad data and data spikes. These records can be rejected in order to make a "clean" data set for importing into the Dynamic Calibration spreadsheet.

5.5.3 III.4. Export data from VBAProc

Data required for the spreadsheet calculations will come from the exported VBAProc sensor data.

GNSS Attitude data is exported as well as each sensor required for the evaluation:

- GNSS – Heading, Pitch, Roll;
- Sensor Hdg (this may be numerous Hdg sensors);
- Sensor Pitch and Roll (this may be numerous Motion sensors).

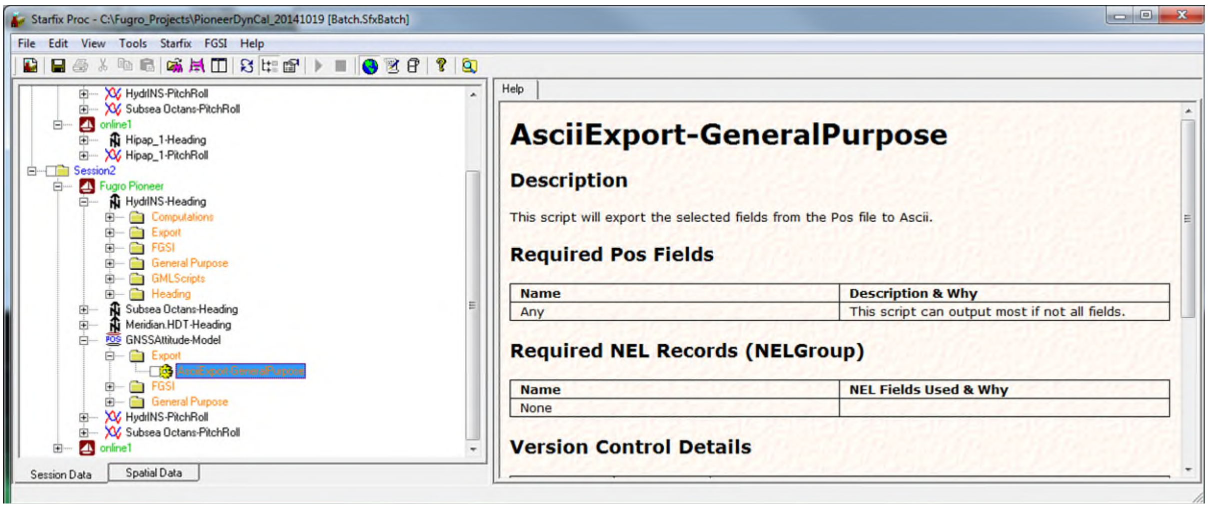


Figure 5.47: Ascii Export of sensor data

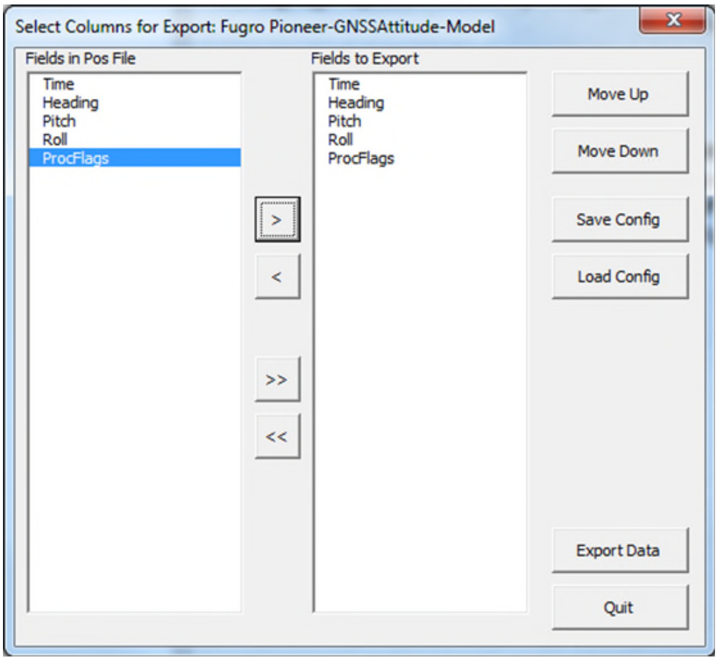


Figure 5.48: Ascii Export parameters selected (example of GNSS Attitude file)

Similar fields will be required for the export of the other sensor files (Heading will not be available in a Motion sensor file).

This will export data to the following folder – [proc project name]\export\ascii.

5.6 IV. Import data from VBAProc

The exported files for GNSS Attitude and sensor Heading, Pitch and Roll can be imported into the spreadsheet .

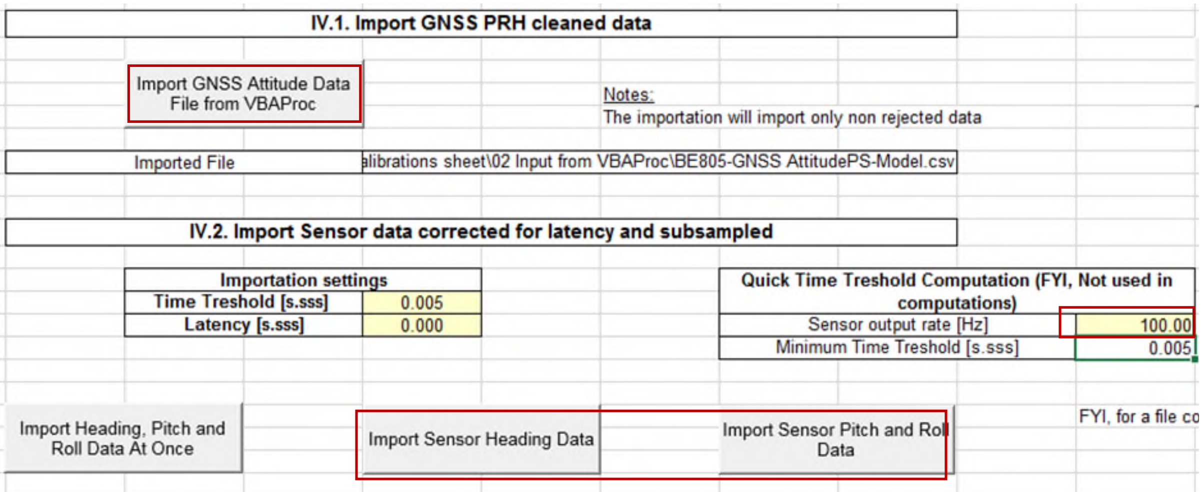


Figure 5.49: Import data into tab IV.

- Import GNSS Attitude Data file from VBAProc (exported ASCII file);
- Time threshold can be set by updating the Sensor output rate (Quick Time Threshold) and calculating the minimum time threshold (Importation settings);
- The minimum time threshold will be used when "aligning" the imported sensor data to the GNSS Attitude data;
- Import Sensor files for Heading and then Pitch and Roll.

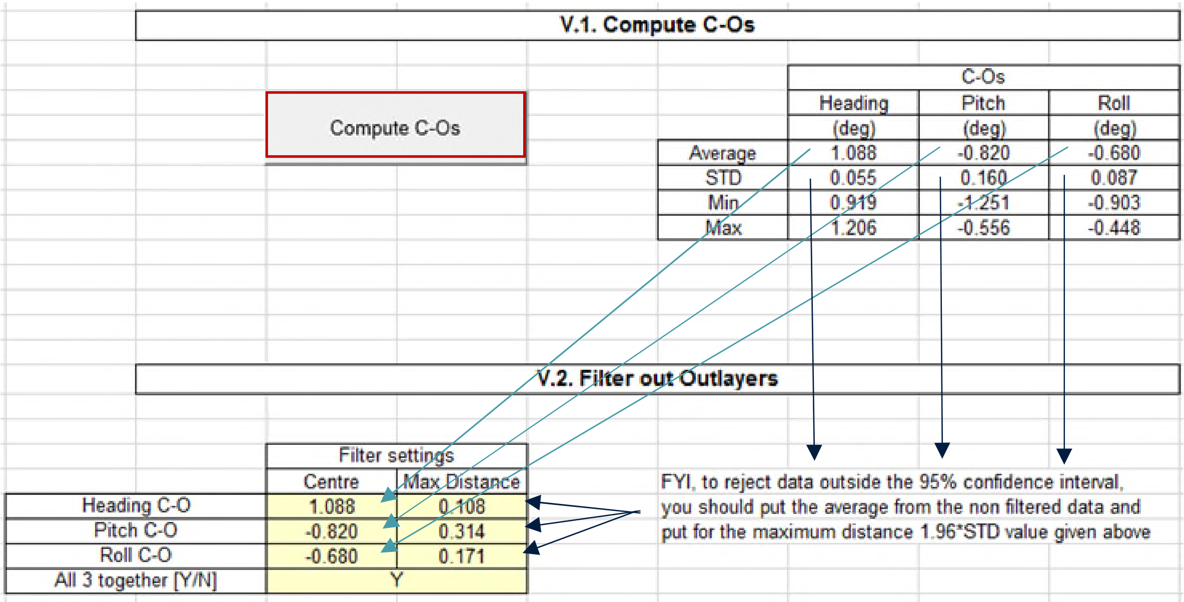
Note:

- Heading C-Os can be calculated without Pitch/Roll data;
- Pitch/Roll C-Os need a vessel Heading source data as well (this can be any of the Heading sources available to you);
- If you’re using Heading and Pitch/Roll data that has a different frequency (update rate) then set the cells in IV.2 for the data set with the lowest frequency (update rate);
- Data update rates need to be determined from looking at the data in MProc – see Figure 5.45.

5.7 V. Compute C-Os and Statistics

V.1 Select Compute C-Os.

V.2 Filter out Outliers – the Filter settings should be the Average C-Os determined in V.1. and the Maximum Distance should be 1.96 * STD. Populate this information into the table in the spreadsheet.



V.1. Compute C-Os

Compute C-Os

	Heading (deg)	Pitch (deg)	Roll (deg)
Average	1.088	-0.820	-0.680
STD	0.055	0.160	0.087
Min	0.919	-1.251	-0.903
Max	1.206	-0.556	-0.448

V.2. Filter out Outlayers

	Filter settings Centre	Max Distance
Heading C-O	1.088	0.108
Pitch C-O	-0.820	0.314
Roll C-O	-0.680	0.171
All 3 together [Y/N]	Y	

FYI, to reject data outside the 95% confidence interval, you should put the average from the non filtered data and put for the maximum distance 1.96*STD value given above

Figure 5.50: Filter out Outliers table

6. Final Results

6.1 VI. Generate DynCal Report

Insert project and sensor details.

Select either Non-Filtered C-Os data for the report or Filtered C-Os. This would be dependent on the report requirements for the client, usually filtered data would be used to generate the C-Os.

Note : The DynCal Report needs to be generated for each sensor set, i.e. each Heading and Motion sensor separately if they are independent sensors, for example Meridian Heading sensor and VRU or MRU. An Octans or POS/MV will output the three parameter from one unit and therefore a single report will encompass this result.

6.2 Evaluate C-Os in VBAProc

The results of the dynamic calibration can be verified in VBAProc and MProc. The previously imported files in MProc as in Figure 5.41 and Figure 5.42 can be updated with the new C-O values as determined for the specific system during the dynamic calibration processing and reviewing the updated graphs in MProc (example below).

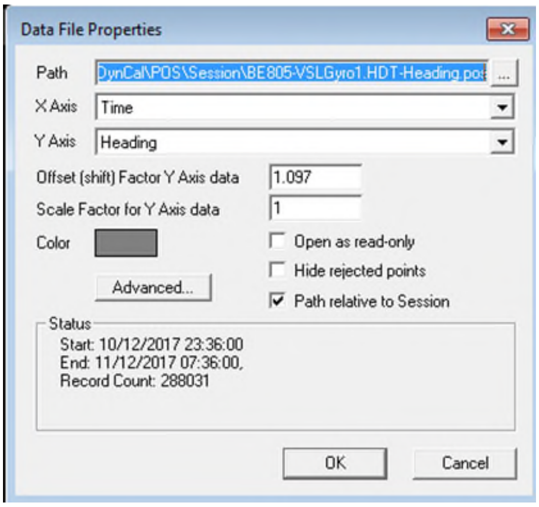


Figure 6.1: Dynamic Calibration result for System Heading C-O

Figure 6.2: System Heading aligned with GNSS derived heading

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7. Revision History

Issue	Date	Comments on Content	Prepared By	Checked By	Approved By
01	19 February 2016	Initial Issue	D. Ralton		
02		Additional screenshots	A. Rowland		
03	15 October 2018	Updated format to WI format	W. Stolk	W. Stolk	
04	15 March 2019	Ammended figure 4.22	P. Garcia	W. Stolk	
05	18 June 2019	Updated formatting error	W. Stolk	W. Stolk	
06	02 March 2023	Issued for IMS	N, Djoekina	W. Stolk	W. Stolk

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