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PRODUCTS GROUP

A NovAtel Precise Positioning Product

GrafNav / GrafNet

GrafNav Lite
GrafNav / GrafNet Static
GrafMov

User Guide

GrafNav / GrafNet User Guide

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Foreword

Congratulations!

Congratulations on purchasing a Waypoint® Products Group's (Waypoint) software package. GrafNav / GrafNet® is a Windows®-based suite of programs that provide GNSS (Global Navigation Satellite System) data post-processing. Whether you have bought GrafNav / GrafNet, GrafMov, GrafNav Lite or GrafNav Static, this manual will help you install and navigate your software.

Scope

This manual contains information on the installation and operation of Waypoint's GrafNav/GrafNet, GrafNav Lite and GrafNav/GrafNet Static software packages to allow you to effectively navigate and post-process GNSS data. This manual also includes components and upgrades of packages including GrafMov. It is beyond the scope of this manual to provide details on service or repair, see *Conventions and Customer Service* on this page for customer support.

How to use this manual

This manual is based on the menus in the interface of Waypoint's software. It is intended to be used in conjunction with the the corresponding version of Waypoint's Inertial Explorer® software. The most recent revision of the *GrafNav/GrafNet User Guide*.

Prerequisites

To run Waypoint software packages, your personal computer must meet or exceed this minimum configuration:

Operating System
Windows XP®, Vista® or 7.

Hard Drive Space
75 MB of available space on the hard disk.

Processor
A Pentium or Xeon processor is required. Simultaneous forward/reverse processing is possible on dual CPU (Central Processing Unit) and Xeon systems. At least 256 MB of RAM is also required.

Although previous experience with Windows is not necessary to use Waypoint software packages, familiarity with certain actions that are customary in Windows will assist in the usage of the program. This manual has been written with the expectation that you already have a basic familiarity with Windows.

Conventions and Customer Service

This manual covers the full performance capabilities of GrafNav / GrafNet GNSS data post processing software. The conventions include the following:

> ✉ This is a notebox that contains important information before you use a command or log, or to give additional information afterwards.

The term "master" refers to the reference station and the base station.
The term "remote" refers to a rover station.

This manual contains shaded boxes on the outside of the pages. These boxes contain procedures, screen shots and quick references.

If the software was purchased through a vendor, please contact them for support. Otherwise, for software updates and customer service, contact Waypoint using the following methods:

Call: (403) 295-4900
Fax: (403) 295-4901
Email: support@novatel.com
Web: http://www.novatel.com/
Write: NovAtel Inc.
    Customer Service Department
    1120-68 Avenue NE
    Calgary AB
    Canada, T2E 8S5

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Waypoint Products Group
1120 - 68 Avenue NE,
Calgary, Alberta, Canada T2E 8S5

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1.1 Waypoint Products Group Software Overview

NovAtel's Waypoint Products Group offers GNSS post-processing software packages including GrafNav (a static/kinematic baseline processor) and GrafNet (a static baseline processor/network adjustment package). Both of these products have a Windows based Graphical User Interface (GUI) and use the same precise GNSS processing engine. This processing engine has undergone years of development effort and has been optimized to give the highest precision with the least amount of operator intervention.

This chapter of the manual contains a description of the hardware requirements, installation instructions and lists the CD contents. This chapter also provides an overview of the product packages (see *Table 1* on *Page 19* for product capabilities).

1.2 Installation

The installation steps are in the shaded box.

1.2.1 What You Need To Start

Waypoint Protection Key
New users are given a Sentinel USB key. This hardlock key is required in order to access the software. Hardlock keys must be burned for the correct product and version number.

Installation file
You will receive an installation CD as part of your purchase. If you upgrade from a previous version, you will be provided with a link to Waypoint's FTP site where you can download the new setup file.

See the *Foreword* on *Page 9* for hardware requirements.

GrafNav
Version 8.40
GPS Baseline Post-Processing Software
8.40.0920
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How to install Waypoint software

1. Plug your hardlock key into the computer's USB port.

2. Insert the CD into the CD-ROM drive.

3. Follow the on-screen instructions.

1.2.2 CD Contents and Installation

GrafNav / GrafNet is distributed on CD media. There are a number of folders on the CD containing additional programs and data. These include the following:

Data
This directory contains sample GNSS data for GrafNav and GrafNet. Browse through the subdirectories to see what data is available. To process, copy the contents of directories to the hard disk.

Geoid
This directory contains geoid files for U.S. (Geoid96, Geoid99, Geoid03, Geoid09), Mexico97, Australia (AusGeoid93 and AusGeoid98) and the world (EGM96, EGM2008). These files allow mean-sea-level (orthometric) heights to be computed using GrafNav and GrafNet. Files are in the WPG (Waypoint Geoid) format. For Canada, download files from the Geodetic Survey Division of Geomatics Canada. Geoids for other regions of the world may also be available. Contact support@novatel.com for more information.

Doc
Contains this manual in Adobe Acrobat PDF format.

1.2.3 *Upgrading*

Waypoint's software is distributed with a Sentinel hardware lock. Upgrading to a new version requires a new hardlock key code for the hardware lock. Expired demo codes need new codes for the software package to continue working. Contact the Waypoint Products Group, NovAtel Inc. to obtain new hardware key codes. For contact information, see the *Foreword* on *Page 9*.
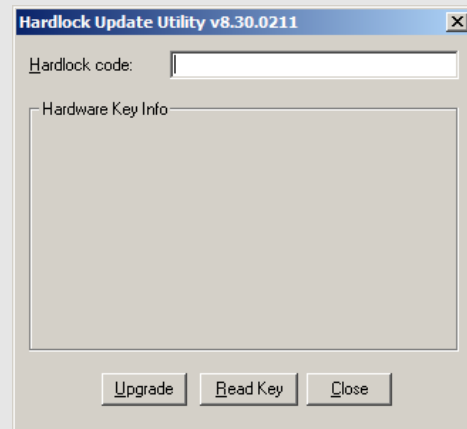
How to upgrade your software

1. Contact Waypoint to obtain a new key code for the hardware lock or expired demo codes. For contact information, see the *Foreword* on *Page 9*.

2. Verify that the software is installed.

3. Press the *Start* button.

4. Click on *Programs | Waypoint GPS | Utilities | Hardlock Upgrade Utility* to start updating the hardware lock.

5. Click on the *Read Key* button to verify that the key is properly connected.

6. Copy down the existing key code and keep the code. This helps prevent the loss of a full working key code when testing out a newer demo or beta version of the software.

7. Enter the provided 16-character alpha-numeric key code and press *Upgrade*.

8. Install the upgraded software from the

⊠ Versions 8.30and greater of *KeyUtil.exe* are not compatible with previous versions. The software only functions if the hardlock key has been upgraded with a newer version of *KeyUtil.exe* that is 8.30 or greater. The version number appears in the title bar.

It is recommended that you uninstall older versions of the software once your upgraded software is installed.

1.3   Processing Modes and Solutions

Processing Solutions

Fixed static solution

This solution is available when sufficient cycle slip-free data is obtainable. This algorithm starts with the float solution, and using this as a starting position (seed), it searches for the nearby integer combinations. Then, it calculates RMS (root mean squared) fits for these integer intersections. The intersection list sorts around this value. In single frequency, fixed static solution requires at least 10 to 15 minutes of continuous static data, and more on longer baselines. Dual frequency receivers require less then half of that time.

Fixed solutions are not reliable on baselines longer than 15 km for single frequency and 30 km for dual frequency. For data sets with multiple static sessions, fixed solutions can be solved for all static periods.

ARTK solution

This solution searches ambiguities after a serious loss of lock and is useful for precise kinematic processing because it achieves centimeter level accuracies.

This is the on-the-fly (OTF) algorithm. This technique requires that 5 or more satellites be in view and is helped considerably by L2 (dual frequency) phase measurements. ARTK can be useful for single frequency receivers if there are enough satellites present for 20 to 30 minutes. ARTK is generally engaged at start up, or after periods of, extremely poor geometry or loss of lock. For dual frequency, it can be used for reliable initialization if baseline lengths are less than 30 km. Single frequency can also be initialized in this manner, but static methods are more reliable.

Float solution

This solution is less accurate than fixed or ARTK solutions, but it is the best alternative for longer baselines that are often not solvable.

The types of solutions are described in the shaded box. The following are the types of processing modes:

Static
Static processing involves the determination of a three-dimensional baseline between two stations. There are two types of static solutions are supported by GrafNav: a float solution and a fixed solution. They are discussed in the shaded box.

Kinematic
Kinematic processing is initialized either with a static survey, from a known point or using Advance® RTK (ARTK). Following initialization, the antenna-mounted vehicle moves from station to station. In some cases, it may be possible to remove the antenna and place it over the desired point. However, in other cases such as an aircraft, positions can be interpolated.

1.4   Overview of the Products

1.4.1   GrafNav

GrafNav is a kinematic and static GNSS post processing package. It supports most single and dual frequency, commercial, receivers and can instantly obtain centimeter accuracies. GrafNav also supports multi-base (MB) processing.

GrafNav switches automatically from static to kinematic processing and a fixed static solution is available for static initialization on short or medium length baselines. A float static solution is available for long and/or noisy baselines. ARTK allows you to start in kinematic mode and GrafNav's ionospheric processing improves accuracies for dual frequency users. See *GrafNav, on page 23* for more information.

1.4.2   GrafNet

GrafNet is a static network processing package; it creates a single network by tying all the ends of static GNSS baselines together. Within minutes, GrafNet processes the entire project in a single operation. When the processing is completed, GrafNet color codes the baselines so irregular ones are isolated from the project and can be easily analyzed. GrafNet allows three types of static baseline processing solutions: fixed static, float and ionospheric free. See *GrafNet* on *page 115* for more information.

1.4.3   GrafNav Lite

GrafNav Lite is a simplified version of GrafNav. It contains all of the conversion and logging utilities, but only supports processing intervals of 1 second or lower. GrafNav Lite only supports single frequency data and will not resolve ambiguities. However, float solution accuracies of 5 - 20 cm are still achievable. See *GrafNav* on *page 23* for more information.

1.4.4   GrafNav / GrafNet Static

GrafNav / GrafNet Static is a simplified static network processing package that provides the same processing features as GrafNav/GrafNet for static baselines. See *GrafNav* on *page 23* for more information.

Table 1: Product Capabilities

Capabilities	GrafNav/ GrafNet	GrafNav Lite	GrafNav/ GrafNet Static	GrafMov
Float Static	✓	✓	✓	✓
Float Kinematic	✓	✓		✓
Fixed Integer Static (Fixed Solution)	✓		✓	✓
Fixed Integer Kinematic	✓			✓
Dual Frequency	✓		✓	✓
Multi-Base Processing	✓			✓
Single Point	✓	✓	✓	✓
PPP	✓		✓ (Static only)	✓
Moving Baseline				✓
Azimuth Determination				✓
IMU Processing[a]				
<1 sec Kinematic Data Rates	✓			✓

a.   *Refer to the Inertial Explorer User manual available on our website at www.novatel.com.*

GrafMov Features

Relative Processing

GrafMov has all of the advanced and fast processing features of GrafNav, including ARTK, a reliable Kalman Filter, forward/reverse/combined processing, single and dual frequency support.

Relative Vector Output

GrafMov can export a number of relative vectors including local level, ECEF (earth-centered, earth-fixed), range and bearing.

Relative Velocity

In GrafMov, the relative position is available and the instantaneous differential velocity vector is computed.

Heading Determination

For applications that require heading, ARTK, a fast integer ambiguity resolution algorithm, can make use of the separation between the antennas to further decrease initialization times. Pitch can be computed from the relative vector output.

1.4.5 GrafMov

GrafMov is a moving baseline module that allows for GPS post-processing between two moving platforms. By processing between the two kinematic objects, the accuracy of the relative trajectory can be improved significantly over that obtained from processing against a stationary base. This is especially true if the base station distance is much longer than the relative distance between platforms. If the two antennas are fix-mounted, then GrafMov can also compute the heading.

You can purchase GrafMov as an upgrade from GrafNav / GrafNet or as a package that includes GrafNav / GrafNet. Some of its features are listed in the shaded box.

1.4.6 Inertial Explorer

Inertial Explorer is a post-processing software suite that integrates rate data from IMU (Inertial Measurement Unit) sensor arrays with GNSS information processed via GrafNav, which is included.

Inertial Explorer is designed to utilize strapdown accelerometer and angular rate information to produce high-rate coordinate and attitude information from a wide variety of IMUs, from high-accuracy navigation grade to inexpensive MEMS (Micro Electro-Mechanical Systems) sensor types. Currently, a loosely coupled methodology is used that permits a quality check of the GNSS data before moving on to inertial processing.

Contact NovAtel's Waypoint Products Group for more information.

1.5   Utilities

Every Waypoint software package sold by NovAtel comes with several additional utilities, including the following:

1.5.1   Copy User Files

This utility runs automatically and allows user files to be copied or backed-up. For more information, see *Utilities* on *page 167*.

1.5.2   Download Service Data

This utility allows you to add a base station to a project to strengthen the static network. This utility also allows additional base stations to be included and downloaded data via FTP from more than 3000 stations observed by the nine supported networks, including CORS, IGS and ARGN.

1.5.3   GPS Data Logger

This utility facilitates GPS data logging directly from a variety of GPS receivers in a Microsoft Windows operating system environment. Features like station-tagging and satellite lock plots are also included. See *Table 2* for the receivers that are supported by this utility.

With this utility, logging can be performed directly in Waypoint's custom format. See *Utilities* on *page 167* for more information.

1.5.4   GPB Viewer

This utility allows you to view the data collected by the GPS receiver in order to detect any problems. The fields that can be viewed here include measurement values and position records. See *Utilities* on *page 167* for information.

1.5.5   Mission Planner

This utility is found under the *Tools* menu and gives you satellite count and dilution of precision values for the GPS constellation. This utility is generally used prior to the mission, but can also compare the theoretical constellation to that observed during processing.

Table 2: Receivers Supported by Data Logger

Make	Model	Data Logging
		Windows
NovAtel	OEM6 OEMV OEM4 OEM3 OEM2	✓ ✓ ✓ ✓ ✓
CMC/ NovAtel	Superstar II Allstar	✓ ✓
Conexant	Jupiter	✓
CSI	DGPS MAX	✓
Javad	All models	✓
NAVCOM	OEM GPS	✓
Thales	Real-Time	✓
Trimble	4000 series (RT) 5700 SSx	✓ ✓ ✓
U-blox	Antaris	✓

Table 3: Receivers Supported for Post-Processing

Make	Model	Supported
NovAtel	OEM6 OEMV OEM4 OEM3	✓ ✓ ✓ ✓
CMC / NovAtel	Superstar II All Star	✓ ✓
Javad	All Models	✓
Leica	System 500 System 1200	✓ ✓
NAVCOM	SF-2050	✓
RTCM	3.0	✓
Septentrio	SBF	✓
SIRF	Star II	✓
Thales	Real Time B-file DSNP	✓ ✓ ✓
Trimble	4000 series (DAT) 4000 series (RT) 5700 SSx	✓ ✓ ✓ ✓
U-Blox	Antaris	✓
RINEX	2.0 2.1 3.0	✓ ✓ ✓

1.5.6   Data Converter

This conversion utility converts raw GPS data files into Waypoint's own format. See *Table 3* for supported receivers and formats.

✓   = Raw data conversion to Waypoint format supported

2.1   GrafNav, GrafNav Lite and GrafNav / GrafNet Static Overview

GravNav

GrafNav is a full-featured kinematic and static GNSS post-processing package that uses a proprietary GPS and GLONASS processing engine. It supports single and multi-baseline (MB) processing as well as most single and dual frequency commercial and OEM receivers. See *Table 2* on *Page 21* for more information.

GrafNav seamlessly switches from static to kinematic processing and has a fixed static solution for static initialization. A float static solution is available for long and/or noisy baselines.AdvanceRTK (ARTK) allows you to start in kinematic mode and fix otherwise unrecoverable cycle slips. GrafNav's ionospheric processing improves accuracies for dual frequency users.

This chapter describes how to get started with GrafNav and goes through each menu of its interface. Step-by-step instructions for first-time users are also included.

GrafNav Lite and GrafNav / GrafNet Static

This chapter also describes the features of GrafNav Lite and GrafNav Static.

GrafNav Lite is a simplified version of GrafNav. It contains all of the conversion and logging utilities, but only supports processing intervals of 1 second or lower. GrafNav Lite achieves accuracies of 5 to 20 cm even though it only includes float static initialization and does not support dual frequency data.

GrafNav / GrafNet Static provides the same processing features as GrafNav / GrafNet, but only for static baselines.

See *Table 1* on *Page 19* for a capability comparison between GrafNav, GrafNav Lite and GrafNav Static.

GrafNav
Version 8.40

GPS Baseline Post-Processing Software
8.40.0920
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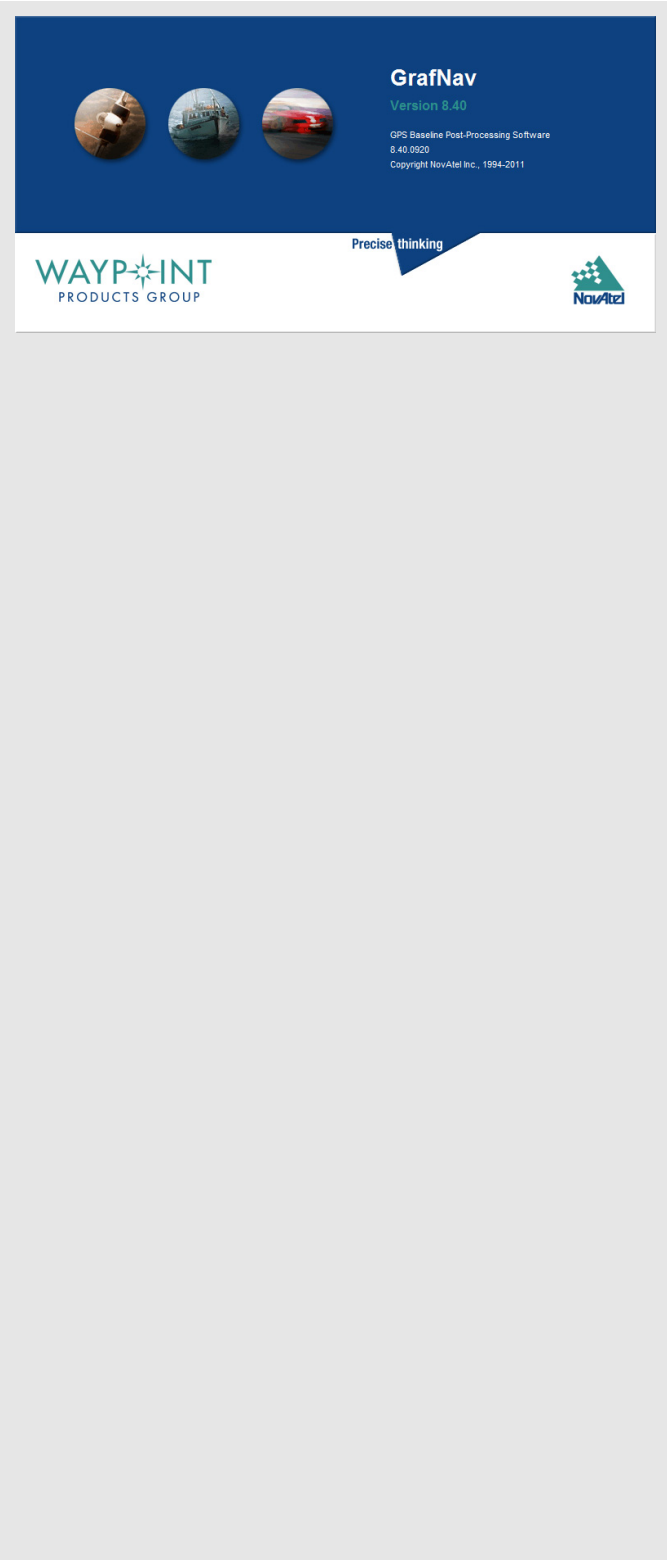
How to install GrafNav

1. See *Section 1.2.2,* on *Page 16* for installation instructions.

How to convert data

1. Select *File | Convert | Raw GNSS to GPB* to access the converter.

2. Navigate with the *Get Folder* button to the directory that contains the data.

3. Click the *Add All* button to auto-detect GPS formats.

4. If you want to change the conversion options, click on *Options* or *Global Options* to set the rover to kinematic mode.

How to download service data

1. Select *Tools | Download Service Data*.

2. Click on the *Add Closest* tab and type in the approximate position of the project area. To compute the average position from the remote GPB file and set the times and file path on the first tab, select *Position from GPB* and choose the converted GPB file.

3. A list of the nearest service stations appears. Highlight those of interest, and click *Add Selected*.

4. On the *Download* tab, enter the time and date of the survey as well as the directory where the files are to be saved.

2.2 Start a Project with GrafNav

Before you start a project in GrafNav, you need to verify installation, convert data and download any required data.

Install Software

Verify that the installation was successful by ensuring that you have a *Waypoint* program group on your computer. If this program group is not there, see *Introduction and Installation* on *page 15* for installation instructions.

Convert Data

To be processed, raw GNSS data files have to be converted into Waypoint's GPB format, including raw data from Waypoint's data-logger program. Instructions on how to convert these files are in the shaded box.

The *GPBView* utility can be used to switch between static and kinematic mode. See *Chapter 6* on *Page 167* for a complete description of the *Convert* utility.

Download Service Data

If no data was logged from a reference station, you have the option of downloading free GNSS data from the Internet. See the shaded box for instructions on how to add the closest service station to your project area.

A reference station can also be added directly from a list. See *Section 2.8.12,* on *Page 107* for these instructions as well as a complete description of the *Download* utility.

2.3 File Menu

2.3.1 New Project

To process a baseline for the first time, start a new project. When you start a new project, choose between *Project Wizard, Auto Start* and *Empty Project*. This section discusses these options and gives step-by-step instructions to follow once you have decided on the method for starting your project.

Project Wizard

The Project Wizard offers you a guided step-by-step way of creating a project. These *Project Wizard* steps are listed in the shaded box

Auto Start

Auto Start prompts you for all the information required to process a data set. This option allows you to add master and remote stations and to use a project setting that best suits your application. The *Auto Start* steps are in the shaded box.

> ⊠ Files should be converted into a GPB fprmat before using Auto Start. For more information about converting your file, see *GNSS Data Converter Overview* on *page 174*

Project Wizard Steps

1. Create and name the project.
2. Add rover data to the project.

⊠ The rover data can be in Waypoint's GPB format, or in the receiver's raw format, in which case the Wizard converts it to GPB for you.

3. Add base station data to the project.

⊠ You can add your own local base station data (in raw or GPB format) or you can have the Wizard download free service data from the Internet.

If you plan to process with PPP, you can skip adding base station data and download the precise satellite clock and orbit files from the Internet

How to create a new project using *Auto Start*

1. Select *File | Auto Start | Browse* to name the new project. Use the *Add* button to choose master station file(s).

⊠ Entering the name of a project that already exists overwrites the file contents.

2. Use the *Browse* button to choose the remote file. The master and remote station files must contain data collected during the same time period. To see the time that the data was collected, click the *Plot Coverage* button to display the *File Data Coverage* plot.
3. In *Settings,* choose the processing profile that best suits your application.
4. Enter the master station coordinates.
5. Enter the remote station antenna height.

⊠ See *Section 2.5,* on *Page 50* for more information on processing.

How to create a new project using *Empty Project*

1. Select *File | New Project | Empty Project*.

2. Enter the name and where you would like to save your project.

⊠ Entering the name of a project that already exists overwrites the file contents.

3. Click *Save*.

4. Select *File | Add Master File (s)* to load master files. Select the GPB files collected at the base station (s) and click *Open*.

5. Select *File | Add Remote File*. Select the GPB file corresponding to the data that was collected at the remote.

6. Select *Process | Process GNSS* and be sure to select a profile before beginning processing.

Empty Project

Empty Project prompts you to select a new project file name. Once you have selected a name and where to save the project, click *Save*. For information on file types, see *Chapter 5* on *Page 153*.

The remaining steps must be performed manually. These steps are in the shaded box.

2.3.2   Open Project

This option allows you to open existing projects.

2.3.3   Save Project

GrafNav automatically saves the project file before processing. Any changes made to features like name, time, antenna height are also saved.

2.3.4   Save As

Use the *Save As* command under the *File* menu to create a new project that has identical processing options as the current project. This allows you to change the options in the new project and process the data without losing the solution computed by the original configuration. This can also be done by viewing the processing history. See *Section 2.4.4,* on *Page 43* for details.

2.3.5   Print

This option allows you to print various items including windows, plots and text files.

How to open a project

1. Choose *File | Open Project*. A dialogue box appears that asks you to select the name of an existing project (CFG file).

2. Choose the name of the project and click *OK*.

How to save a project

1. Choose *File | Save Project* from the menu.

How to save a project "as"

1. Choose *File | Save As* from the menu.

2. Enter the name, file format and where you would like to save your project.

⊠ Entering the name of a project that already exists overwrites the file contents.

3. Click *Save*

How to print

1. Select *File | Print* and a dialogue box appears.

2. Choose the printer.

3. Choose the item you would like to print.

4. Set the page orientation, color and any other settings you need offered in the dialogue box.

5. Click *OK*.
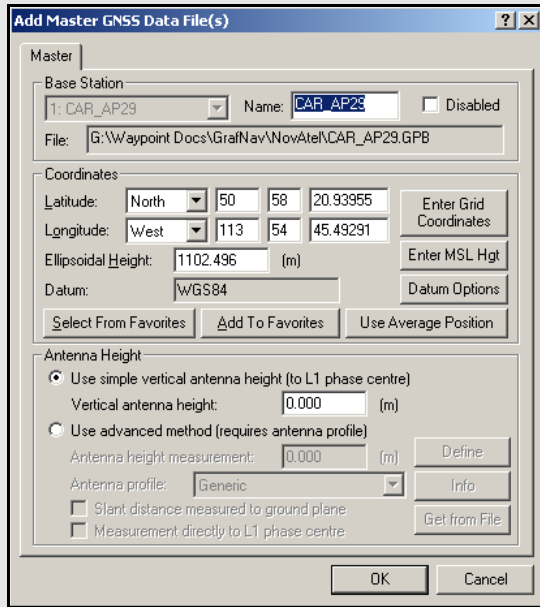
How to add a master file

1. Select *File | Add Master File(s)* after the new project has been given a name.

2. Select the files which contain the data collected at the base station(s) from the list of available GPB files. Click *Open*.

3. Enter the coordinates of the base station.

4. Verify that the coordinates are in the datum being used for processing. For more information, See *Section 2.6.2,* on *Page 65* .

5. Enter the antenna model and height information and click *OK*.

How to change the antenna height on static sessions

1. Select *View | Objects | ARTK/Static*.

2. Select *Edit* for each static session.

2.3.6 Add Master File (s)

When starting a new project, the program needs the measurement data collected at the master station(s). Steps on how to add a master station are in the shaded box.

Master Station Position

After you select a master station, the *Add Master GNSS Data File (s)* dialogue box appears with values averaged from the GPB file. These values might have errors of 10 meters or more. For IGS the GRP (Ground Reference Point) and for CORS stations the ARP (Antenna Reference Point) coordinates are pre-loaded in the *Favourites Manager*. See *Section 2.8.10,* on *Page 102* for more information.

Datum Selection

Proper datum selection is very important. Coordinates for CORS sites within favourites are stored in NAD83 and IGS sites in WGS84. WGS84 coordinates may differ from NAD83 coordinates up to 2 m, so be careful when using these coordinates. See *Section 2.6.2,* on *Page 65* for more information.

Coordinates

By default, the program loads the average coordinates. It is important that the proper coordinates are entered if they are known. This is especially important for multi-baseline projects. If the known elevation value is orthometric, then click the *Enter MSL Height* button. This will cause the mean-sea-level (MSL) height to be converted to ellipsoidal.

⊠   The difference between ellipsoidal and orthometric heights can be as large as 100 m

---

Antenna Height

The antenna height entered in this box applies primarily to kinematic trajectories. It is overridden by features (stations / events) and static sessions. The steps on how to change the antenna height on static sessions are in the shaded box.

If you do not enter the antenna height, the height coordinates include the antenna height and this causes a vertical shift. If you are only interested in the ellipsoidal or orthometric height of the antenna, then enter zero.

Antenna Models

The simple model, and generic profile, for the advanced method are identical. They assume that the L1 and L2 phase centers are coincident and have no offsets from the antenna height measurement. For each antenna profile, the following information can be edited:

- The antenna model
- The manufacturer
- The horizontal distance from the phase centre to the edge of the ground plane
- The L1 and L2 phase offsets from the origin
- The location of the origin on the antenna

To measure to the ground plane, enter a slant distance instead of a vertical antenna height. GrafNav uses Pythagorean Theorem to calculate the antenna height using the slant distance and the horizontal distance in the antenna profile. However, this requires the creation of a profile, as those loaded with the software are obtained from the NGS (National Geodetic Survey), who do not often measure the ground plane radius. See *Section 2.4.7,* on *Page 46* for information about antenna heights for static sessions.

⊠   The antenna origin must be moved to antenna ground plane. Refer to the Waypoint FAQ section of the NovAtel website for more information.

2.3.7   Add Remote File

When starting a new project, the program needs the data collected from the remote station.

This antenna height applies primarily to kinematic trajectories and features, such as stations or events, and static sessions override it.

If an antenna height is not entered, the program assumes that the height was zero and calculates heights based on this information. If an STA (station) file exists and a station mark is present in that file, the last antenna height shows up by default.

See *Section 2.3.6,* on *Page 28* for information regarding antenna height models.
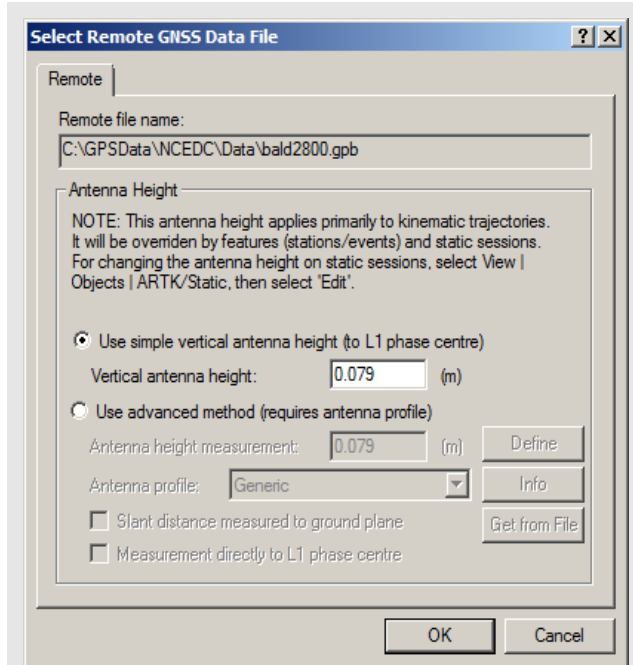
How to add a remote file

1. Select *File | Add Remote File* after giving the new project a name and adding the master GPB file(s). From the list of available GPB files, choose the file collected at the remote station.

2. When prompted, enter the remote station antenna height.

How to change the remote antenna height on specific static sessions

1. Select *View | Objects | ARTK/Static.*
2. Click *Edit* for each static session.
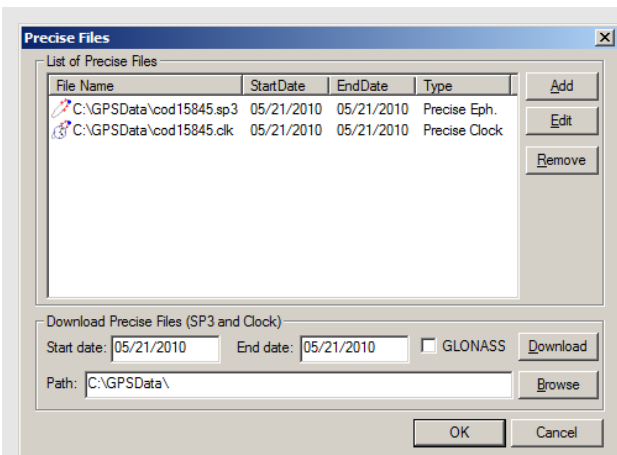
How to specify alternate ephemeris files

1. Go to *File | Add Precise Files*. The program displays a list of ephemeris files (EPP), precise ephemeris files (SP3/SP3c), IONEX files (*yy*I), and clock files (CLK).

2. Select the appropriate EPP file.

2.3.8 Add Precise Files

Broadcast Ephemeris

The ephemeris file contains trajectory information used to reconstruct the orbit of each satellite. This data is necessary for positioning.

Generally, the GNSS receiver includes broadcast ephemeris data with its raw data files. Either the decoder or the logging software converts these files into EPP format. You should monitor data logging to ensure that enough ephemerides are being saved. Ephemeris information is usually updated every 1-2 hours. Receivers will also output ephemerides at startup or as satellites rise into view.

GrafNav overcomes missing ephemeris data by searching all EPP files associated with the master, or remote, files in the project. If none of the EPP files in the project contain the necessary ephemeris, you can obtain them from the Download Service Data utility.. See the shaded box for steps on how to specify alternate ephemeris files.

Ephemerides from different stations, or precise ephemerides that span over a day, can be added to the list to be included with the processing. See the shaded box for steps on how to load ephemerides from different stations.

Precise Ephemerides

Precise ephemerides are satellite trajectories computed post-mission. They are much more accurate than broadcast ephemerides but for differential processing, this accuracy improvement is not noticeable and is generally lost in the noise. However, for PPP processing, precise ephemerides are required.

A precise ephemeris is useful for single point processing. Geodetic services such as National Geodetic Survey (NGS) in the United States, the Geodetic Survey of Canada and some European agencies compute these orbits on a continual basis. In most cases, this data is available at a few days latency. The easiest way to download SP3 files is via Waypoint's download program. See *Chapter 5* on *Page 153* for details.

Waypoint software only supports precise orbits stored in the SP3 format (most agencies use this format). Orbits which have been optimized for the United States are available free of charge from NGS via their Web site.

Waypoint software's precise orbit implementation requires that a broadcast ephemeris orbit is available. Precise ephemerides cannot be used to circumvent missing broadcast orbit information. If a broadcast ephemeris is missing, consider using the Download Service Data utility to obtain the data from on-line sources. See *Section 2.8.12,* on *Page 107* for help.

IONEX and Satellite Clock Files

IONEX (Ionosphere Map Exchange files) contain information concerning the Total Electron Count (TEC) in a two-dimensional grid. For single frequency long-range differential or single point processing, the information in an IONEX file adds corrections helpful to the L1 frequency and are available through the *Download Service Data* utility.

Satellite clock files can also be downloaded using the *Download Service Data* utility. These files contain a list of biases that can assist single point positioning because the clock bias is only differenced out in differential positioning. For PPP, these files are required.

2.3.9   Load

GNSS Solution

This feature allows for the loading of GNSS solution files. Choosing *Load Forward Solution* or *Load Reverse Solution* automatically loads the solutions most recently processed in the chosen direction.

PPP Solution

This feature allows for the loading of GNSS solution files. Choosing *Load Forward Solution* or *Load Reverse Solution* automatically loads the solutions most recently processed in the chosen direction. *Load PPP Solution* will only be available if the single point processor has been engaged. See *Section 2.5,* on *Page 50* for more information about single point processing.

Any Solution

Opening a project that has already been processed automatically loads the processed solution. The FWD, REV and CMB files contain all the information computed for each GPS epoch by the software. Writing these files to disk allows you to load the solution from another project. To load a solution from another project, follow the steps in the shaded box.
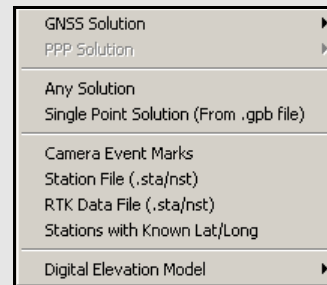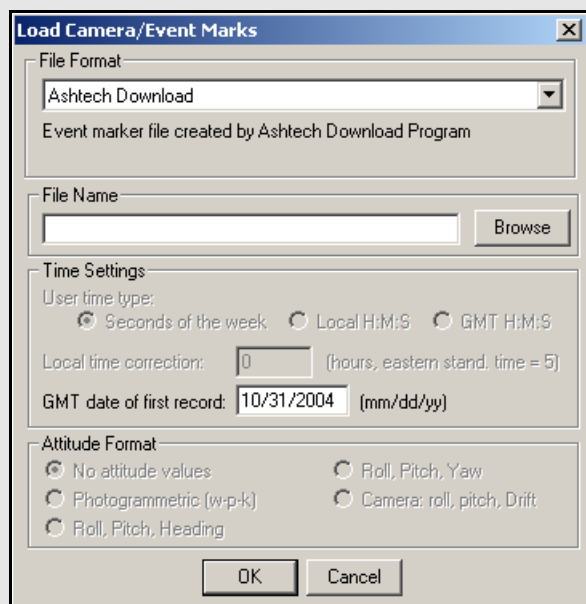
How to load single point solution (from *.gpb file)

1. Choose *File | Load | Single Point Solution (From .gpb file)*.

How to load camera event marks

1. Under *File* select *Load | Camera Event Marks*.

2. Choose the preferred file format from the selection in *File Format.*

3. Under *File Name,* use the *Browse* button to select the file of interest. The file name depends on the receiver format and is explained *Page 28*.

⊠ If the files formats you use are User1- User6, use *Time Settings* to select time formats. UTC time cannot be loaded and the correction has to be applied externally.

Single Point Solution (from .gpb file)

This option loads a single point solution from a GPB file. The shaded box contains directions on how to use this option.

Loading Camera Event Marks

Use this feature to load external time-tagged events from an ASCII file. When you load these events, they must be referenced to GPS time and not UTC (coordinated universal) time. The source of the events can come from an aerial camera, sounding equipment or other real-time devices. The GPS receiver must support a mark or pulse input for this feature to work. See *Section , on Page 67* for a discussion on how the event positions are interpolated in GrafNav.

Most events are automatically stored in the STA file during the conversion to GPB format and appear when the remote is added to the project. For user events and a few receivers such as Ashtech or B-file, this feature must be used.

File Format

STA File

Many new converters save the camera event marks directly to the station file. If you are logging NovAtel data with LOGGPS, then your event marks are saved in a station file. The marks load when you add the GPB file to the project. If they do not load, then use the *File | Load | Station File* feature.

MRK File

Leica SR receivers save event marks into a EVT file, which is converted into a MRK file by the Leica decoder. The MRK file can be loaded using this option. Numbering is performed by the converters.

Ashtech Download

Ashtech receivers with internal memory usually outputs a PHOTO.DAT file after the receiver data has been downloaded using HOSE or another corresponding utility. Newer variants might be under the format M????.###. Either file can be loaded using this option. The GMT date of the first event mark must be entered if it is not detected. Events are automatically numberedstarting at 1.

Leica GeoSystems

EV0 and TDU files are produced by the Leica software and can be imported using this option. This file might contain time in the local time zone. If not, enter the time zone offset as zero. The time zone correction and the GMT date of the first mark must be entered. Events are automatically numbered starting at 1.

LH-Systems Ascot

LH Systems ASCOT (RC-30) has a format very similar to EV0 except that it contains the relative angles of the camera mount, which can be used to apply a 3-D offset for the antenna/camera difference.

User#

These formats allow you to import the time and name of each event mark. Optional variables include line number (description) and altitude information.

File Name

The file name depends on the receiver format. Examples include the following:

- NovAtel is MRK

- Ashtech is PHOTO.DAT

- Trimble is SUM

- Leica is EVO

Time settings

User time type:

Seconds of the week – GPS time ranging from 0 to 604800.

Local H:M:S – Local hours, minutes and seconds (HH:MM:SS.SSSS).

GMT H:M:S – GMT hours, minutes and seconds (HH:MM:SS.SSSS).

Local time correction:

This is necessary for both Leica and User# formats using *Local H:M:S*. This is the offset, in hours, from GMT. For the Eastern Standard Time zone, this number is 5. For the Pacific Standard Time zone, this number is 8. During daylight savings time, these numbers are reduced by one. An incorrect entry causes the camera marks to be displayed incorrectly or not be displayed at all.

GMT date of first record:
This is necessary for Leica, Ashtech and User# formats implementing H:M:S time-tagging. Enter the date of the first exposure record in month/day/year format. It is not the date in local time, which may differ towards the end of the day. An invalid date results in the marks not being displayed.

Attitude Format

For *User5* and *User6* formats that include attitude information, a definition of how the angles are defined is required. Currently, the following attitude formats are supported:

Photogrammetric (w-p-k):
These angles are defined as omega primary, phi secondary and kappa tertiary (ground-to-air).

Camera (roll, pitch, drift):
These angles are the relative ones between the frame of the camera and that of the aircraft.

If the raw GPS receiver data logs position records, there are small circular event marks on the trajectory map in bright blue. These also appear if the data has been processed. If no event marks are present after processing, then it is likely that the time tags are wrong or no event marks have been loaded. To determine what has been loaded, use the *Feature Editor* by going to *View | Features*.

Station File (.sta/nst)
The program automatically loads the STA station file as long as the filename is the same as that of the remote GPB file. If the station file has a different filename than the GPB file, then load the file separately. Waypoint's data logging software and most of the decoders produce station files.

RTK Dat File (.sta/nst)
This option loads converted RTK solution files and then uses the Export Wizard to re-format them for output.

Stations with Known Lat/Long

This option allows you to load and display a file that contains stations with known coordinates. The coordinates are displayed with pink triangles and pink lines. The stations computed by the program have yellow triangles. To join the stations and generate a pink line, include a + sign before each station ID in the input file.

Lat/Long Format
This is a list of formats that the coordinates from the file are in. These formats include the following:

> *Degrees Minutes Seconds*
> For example: 51° 03' 28.3214"
>
> *Degrees Decimal Minutes*
> For Example: 51° 03.4720'
>
> *Decimal Degrees*
> For Example: 51.0579°

Id String Handling
The settings under this option tell the program how to separate the ID from the coordinates.

> *Use first continuous word (no spaces)*
> To be used if the station names are separated from their coordinates by a space.
>
> *Comma separation*
> Use this if commas separate the IDs from the coordinates.
>
> *Use first 'n' columns*
> If you know which column the coordinates start in, you can enter the number for the program to begin at. Each character is a column.
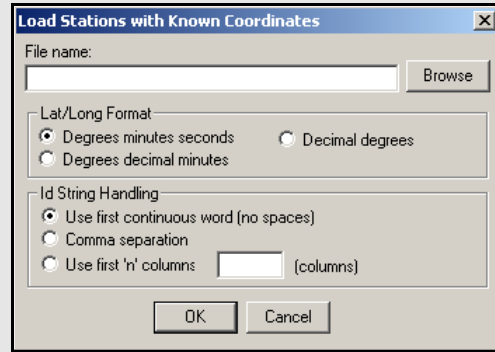
How to load Stations with known Latitude and longitude

1. Select *File | Load | Stations with Known Lat/Long*.

2. Choose the file, under *File Name*, that contains the station information in one of the formats from the *Lat/Long Format* option list.

3. Choose the format, under the *Lat/Long Format*, that the coordinates from the file are in.

4. Choose an option under *Id String Handling* to tell the program how to separate the ID from the coordinates. The first column usually contains the station IDs.

Leica IDEX File (.idx)

Time-tagged points created with Leica 5 data collectors can be given a name, position, and antenna height. However, firmware versions 3.0 and greater do not store the station names within the TTP file. These names are stored within the database structure (control.db) and cannot be accessed directly by the software. The point information contained within the database has to be converted to ASCII, which is done by creating an IDEX file using Leica's Ski software.

Once an IDEX file has been created, it can be loaded into GrafNav. You should see a message indicating how many IDEX points were matched to TTP points. After processing, at least one direction, the TTP points should be visible and numbered sequentially. These have been loaded from the STA file.

Points are matched via their times. Often, there are fewer matched points than the original number of TTP points due to several reasons, including the deletion of points in the field, and/or the addition of static session marks.

Aschtech OUT File (.out)

This type of file is created by Ashtech's Seismark surveying system and can be loaded into a project.

Digital Elevation Mode (DEM)

You may import a DEM after processing the area of interest. Adjust the processing range to only include the mapping area. This limits the scope of the DEM to the observation area, save hard drive memory and improve speed.

DEM Points File

File
The DEM file has to be organized in one of the formats listed under the *Format* drop-down list.

Format
These options are available to help read the input file. They are listed in the shaded box.

Grid
This option defines the DEM source or working grid. If the horizontal coordinates of the DEM are in a map projection, such as UTM (Universal Transverse Mercator) or State Plane, then GrafNav requires the details associated with this projection. If the DEM is stored in geographic coordinates, then a working map projection (grid system) is required. UTM is the easiest, but any system will do.

Datum
This option specifies the processing datum for the project, which should match the datum that the DEM values are stored in. Since only the ellipsoid component of the datum is used, NAD83 and WGS84 can be used in place of each other for most applications that do not require the utmost DEM accuracy.

Geoid
Generally, a geoid model should be selected since DEMs are generally stored in MSL (Mean Sea Level). This requires a WPG file, NRCAN or NGS geoid.

⊠   After a DEM has been imported, the TIN model does not need to be re-formed. Load the TRI file by selecting *File | Load | Digital Elevation Model | Load Triangulation (*.tri)*.

How to import a Digital Elevation Model (DEM)

1. Select *File | Load | Digital Elevation Model | Import DEM Points*.

2. Browse to the DEM points (.pts) file in *File*.

3. Select a formats under the *Format Menu* to organize the DEM file.

4. Select the options that you would like to use to help read the input file.

5. Press *Import*. It takes the program some time to form a TIN model.

6. Press *Accept* once the geoid is formed and a TRI file is saved.

⊠ If no contour lines are visible, then the DEM is outside of the area.

How to load a DEM

1. After a DEM has been imported, select File | Load | Digital Elevation Model | Load Triangulation (.tri).

2. Select the formed TIN file and press Open.

DEM file format options:

First field contains ID string
Shows if a point name leads each line.

Stop reading if incomplete line encountered
Aborts if there is any line missing from the required fields.

Skip 'n' lines at start
Skips past any header lines in the file.

Reject DEM points outside GPS observation area
This is recommended because it limits the size of the DEM to just the GPS observation area. To use this option, valid GPS position data has to be available from the GPS receiver or through processing.

Reduce DEM density using error tolerance
Rejects points if their height can be estimated from nearby ones within the error tolerance that are defined. Tolerances of 5-10 m are acceptable for VSF purposes. Larger error tolerances reduces densities significantly. This option should be used if you have either a DEM grid or a large high-density DEM that causes memory or speed problems.
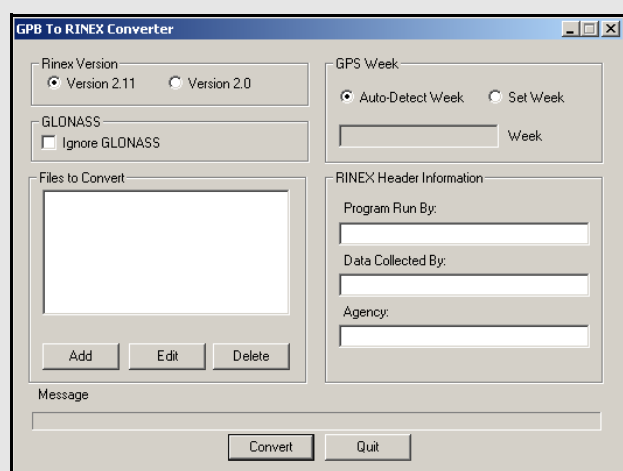
✉ Regardless of the option selected, only data measurements that exist in the GPB file are exported so columns of zeroes are not created for missing data.

Multiple files can be added for conversion. For each file added, you are prompted for a station name, an antenna height, and, if needed, an alternate EPP source for ephemerides.

2.3.10 Convert

The two conversion utilities that are available are the following:

Raw GPS to GPB

If you have logged your data without using Waypoint's logging software, then convert your files to GPB format in order to process them with the software. See *Chapter 6* on *Page 167* for more information regarding this utility.

GPB to RINEX

See *Chapter 6* on *Page 167*.

2.3.11 GPB Utilities

This is available for use with GPB files and includes the following:

Concatenate, Slice and Resample

See *Chapter 6* on *Page 167*.

View Raw GNSS Data

See *Section 2.4.1,* on *Page 41* .

Convert GPB to RINEX

This utility converts a GPB file into a standard RINEX file, version 2.0 or 2.10.

Rinex Version
Choose between *Version 2.1* and *Version 2.0* format.

GLONASS
If present, GLONASS measurement data writes to the observation file, while the ephemerides writes to their own navigation file. This option can be enabled to create GPS-only RINEX files.

Files to Convert
Allows you to select the files that are to be converted.

GPS Week
Sets the week number in which the observations were made. If the *Auto-Detect Week* button is selected, then the program determines the week number from the EPP file. Sometimes, an incorrect week number is output to the EPP file during the conversion from a raw data format. In such a case, you must manually enter the week number via the *Set Week* button.

RINEX Header Information
Several fields are available here for editing. This information is used only for the purpose of being written to the header of the RINEX observation file.

Insert Static/Kinematic Markers

This utility is available in all of Waypoint's programs. It is an alternate method of switching data between static and kinematic modes. Such a task can also be performed on a GPB file with the *GPBViewer* utility. See *Chapter 6* on *Page 167* for additional information.

GPB File Name
Specifies the GPB file to modify.

Operation to Perform
Select *Make all epochs static* or *Make all epochs kinematic* to set the mode for every epoch in the GPB file. Select *Use user generated file to define static periods* to define specific time ranges as being static. This enables the *User File Settings* section on the window.

User File Settings
Converts user-defined time ranges to static mode. The input file containing the definitions of the static periods must contain the space-delimited fields listed in the shaded box.

File name
Click the *Browse* button to locate this input file. The *View/Edit* button allows for the revision and modification of the file.

> **Begin time offset**
> The number of seconds added to all user-defined *StartTime* values in the input file.

> **End time offset**
> The number of seconds to subtract from all user-defined *EndTime* values in the input file. Only the epochs lying between these adjusted times are converted to static mode. This is to ensure that no kinematic data is incorrectly set to static.

> **Minimum session time**
> The minimum number of seconds that a static session must contain to be converted to static mode.

> **Antenna height**
> If the *Create station file* option has been enabled, this value is written to the station file for all user-defined static sessions.

> **Create station file**
> Writes all static sessions to the station file (STA), regardless of whether an antenna height has been entered.
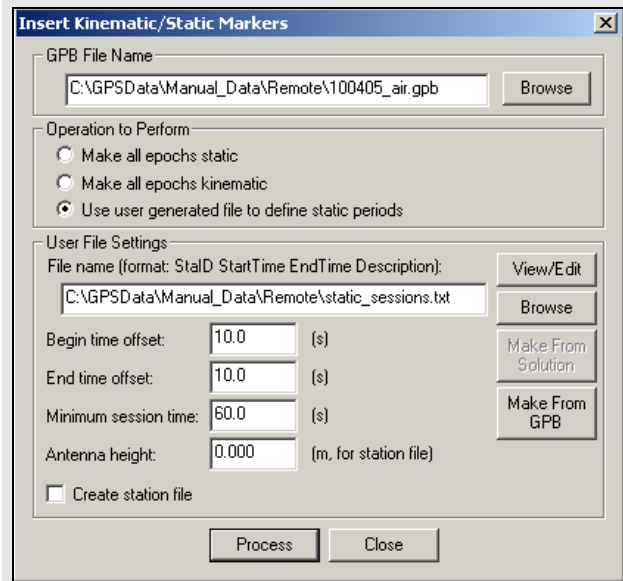
Space-delimited fields

- StationID
- StartTime
- EndTime
- Description

Files that are affected with each *Remove Processing Files* option

Project(s) to Remove

Allows you to select what project(s) you want to delete processing files from.

Current project

Only removes the selected files that are associated with the project that is currently loaded.

All files in

Allows you to select the folder that you want to have the selected files deleted from.

Selected projects

Allows you to select a specific project whose associated files you want to delete.

Files to Remove

Allows you to select the files to remove from the specified project or folder.

GPS trajectories

Contains the solutions computed during processing.

Additional processing

Includes message logs, static summaries and binary files.

Processing history

Contains information regarding any earlier processing run performed in project. *Section 2.4.4,* on *Page 43* for more details.

Project files

Contains project configurations and processing options.

Html/GE files

Deletes everything in the *HTML* sub-folder for a project. This includes any bitmaps, HTML reports or Google Earth output files.

2.3.12 Remove Processing Files

This option removes files from a project. The shaded box contains a list of the files that are affected with each option.

2.3.13 Recent projects

Provides a list of recent projects for quick access.

2.3.14 Exit

Exits Waypoint software.

2.4 View Menu

2.4.1 Project Overview

This window provides a summary of the data in the current project. From here, you can view information regarding the base and remote files, including receiver/antenna types, time coverage, and data gaps.

2.4.2 GNSS Observations

These options are available via *Master* or *Remote*:

View Raw GNSS Data
Opens the master file in *GPB Viewer*.

View Ephemeris File
Opens the EPP file in the internal viewer.

View Station File
Opens the STA file in the internal viewer.

Insert Static/Kinematic Markers
Opens up the menu to insert static/kinematic markers.

Resample/Fill Gaps using the following options
File Interval
Fills all gaps by resampling using the data interval.

Processing Interval
Fills gaps and lowers or raises the data rate in accordance with the specified processing interval.

Remote File Times
Produces a GPB file with epoch times that match the remote file. Any data gap present in the remote file is also present in the new master GPB file. This method of resampling removes unneeded data logged before, and after, the observation time period at the remote. It allows resampling of GPB files that do not sample at a constant rate, examples of these files include SiRF, GSU and I/II.

⊠   Resampling can cause additional errors. If you are resampling intervals of 5 seconds or less, the error is negligible for kinematic processing but for 30 second data, this error is 1-2 cm and hampers integer ambiguity resolution. Resampling should not be performed for static processing.

Disable
Disables the selected master station from being used for processing.
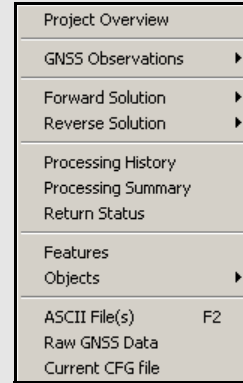
Messages reported from message log

- Times at which ARTK was engaged and the reasons for its engagement. These messages are preceded by *******.

- Any satellites with no ephemeris information.

- Epochs of less than 4 common satellites between the master and remote.

- Periods of extremely poor satellite geometry where the DD_DOP is greater than 100. The epochs are skipped and not used for plotting or outputting. This message is the only means of determining these periods.

- The occurrence of cycle slips. This log gives a time and record of these slips that mean problems in kinematic data.

- Data errors, like invalid measurements, that cause filter resets or the rejection of satellites. These messages are preceded by $$$.

- Entering static and kinematic modes.

- Events resulting from significant changes in the satellites' geometry. These include changes in the base satellite and the rising or falling of satellites above or below the elevation mask.

- The fixing of the remote's position. These messages are preceded by ###.

- The omission of satellites, baselines or time periods from processing.

Remove

Removes the master file completely from the project.

2.4.3 Forward and Reverse Solutions

GNSS / PPP Message Log

This file displays all messages sent to the message window during processing. There is one present for each direction processed. Possible messages reported here are listed in the shaded box.

GNSS Summary

This summary file displays the processing settings and the statistics for successful ARTK fixes and static sessions. Other items reported in this summary are listed in the shaded box. See *Chapter 5* on *Page 153* for an example of this summary file.

GNSS / PPP Trajectory

This file gives a detailed output for each epoch. It keeps a record of the data computed during kinematic processing. There is a plot available for most of the statistical information contained in these files. This file is normally used for the following reasons:

- Comparison of numerical values between epochs or solutions.

- Searching for information relevant to a specific epoch via use of the *F3* key.

- Determining which satellites were used in the solution and which was designated the base satellite.

- See *Section 5.4.3,* on *Page 165* for a complete description of both the old and new output formats.

2.4.4   Processing History

This feature displays the processing history in a chronological list and can be used to restore a previous processing run. It contains the date and time when each run was performed. It also contains a description of the run, including the directions being processed, your initial processing settings and the return status. View options in the *Process History* box are listed in the shaded box.

2.4.5   Processing Summary

This option gives statistics on the current solution loaded in GrafNav. It is for kinematic processing and static processing. The *Processing Summary* options are the following:

- Solution type

- Baseline distances

- Number of epochs not processed, percentage of epochs having double difference DOP over 10 and epochs with bad measurements

- Total number of epochs

- Quality number percentages

- Estimated position standard deviations calculated from the Kalman filter

- RMS values of the GPS measurements and the RMS forward/reverse separation values for east, north and height.

Where the float solution has had time to converge to a lower value of error since the larger error values occur at the beginning of the processing direction, the RMS values are represented for 25%-75% weighting. These values take into account the weighting of the forward/ reverse combined solution in this percentage range. This also applies to a ARTK fixed solution. The RMS values for the 25%-75% weighting of the combined solution are generally lower than the RMS values from the forward/reverse separation because if one solution has high error values, most of the weight is placed on the other processing direction. C/A code and L1 phase measurements are deemed unacceptable based on the standard deviation rejection tolerances and PPM distance error specified in the processing options.

The *Processing Summary* can be added to the end of an output text file created through the *Export Wizard*. See *Section 2.7.4,* on *Page 80* for information about the *Export Wizard*.
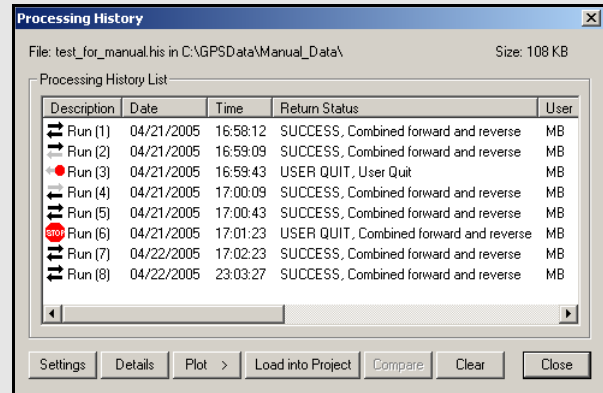
Processing history view options

Settings
Brings up the processing settings used for the selected run.

Details
Displays more information about the selected run, including the following option for the configuration file.

Save CFG As
Saves the processing settings into a new configuration file. This is an effective way to start a new project using a previous configuration. You are prompted to enter a new name.

Plot
Accesses the *Combined Separation, Estimated Position Accuracy, Quality Factor* and *Float/Fixed Status* plots for the selected run. Be aware that if processing was not performed successfully in each direction, certain plots can be unavailable or incomplete. This feature is very useful for comparing different runs.

Load into Project
Loads the processing settings for the selected run into the current project. You are prompted to back-up the current project to a BAK file.

Compare
Compares two configuration files that are selected by holding down the *Ctrl* key. This feature is useful for determining the difference between the settings used for two runs.

Clear
Deletes the entire processing history.

Displayed in the *Features Editor* window

Name
The name of the feature. The symbol next to the name is the type of point. Examples include a station, camera mark or GIS mark. The symbol appears grey if the feature has been disabled.

Time
This is the feature's GPS capture time. To show the time in HH:MM:SS, select *Show HMS*.

Q
Shows quality number of the feature's solution:

1= fixed integer   **3 & 4** = converging float
2 = stable float   **5 & 6** = DGPS

Std(m)
Combined standard deviation of the north, east and height components, including additive PPM based error.

Fix
Shows the ambiguity status of the feature's solution:

Y = fixed integer   **N** = float solution

Azimuth
Azimuth, in degrees-minutes-seconds, from previous feature to current feature.

Dist(m)
Distance, in metres, from previous point to current point.

Dt(s)
Time difference, in seconds, between current and previous point.

Height
Height, in metres, of feature. This is normally an ellipsoidal height, but if the master station height was entered as orthometric, then this height is more orthometric. Use the *Export Wizard* to get the exact orthometric height. For stations, like STA and GIS, with antenna heights, this height is of the monument and not the antenna.

AntHgt
The height of the antenna above the monument. Camera marks do not have an antenna height, and so *N/A* is displayed.

Desc/Info
Describes the feature or line information for the camera mark.

Remarks
Remarks field.

2.4.6 Features

The *Feature Editor* window is used for the following reasons:

- Examining which features are loaded.

- Examining the quality/accuracy of features after processing.

- Examining the time difference, azimuth and distance between successive marks to identify timing and numbering errors.

- Editing station feature names, time-tags, as well as antenna heights and models. For camera marks, the line number can be inserted into *Desc/Info* field.

- Re-numbering stations and camera event marks.

- Disabling features so that they are not displayed or exported.

- Editing the crab/drift angle for applying 3-D offsets to camera event marks.

The shaded box has a list of the columns that are displayed.

⊠   Changes made to stations are now saved automatically to an NST file. To revert back to the original station information, use *File | Load | Station File* or *File | Load | Camera Event Marks*.

The shaded box contains a list of the options that are available with the buttons on the right-hand side of the *Features Editor* window.

Options in the *Features Editor* window

Add Station
Lets you manually add a station. Also add stations by right-clicking on epochs in the map window. You might want to add stations to static sessions that have none because static sessions cannot handle a varying antenna height and a station can

Remove
Removes the selected stations. Multiple stations can be selected and you might consider disabling a feature instead of deleting it.

Edit
Edits the station name, time-tag, description and antenna height of the selected feature.

Select All
Selects all features.

View Info
Shows processing information for any selected feature enabled during processing.

Global Edit
Make changes to multiple selected features. Modifications can be made to the antenna heights, descriptions, camera line information, remarks and drift/crab angles.

Re-Number
Re-number a selection of stations. Numbering can be performed starting from the bottom or the top of the list. You can specify the starting number and the increment value. To decrease numbers, use a negative number.

Move to Static
Use this option for surveys with short static segments. This process moves stations within static sessions to the end-points. Each static session with a station is replaced with one at the start and one at the end. The remarks field is modified to be BEGIN_STATIC or END_STATIC and notifies the *Export Wizard* to combine the two solutions upon output. During combining, features where the begin solution and end solution do not match are flagged to aid quality control. This option only works for static sessions with features.

⊠ *Global Edit, Re-Number* and *Move to Static* work with multiple features selected. To select a continuous block, hold down the *Shift* key while clicking on features. To select individual features, use the *Ctrl* key.

Options available in the *Objects Menu* window

View
Brings up the *Object Info* message box for the selected object.

Edit
Edits the station name, description and remarks for the current selection. If a master station is selected, this allows you to edit the coordinates and antenna height.

View/Edit GPS
See *Section , on Page 31* for a description of the options available here.

Add as Station
Lets you manually add a station. The station's time is automatically set to the time of the selected object.

Initialize Remote
Lets you to fix the remote's position at the time of the selected object. This will only work on objects with valid solutions.

Engage ARTK
Forces the software to engage ARTK at the selected object's time.

Add to Favorites
Adds the object's solution to the list of *Favourites*.

Set Start Time
Uses the selected object's time as the start time for GPS processing.

Set End Time
Uses the selected object's time as the end time for GPS processing.

Find on Map
Finds the selected epoch on the map window.

Go to FML
Searches the forward GNSS differential message log for a record closest to the time of the selected object.

Go to RML
Searches the reverse GNSS differential message log for a record closest to the time of the selected object.

2.4.7 Objects

This command brings up the *Object Menu* for all of the epochs, static sessions, ARTK fixes, features, stations, and RTK data in the project. The *Object Menu* can also be activated by right-clicking on an epoch of interest in the map window. This displays the features and epochs around the selected epoch.

The options that are available with the buttons on the right-hand side of the window are listed in the shaded box.

Static Sessions

Be aware of the antenna height when processing static sessions or features within a data set. For static sessions, determine antenna height in the following order:

1. Use manual override. To override an antenna height, select the static session from the *Object Menu* and click the *Edit* button. Manual override is disabled by default.

2. Use station feature antenna height. The antenna height of a given feature is read from the STA file. If you need to edit it, use the *Feature Editor* menu. This method of antenna height determination applies only if the feature is found within the static session. See *Section 2.4.7, on Page 46* for details.

3. Use remote antenna height. See *Section 2.3.7, on Page 29* for help changing the remote antenna settings.

GrafNav requires the vertical offset between the marker and L1 phase centre. Most often the distance between the marker and the ARP (or measurement mark) are measured and a correct antenna model is required to add the offset from the ARP to the L1 phase centre.

For features and static sessions, GrafNav lets you select the antenna model and height. It also allows you to enter the height measurements of the antennas long as a proper antenna model is being used. When using this option, ensure that the correct antenna height is entered and prepare to be required to edit the antenna information after a new project is created.

The antenna models are created from data acquired from NGS, and cannot use the measuring mark on the antenna as the origin. This adds an error of several centimeters to the antenna height. Check each antenna model before using it and ensure that the final overall vertical antenna height is from the monument to the L1 phase centre. The greyed *Vertical antenna height* field under *Settings | Coordinate*, for either the master or remote, shows this value. It is better to create your own profile if you have the following knowledge about the antenna characteristics:

- Vertical offset from the measurement mark to the L1 phase center

- Vertical offset from measurement mark to L2 phase center

⊠ Existing antenna profiles can be used for difference between L1 and L2 offsets.

- Horizontal radius of antenna from measurement mark. Used only for slant measurements

- Elevation-based antenna errors (optional)

Once you know these characteristics, follow the steps in the shaded box to create an antenna profile.

An antenna height model can also be created with correction values from another antenna. To do this, follow the steps in the shaded box.

See *Appendix A Page 211* for a diagram of different methods for making antenna measurements.

⊠ You can specify each antenna profile's origin. If the antenna has multiple origins, then create a new profile for each one. Ensure that the final overall vertical antenna height is from the monument to the L1 phase centre. Refer to Waypoint FAQ section on the NovAtel website for more information.

How to create an antenna profile

1. Once you have the antenna characteristics, go to *Settings | Coordinate*.

2. Press the *Define* button next to the antenna profile name under the *Use advanced method* option in the *Antenna Height* box.

3. Select *Add Empty*, enter a name and the characteristics.

4. Press *OK*.

How to create an antenna profile with correction values from another antenna

1. Click the *Define* button under the *Coordinate Settings* window for the master or remote.

2. Select the model to copy from in the *List of Antennas* and click *Add From*. The vertical distance values may need to be modified and the horizontal distance may need to be inserted.

3. Be sure that the relationship between the L1 and L2 vertical offset is unchanged.
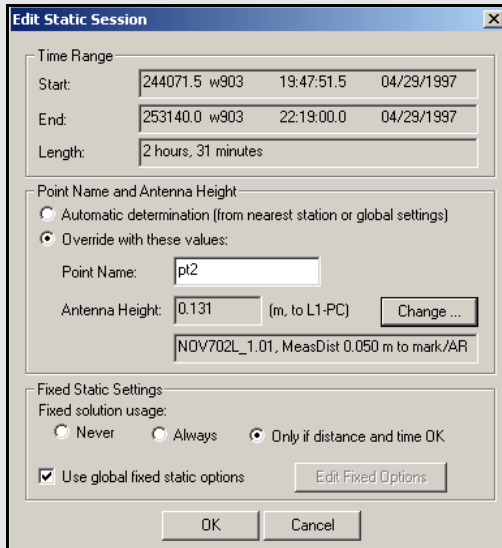
Override values

Point Name
Allows you change the station's name.

Antenna Height
If this value is known. enter the antenna height, especially if a static session is being processed in GrafNav. To select an antenna model, click the *Change…* button.

Fixed solution usage settings

Never
Float solution are used for the static sessions.

Always
Fixed integer solution are attempted for the static sessions.

Only if distance and time OK
Fixed integer solution are attempted if the baseline distance and session length are within the constraints which are found under *Settings | Individual | Advanced*. Otherwise, a float solution is used.

Edit Static Sessions
Select a static baseline from the *Object Menu* and click the *Edit* button to display the *Edit Static Session* window. The options in this window allow you to change station names, antenna heights and processing options for the static session.

Time Range
Displays information regarding the static session.

> ### Start/End
> Displays GPS seconds, GPS week number, GMT time and date (*mm*/*dd*/*yyyy*) for the beginning/end of the static session.
>
> ### Length
> Displays the difference between the start and end time.

Point Name and Antenna Height
Displays information regarding the observed point's name and antenna height.

> ### Automatic determination
> Applies the antenna height and point name from the nearest station, if one exists within session. If not, then it uses the global remote antenna height and a station name of *STATIC_???*.
>
> ### Override with these values
> Allows you to manually enter the parameters that are listed in the shaded box.

Fixed static settings
Customizes the conditions and settings for the use of a fixed static solution.

> ### Fixed solution usage
> Gives you a choice of settings for the use of a fixed solution. The settings for this option are in the shaded box.
>
> ### Use global fixed static options
> Enable this feature to use the options under *Settings | Individual | Fixed Solution* for the static session. Otherwise, click on the *Edit Fixed Options* button to customize the options for this session.

2.4.8 ASCII File (s)

The *View ASCII File(s)* option allows you to view any of the ASCII files generated by the software. Examples of these files include the following:

- Epoch Solutions (FWD, REV and CMB)
- Message Logs (FML and RML)
- Static Summaries (FSS and RSS)
- Station Files (STA)
- Ephemeris Files (EPP)
- Configuration Files (CFG).

2.4.9 Raw GNSS

This option is also available under *File | GPB Utilities | View Raw GNSS Data*, or through a separate utility called *GPB Viewer*. This option lets you view and edit binary GNSS data in Waypoint's receiver-independent GPB format. See *Chapter 6* on *Page 167* for more information.

2.4.10 Current CFG File

This option lets you view the Configuration File (CFG) of the current project. The CFG file is simply an ASCII file containing all of the processing options and user commands for the project. Definitions of all the commands shown in this window are available in Appendix A.

How to view ASCII files

1. Select *View | ASCII File(s)*.

2. Highlight the file to view and click *Open*.

3. Right-click the file to view additional features. This lets you change the font or copy selected regions for pasting into other applications.
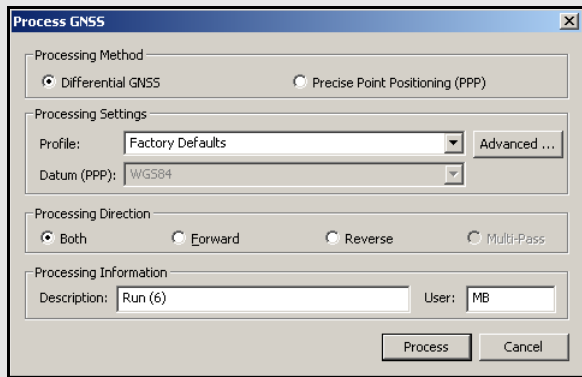
Process direction options

Both: Processes in both directions. If this option is activated, the two solutions are combined after processing. See *Section 2.6.7,* on *Page 69* for help doing so. This method is most effective for kinematic processing. For differential static processing, only use the forward or reverse options.

Forward: Processes the data chronologically from the beginning and in the same direction that it was collected in.

Reverse: Starts processing the data from the end to the beginning.

Multi-Pass (PPP processing only): This option processes the data three times sequentially: forwards, reverse, and forwards again. The converged Kalman filter states (position, velocity, tropospheric delay, ambiguities) are preserved after each run and applied to the following run. The result is that improved accuracies are possible for data sets ranging from 1 to 4 hours in length. All the requirements for the default processing style are still applicable here. The final solution is the weighted combination of the reverse solution and the second forward solution.

2.5 Process Menu

2.5.1 Process GNSS

The *Process GNSS* window provides access to most settings related to data processing and lets you choose the options best suited to your application.

Processing Method
Differential GNSS
Use this option to perform differential processing using one or more base stations.

Precise Point Positioning (PPP)
This feature performs precise point positioning (PPP). Base stations are ignored in this mode of processing and only the remote is used. For help adding a remote file to a project, see *Section 2.3.7,* on *Page 29* .

Processing Settings
Profile
Select the profile that best suits your application. The processing settings will be adjusted accordingly.

> ***Advanced...***
> Advanced processing settings for both Differential GNSS and PPP are found here. See *Advanced... Page 51*.

Datum (PPP processing only)
The datum selected here depends on the coordinate system in which the final results are needed. The final trajectory output will be produced in this datum.

⊠　　The software scans the SP3 file to determine the reference frame. If you require final coordinates in any other datum, a transformation is required. Datum conversions are defined in the Datum Manager. Any error in the selected datum conversion affects the final trajectory.

Processing Direction
Defines which time direction to process data in. The direction options are in the shaded box.

Processing Information
Description
Enter a description of the run here. The program numbers the runs numerically.

User
Enter your name or initials.

Advanced...
This provides access to advanced settings related to data processing and lets you choose the options best suited to your application.

⊠ Some options are only available for a specific processing mode.

General
Process Data Type
Defines the type of data used for processing.

Automatic
Detects dual frequency, single frequency or code only receiver data. If the master(s) and remote are logging different data types, then it selects the one with the least measurements.

The order of increasing measurement availability is C/A code only, single frequency carrier phase, and then dual frequency carrier phase. If L2 tracking is very poor, then a dual frequency GPS receiver may be detected as single frequency.

C/A code only
Processes in an advanced differential correction mode and is performed on data with little or no carrier phase information. For kinematic data, the accuracy is the same as real-time differential or RTCM corrections. In static mode, the accuracy is higher due to the averaging effect.

Dual frequency carrier phase
Processes same measurements as single frequency mode, but with the addition of L2 carrier phase. Processing dual frequency has two benefits that are listed in the shaded box. By combining the L1 and L2 carrier phase the widelane is formed. When used for Fixed Static (ARTK), this technique is more reliable, solves on longer distances and requires less observation time. For example, ARTK resolves in a few minutes what could take up to 20 minutes in single frequency mode.

Single frequency carrier phase (Differential GNSS processing only)
Processes with C/A code, L1 carrier phase and L1 Doppler data in a combined Kalman filter, so each variable must be available. Single frequency is generally more accurate than C/A code only. Carrier phase ambiguities can be fixed but the process is less reliable than the dual frequency mode because you can't make ionospheric corrections.
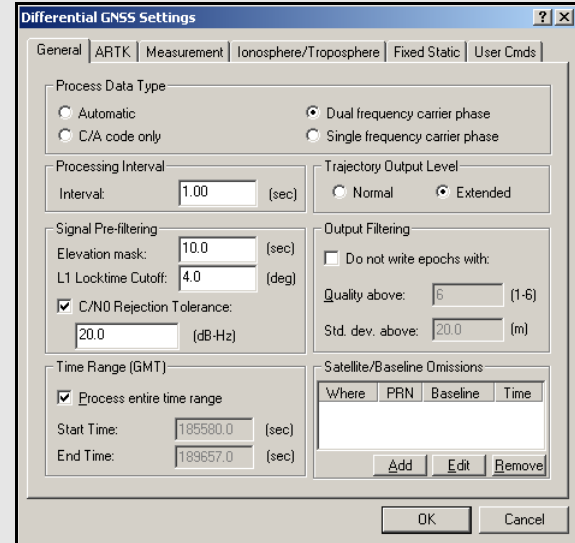
Benefits of using the dual frequency carrier phase
The benefits of processing in dual frequency mode includes the following:

- Better accuracy on baselines longer than 10 km when ionospheric corrections are enabled.

- Improves the reliability of integer ambiguity search techniques.
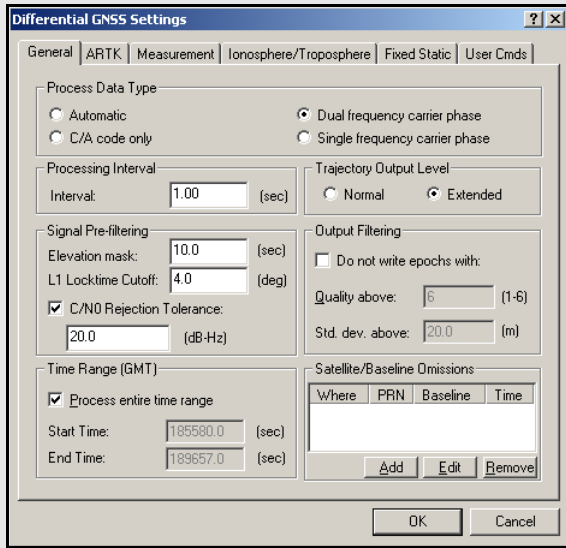
Signal Pre-filtering Options

Elevation Mask
Defines the minimum elevation above the horizon that a satellite must reach before being used for processing. The default elevation cut-off is 10 degrees.

You can raise the elevation to 15 degrees for static baseline processing, but be aware that raising this value too high might cause satellites that are important to the geometry to be missed. Lowering this value may cause noisy satellites at low elevation to degrade the solution.

L1 Locktime Cutoff:
The number of seconds of continuous carrier phase lock before data for that channel is deemed usable. This allows you to reject data for the first *n* seconds after acquiring lock. The default value is 4, but higher numbers (8 to 12 s) can be very beneficial to some GPS receivers, especially low-cost ones.

C/N0 Rejection Tolerance
This option specifies a threshold below which a measurement is not to be used.

Trajectory Output Level Options

Normal
Default for GrafNav.

Extended
This format is suggested for users who require additional information. It is identical to *Normal* except that additional fields exist for the relative vector information, position and velocity covariances, ambiguity values, as well as multi-base and satellite information.

Processing Interval
For kinematic and float static processing, the program automatically synchronizes both the master and remote data sets at the collection rate. With this option, you can specify the interval to process the data. Entering zero results in all epochs being processed.

Signal Pre-filtering
These options are listed in the shaded box.

Time Range (GMT)
Defines the time range to be processed. If the *Process entire time range* option is enabled, GrafNav processes starting at the first epoch the master and remote have in common and end at the last. To limit the scope of processing, use the *Begin* and *End* fields. The default time system is GPS seconds of the week (0-604800).

Trajectory Output Level
This option allows you to select the format of the epoch output files. The setting options are described in the shaded box.

Output Filtering
Do not write epochs with:
This setting removes epochs that have quality numbers or standard deviations greater than the specified threshold. Use this option to try to filter out bad positions from the output.

Satellite/Baseline Omissions
This option brings up the *Omit Satellite Info* window, in which you can enter omissions.

Satellites to Omit
All Satellites
Disables all satellites from being used.

Only specified satellite
Disables individual satellites.

Baselines to Omit
Omit satellite for all baselines
Applies the satellite omission to all baselines in the project.

Only selected baseline
Applies the satellite omission only to the specified baseline (applies to multi-baseline projects only).

Time Period
Omit for entire data set
Applies the omission to the entire processing time range.

Use specified time range
Applies the omission to a specific time period, entered in GPS seconds of the week.

Where to Omit
From processing
Applies the omission to all types of processing.

From ARTK/Fixed-Static only
Applies the omission only during ambiguity resolution.

Precise Files (SP3 and Clock) (PPP processing only)
This button gives you the opportunity to add or remove any required precise files for the project. It is used to add precise clock (CLK) or ephemeris (SP3) files, but it can also be used to add IONEX (*yy*i) and broadcast ephemeris (EPP) files, if need be. Once the files have been included in the project, via the *Add* button, they appear in the window, alongside information regarding the time span that they cover. To disable the use of any of these files without removing them from the project, use the *Edit* button.

Download Precise Files (PPP processing only)
A portion of the Download Service Data utility has been integrated here to allow you to download the precise CLK and SP3 files. You need only specify the range of days for which the data has been collected, in MM/DD/YYYY format, and click the *Download* button. The files are downloaded and saved to the directory specified via the *Browse* button.

Integer Ambiguity Resolution processing option settings

On
Forces ARTK to be enabled for single and dual frequencies.

Off
Forces ARTK to never engage. This will produce a float solution.

Criteria for accepting new fixes

Default tolerance
Accept fixes if they are different by 1.2cm + 0.8 PPM. This setting is suitable for most ground applications.

On engage only
This level rejects all fixes unless ARTK has been specifically engaged by the user. For airborne, ARTK can sometimes resolve incorrectly due to the long distances and height separation. Therefore, this level is suggested for such applications.

ARTK Options (Differential GNSS processing only)

ARTK is a technique that computes an integer fixed solution of 2 cm while the remote antenna can be in motion.

Due to the additional measurements present with the L2 phase, ARTK solutions that use dual frequency data are considerably more reliable than those using only single frequency data. ARTK delivers accurate results with single frequency, but it requires more time.

> ⊠   Both single and dual frequency ARTK require at least 5 satellites, but 6 or more are preferable. If ARTK fails after a given length of time, it starts searching over again.

As long as ARTK successfully resolves, GrafNav restores the ambiguities from the moment it engages so that centimeter accuracies are only unavailable for the actual period of signal obstruction. If no additional complete signal obstructions are encountered following the initial loss of lock and there are good quality phase measurements and low multi-path, then ARTK resolves.

Integer Ambiguity Resolution
ARTK computes integer ambiguities for both static and kinematic trajectories. ARTK resolves very quickly, which benefits ground vehicle applications where there are only short periods of continuous data between obstructions. In addition, ARTK fixes often, which is beneficial for ground mapping and surveying applications, as it maximizes ambiguity determination accuracy. However, in airborne, it can cause unnecessary jumps or spikes in the trajectory, thereby increasing relative positioning error. To mitigate this, it is suggested that the *On engage only* level is used for the *Criteria for accepting new fixes* setting in airborn applications.

Generally, ARTK produces few incorrect fixes but this can vary by data set. ARTK can use GLONASS but the advantage is often minimal. For LiDAR users requiring the highest level of accuracy, ARTK can be a valuable tool. The integer ambiguity processing options are listed in the shaded box.

General
> #### Criteria for accepting new fixes
> Controls how easily the Kalman filter accepts integer fixes generated by ARTK. The levels are listed in the shaded box.

Quality acceptance criteria

This determines how strict ARTK is in signaling a fixed integer solution as a pass. It should be left at Q1, but if ARTK is having trouble computing a fix at all, try Q0. If ARTK is computing many incorrect fixes, try a higher number such as Q2.

Use GLONASS

Enable this option to include GLONASS data in the ARTK filter. If disabled, GLONASS data will only be used in the float solution, which seeds the ARTK filter.

Maximum Distance

The distance tolerance for engaging ARTK in both single and dual frequency can be defined here. ARTK does not engage if the remote is too far from the base station. This improves reliabilities. The default distance is 4 km for single frequency.

Engage Options

These options control when ARTK is engaged.

Only accept fix from closest baseline

Enabling this option results in ambiguities being used only if they were resolved using the closest base station. If enabled, the software ignores ARTK fixes from further base stations. This results in a float solution if a fix is not obtained from the closest base.

Engage if distance < tolerance1, reset if distance> tolerance2:

This is useful for airborne multi-base processing applications where the aircraft flies over various base stations. It engages the first time that the distance is closer than *tolerance1*. If the distance becomes greater than *tolerance2*, a flag is reset and *tolerance1* is tested again.

Engage continuously every:

Engages ARTK at a specified interval and is often used for monitoring applications. This value is set around 5 to 20 minutes. Because this mode does not check either baseline distance or data quality, it is the least desirable method for engaging ARTK in airborne data.

Engage on event of poor DD_DOP:

Four is the minimum number of cycle slip free satellites needed to compute a solution. Even if this minimum is maintained, the geometry can be very poor, as shown by spikes in the *Double Difference DOP* plot. This option forces ARTK to engage after the DOP recovers. The default tolerance is 25.
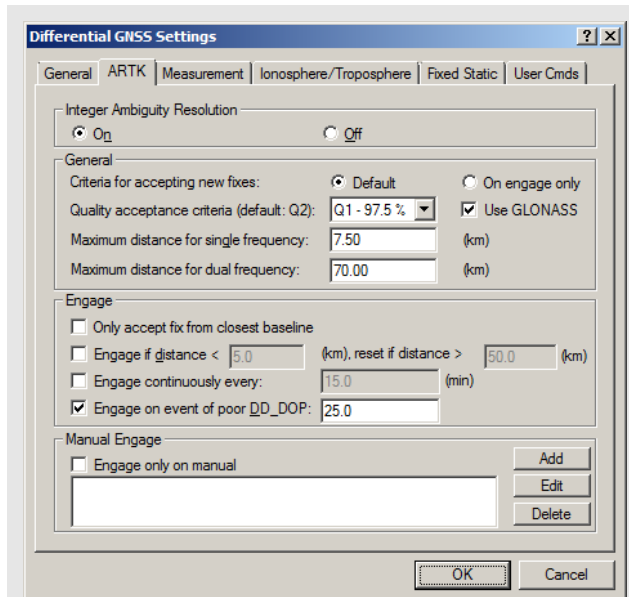
⊠ If the DD_DOP is greater than 100, the epochs are not plotted because GrafNav skips them. This creates a gap in the data, so check the message logs for these instances.

Measurement Standard Deviations Options

Code
Controls the standard deviation at reference elevation or C/N0 for C/A, P1, and P2 codes.

Carrier phase
Controls the standard deviation at reference elevation or C/N0 for L1 carrier.

Doppler
Controls the standard deviation at reference elevation or C/N0 for the Doppler.

> *Automatic* – Sets the standard deviation to 0.25 or 1.0 m/s, depending if the receiver measures Doppler.

Outlier Detection/Rejection
These settings control how the processing engine treats bad satellite measurements using the residuals. The engine rejects measurements based on the number of standard deviations needed to flag an outlier (sigma tolerances). When an outlier is detected, it rejects satellites, measurements or baselines but if too many continuous rejections are encountered, then the software issues a cycle slip to all satellites. This is known as a filter reset.

To control the amount of rejection, click on the *Outlier Detection Level* button. You can enter the rejection and reset values for each measurement or use a stricter phase tolerance to reduce the number of visible spikes in the *Carrier Residual RMS* plot.

GLONASS Usage Options

Enable GLONASS Processing
Forces the use of available GLONASS data. Disable this option if you wish to perform GPS-only processing.

Share GPS base satellite
Converts GLONASS measurement to GPS wavelengths which permits a GPS base satellite to be used. Use this method if the number of GLONASS satellites is very low because it works with just one satellite.

Use base GLONASS satellite
By using a separate GLONASS base satellite, GLONASS satellites now have the ability to be used in ARTK, while trajectories can be cleaner on longer baselines utilizing ionospheric free processing. This mode requires at least two GLONASS satellites (with one as the base).

Manual Engagement
Manually engages ARTK when it is necessary. For example, when an airborne platform is very close to the base. You must specify the process direction. This feature works well combined with the *Engage only on manual* setting. This allows ARTK to engage only at specified times

Measurement

Measurement Standard Deviations
Sets the standard deviations of the measurements. These values are applied to all baselines. These options are in the shaded box.

> ⊠ The standard deviations are specified here as double differenced values and are at least twice that published by the manufacturer.

GLONASS Usage (PPP processing)
Enable this setting if you want to include GLONASS data in the PPP filter. This requires that the precise files include data for GLONASS satellites.

GLONASS Usage (Differential GNSS processing)
GLONASS Usage applies only to data logged using GLONASS-enabled receivers.The options are in the shaded box. Advantages and disadvantages of using the float method include the following:

Advantages
- Maximizes satellite usage
- Even one or two GLONASS satellite can be very beneficial

Disadvantages
- ARTK ignores GLONASS

Advantages and disadvantages of the enhanced method includes the following:

Advantages
- GLONASS satellites can be used in ARTK resulting in faster, more reliable ARTK fixes
- GLONASS processing can be cleaner especially on longer baselines

Disadvantages
- Needs a GLONASS base satellite which effectively reduces satellite count by one

Measurement Usage (Differential GNSS processing)
> *Use P1 instead of C/A code in the Kalman filter*

By default, the processing engine uses C/A code in the Kalman filter. Some receivers deliver better performance if the P1 code is used instead.
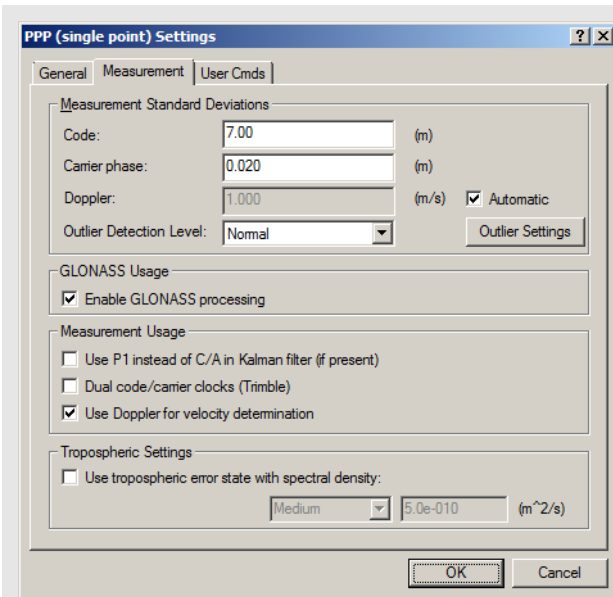
Distance Effects (PPM error added to measurement SDs) Options

Distance effect amount

High would be used during heavy ionospheric disturbance and would cause a stronger weighting on the nearest base station. The actual PPM values used for each of these levels is determined by the processing engine and depends on the type of processing. Manual distance effects can be entered as well. In this case, you would enter the horizontal values directly. To view the PPM values used, bring up the *Static/ARTK Summary* file after processing and look for the *Dist. Effects* field. For very long spatial distances, consider using *Low*. Otherwise, the Kalman filter may destabilize.

Disable baselines when distance becomes greater than "n" km

Use this option when MB processing has many Kalman filter resets or errors. Enabling this option removes a baseline from use during processing if its distance extends beyond the specified tolerance.

Use Doppler for velocity determination

By default, Doppler measurements are used to compute velocities but you can disable it if there are Doppler error warnings in the message log.

Measurement Usage (PPP Processing)

Use P1 instead of C/A code in the Kalman filter

By default, the processing engine uses C/A code in the Kalman filter. Some receivers deliver better performance if the P1 code is used instead.

Dual code/carrier clocks (Trimble)

This option enables or disables the use of separate clock states for the carrier phase and C/A code measurements. It will likely need to be enabled for Trimble users.

Use Doppler for velocity determination

Enable this option to allow the processor to use the Doppler measurements found in the GPB file for velocity determination.

Tropospheric Settings (PPP processing)

See *Page 60*.

Distance Effects (PPM error added to measurement SDs)

To properly account for distance dependent error sources, a part-per-million (PPM) value is added to code and carrier phase measurement standard deviations. A PPM is added for the horizontal (spatial) distance and the vertical (height) distance between each master and the remote. These options are listed in the shaded box.
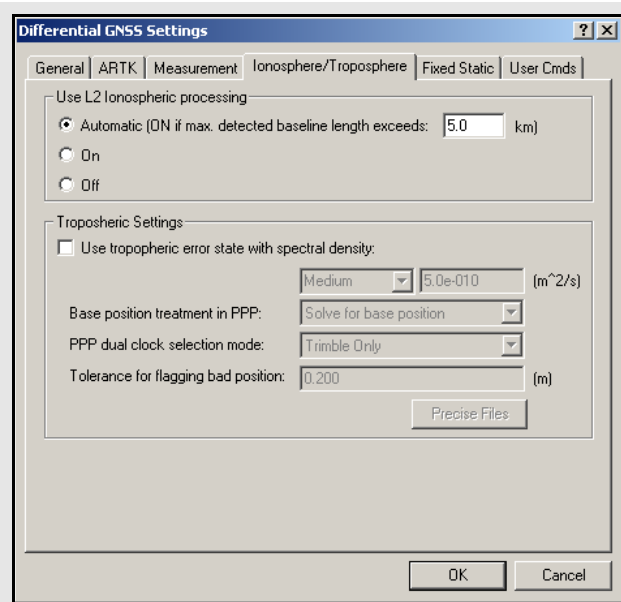
The options for Use L2 Ionospheric processing

Automatic
This option only enables ionopheric corrections if the maximum length of the baseline is greater than the specified tolerance.

On
Use this option to force the use ionospheric corrections.

Off
Use this option to disable the use of ionospheric corrections.

Ionosphere/Troposphere (Differential GNSS processing)

GrafNav supports full dual frequency processing. For this feature to work, both the master and remote receivers must be dual frequency.

Ionospheric Correction

By making measurements on both L1 and L2, the ionosphere error can be resolved. The effect of the ionosphere under normal conditions and in the absence of ionospheric storms is a relatively small effect at 0.5 to 2 PPM (5 to 20 cm per 100 km). Since L1 and L2 carrier phase need to be combined to remove the ionosphere, the measurement noise increases from sub 1 cm to 1-3 cm. A further problem occurs because L2 is more prone to cycle slips. Ionospheric correction becomes beneficial on baselines greater than 7 km.

Use L2 Ionospheric processing
The models are listed in the shaded box.

Tropospheric Settings
> *Use tropospheric error state with spectral density*
> The processing engine adds a tropospheric error state to the Kalman filter.

✉   This option is only recommended for high altitude (vertical separation between base and rover is at least 1000m) or long distance data sets (baseline length exceeds 60km) that are 2 hours or longer. Using it on other data sets may increase the noise in the solution.

Removing the tropospheric error bias is done in two steps. In the first step, GrafNav uses the PPP processor to solve for the tropospheric zenith path delay at all base stations. This is done by either fixing the base station coordinates or by letting the PPP processor solve for them. See the *Base position treatment in PPP* option. The second step is the addition of a tropospheric error state to the Kalman filter. By solving for the base stations tropospheric zenith path delay in the first step, the rover's tropospheric error bias becomes more observable in the Kalman filter.

Base position treatment in PPP
The settings for this option are listed in the shaded box.

PPP dual clock selection mode
Concerns the use of separate clock states for carrier phase and C/A code measurements. The need for this option has only been observed on Trimble receivers, but users can enable or disable this option for any receiver.

Tolerance for flagging bad position
If the solved position from PPP differs from the user-specified coordinates (via *Settings | Coordinate*) by the tolerance specified, then an error message is displayed and differential processing is not performed.

Fixed Static

Fixed Static Data Interval
The recommended interval for fixed static is 15 seconds. Shorter intervals result in overly optimistic accuracy estimates because of high time correlation of carrier phase data over periods less than 15 seconds and does not improve accuracies.

Static Initialization
The two options are listed in the shaded box.

Static Session Setting
These parameters govern how GrafNav processes static baselines. The options for this setting include the following:

> #### Split into two sessions if time gap greater than:
> If selected, GrafNav treats time gaps greater than the tolerance as an indication of a new station occupation. This setting is useful if the raw GPS data contains no kinematic epochs between static sessions. It is also useful if there are some blockages so severe that the receiver outputs no raw data records between static sessions.

> #### Tolerances for fixed static solutions:
> Allows you to specify distance and time tolerances to prevent unreliable static fixes on very long baselines or short time periods. GrafNav computes a fixed static solution for any number of static sessions. Dual frequency has a separate setting option because it sometimes spans a longer distance and requires less data.

> ⊠   For these settings to be applied, *Fixed static solution* has to be selected on this tab.
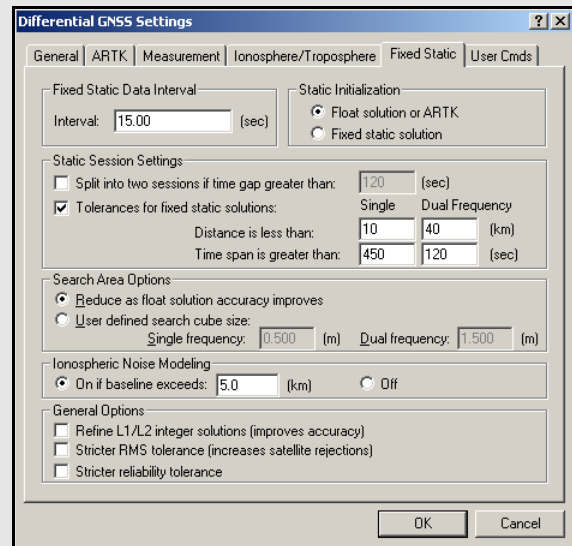
Static Initialization Options

Float solution or ARTK
This setting is necessary for kinematic initialization. For static data, the float solution does not solve for integer ambiguities, so it is less accurate than the Fixed Static solution. These integers are often not solvable for baselines greater than 10 km in single frequency and up to 25 km in dual frequency. In these cases, the float solution is the best alternative.

Fixed static solution
Processes the carrier phase to get a static fixed integer solution. If the integers are correctly determined, this mode is the most accurate. For longer static baselines, an ionospheric correction is applied to the fixed solution. For single frequency 15 minutes is suggested. For dual frequency, only a few minutes will work. To lessen the likelihood of having to re-observe a point, extend the time. Time should be increased with baseline lengths for both single and dual frequency. See *Section 2.4.7,* on *Page 46* for important information regarding the processing of static sessions.
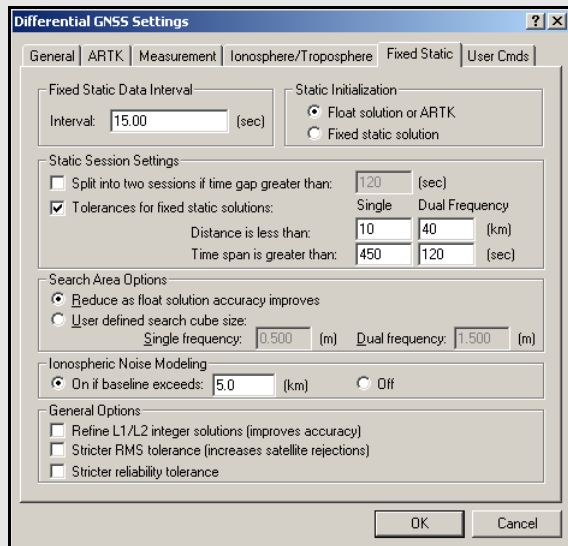
Search Area Option settings

Reduce as float solution accuracy improves
An auto-reducing or adaptive search area is helpful for situations where the fixed solution is failing the reliability tests. Normally, this would be the case on short baselines with single frequency measurements.

User defined search cube size
A user defined search area is not often used. But if the float solution is known to converge very close to the correct solution, then enter zero here.

Ionospheric Noise Modeling settings

On if baseline exceeds
Corrects for the ionosphere if the baseline exceeds the specified length.

Off
Use this option to disable the use of L2 for ionosphere corrections.

General Options

Refine L1/L2 integer solutions
This setting gets more accurate integer fixes but be aware that it can occasionally hurt the solution.

Stricter RMS tolerance
This option applies a stricter tolerance to the RMS value of the best intersection.

Stricter reliability tolerance
The reliability is the ratio of the carrier RMS values between the second-best and best intersections. Enabling this option applies a more stringent tolerance.

Search Area Options
The search region size can be controlled with the options listed in the shaded box.

Ionospheric Noise Modeling
The ionospheric noise model controls how the L2 measurements are treated in the fixed solution. Due to anti-spoofing, L2 can be noisier than L1. So, on shorter baselines, a noise model placing more weight on L1can deliver better results. These options are listed in the shaded box.

General Options
These options are listed in the shaded box.

User Cmds

This changes any command that is passed to GrafNav. It can be used to change commands that are set by the other option tabs, or set commands that are not handled by the other option tabs. See *Appendix A Page 211* for a list of commands.

When a configuration file is loaded, all commands that are not handled by the other option tabs appear here. This includes commands that are not supported in the version of GrafNav being used that can easily be deleted here.

⊠   PPP commands always start with the prefix "PPP_".

2.5.2 Combine Solutions

This processing combines GrafNav solution files processed in forward and reverse mode to form an optimal solution using variance weighting.

The benefit of combining these solutions is that the overall accuracy is improved because in many cases, one direction is more accurate than the other for a given epoch. This accuracy difference may change during the mission but the weighting function should reflect these accuracy differences.

By combining the forward and reverse solutions, a difference can be computed and plotted. This difference graph, available via the Combined Separation plot under *Output | Plot GPS Data*, gives an indication of solution accuracy and problem areas. However, the actual accuracy is often better because the combining process places more weight on the solution with greater estimated accuracy.

Before this process can be executed, there must be a forward (FWD/FSP) and reverse (REV/RSP) solution file present. A weight between 0 and 100 is assigned to both the forward and reverse solutions. The sum of both equal 100. All three axes (latitude, longitude and height) are assigned the same weighting value. The weight is computed by (1 / variance). Fixed integer positions are weighted much stronger than float solutions.

This process combines trajectory data (for kinematic) and also static sessions if any exist. For static sessions, the best solution may be chosen.

Enable the *Automatically write.CMB file when combining* option under *Settings | Preferences* to automatically create a combined trajectory file (CMB/ CSP).

Combine Settings
These setting are listed in the shaded box.
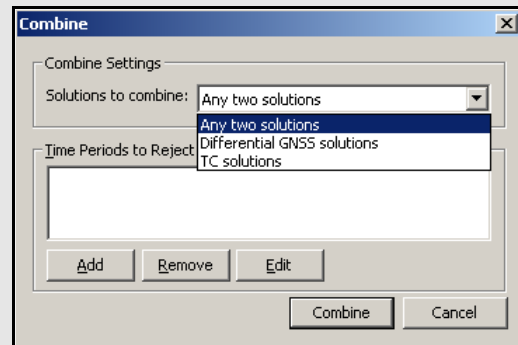
Combine Settings

Any two solutions
This feature allows you to combine any two solutions that contain overlapping data. It is most commonly used to compare solutions obtained from different processing methods. For example, you can use it to compare the differential solution (*.CMB) to the PPP solution (*.CSP). NovAtel customers can also use it to compare the post-processed solution to the real-time solution (if the appropriate data record was logged)**.**

> ⊠ In order for a combination to be valid, the solutions must be computed from data that was collected at the same time, using the same antennas and the same receivers.

Differential GNSS Solutions
This option is only available if you have already successfully processed the current project in differential mode. In this case, it will combine the forward (*.FWD) and reverse (*.REV) solutions.

PPP Solutions
This option is only available if you have already successively processed a PPP solution for the current project. In this case, it will combine the forward (*.FSP) and reverse (*.RSP) solutions.

Time periods to reject
This feature rejects certain time intervals of the forward or reverse solution so that areas with bad results are not included into the combined solution.

Click on the *Add* button to enter the times to exclude the forward or reverse solution from the combination.
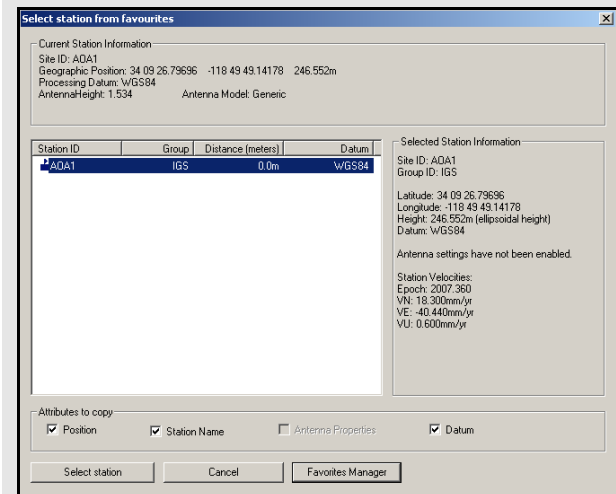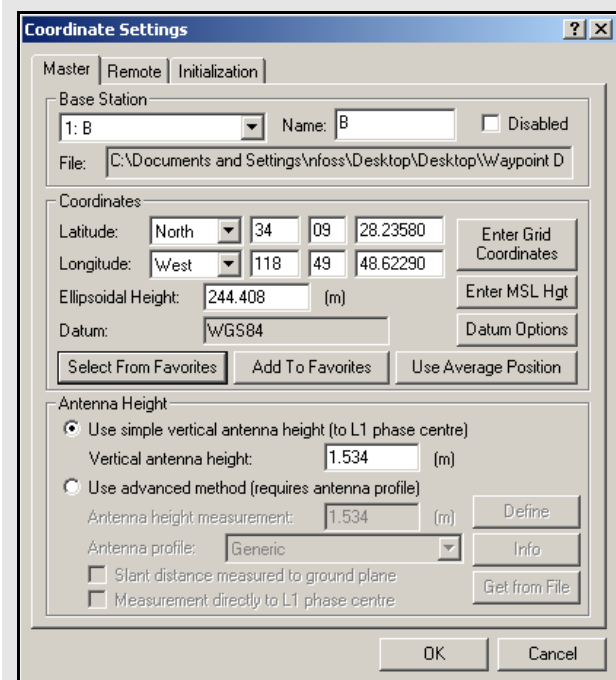
Select From Favorites

Allows you to easily find any pre-loaded station information. This feature searches through the Favorites Manager to find all stations within 5km of the input coordinates. This large search radius allows for the use of approximate coordinates as a search input. The window that appears lists all stations in order of proximity. When a station is chosen, the corresponding information is displayed in the *Selected Station Information* window on the right-hand side. Under the *Attributes to copy*, you can specify which

2.6 Settings Menu

2.6.1 Coordinate/Antenna

Master Station Settings

This option lets you modify the master station coordinates. See *Section 2.3.6,* on *Page 28* for more information of the settings available.

Remote Settings

This option lets you customize the remote's antenna information. See *Section 2.3.7,* on *Page 29* for additional information.
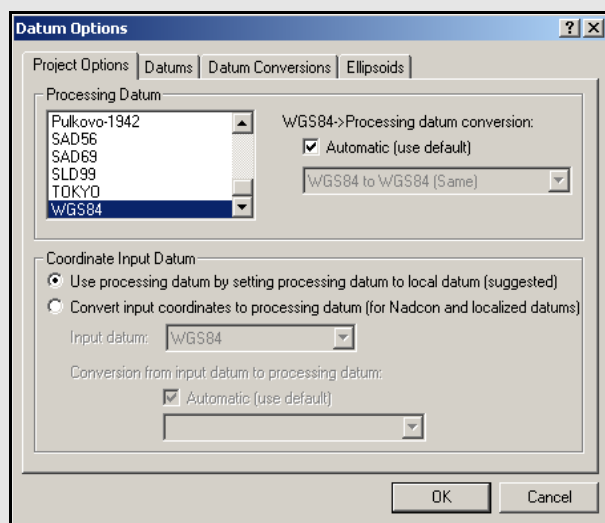
Reasons to use coordinate input datum

A grid style, like NADCON, conversion is used to transform between datums. Such a transformation does not convert satellites because they are often outside of the boundaries.

The datum conversion is heavily localized. This means that it may have very large rotation values and its transformation is only valid over a small area, like a city or state. Similar to NADCON, a you would not want to convert satellite coordinates using this transformation.

✉ Currently, only the *Export Wizard* supports datum transformations. Be cautious with datum conversions, as their accuracy can always be suspect.

2.6.2 Datum

These settings can also be accessed under the *Tools* Menu through the *Datum Manager*, which has additional coordinate transformation capabilities.

Project Options

Processing Datum

The datum selected here is the one that the data is processed in. This means that the software will convert the satellite coordinates into this datum. The easiest procedure is to select the local datum from the list of datums. If it is not available, then select the *Datums* tab and enable the datum. If the desired datum does not exist, then add a datum and a conversion.

> ***WGS84 Processing datum conversion***
> This setting specifies the set of transformation parameters used to convert between datums. Enabling *Automatic* chooses the default datum conversion. A different datum conversion can be made the default by selecting the *Datum Conversions* tab. Otherwise, disabling *Automatic* allows you to select a datum conversion more appropriate for a given area. The accuracy of the datum conversion becomes more important with increasing baseline length. You can change the default conversion between datums with the *Tools | Datum Manager*.

Coordinate Input Datum

Use this setting to process in a more global datum, like WGS84, while entering the base coordinates in the local datum, like NAD27. The reasons to do this are listed in the shaded box.

To enter coordinates in a different datum than the processing datum, *Convert input coordinates to processing datum* must be enabled. In this case, the datum conversion becomes very important.

✉   It important that the same conversion is used to transform the output back into that datum. Otherwise, a datum error of several meters may be induced on the final coordinates.

Datums

This feature allows you to enable or disable datums. While there are over 100 datums in the list, only a few are enabled. This makes it easier to find a datum, because some are far more commonly used than others. New datums can also be added via the *Add* button. If a new datum is added, be sure to add a conversion as well.

Datum Conversions

This tab allows you to inspect, edit or add conversions between datums. Normally, conversions are from/to WGS84, although conversions between any two datums can be added. This tab can also be used to make a particular conversion the default conversion between a given datum pair.

Ellipsoids

This page allows you to inspect the *a*, *b* or *1/f* values for a particular ellipsoid. You can also add new ellipsoids, although most of the world's ellipsoids should already be present.

2.6.3   Grid

GrafNav projects store grid information. Set up a grid for the following reasons:

- Master coordinates can be entered directly in a grid system. This may be very convenient if data sheets do not give geographic coordinates.

- The *Map Window* can plot in grid coordinates. See *Section 2.7.10,* on *Page 93* for more details.

- DXF output uses these grid settings. See *Section 2.7.11,* on *Page 94* for more information.

- *Export Wizard* can use a defined grid for coordinate output. See *Section 2.7.4,* on *Page 80* for details.

New grid definitions can be added by clicking *Define Grid* or via *Tools | Grid/Map Projections | Define*. See *Section 2.8.7,* on *Page 100* for more information.
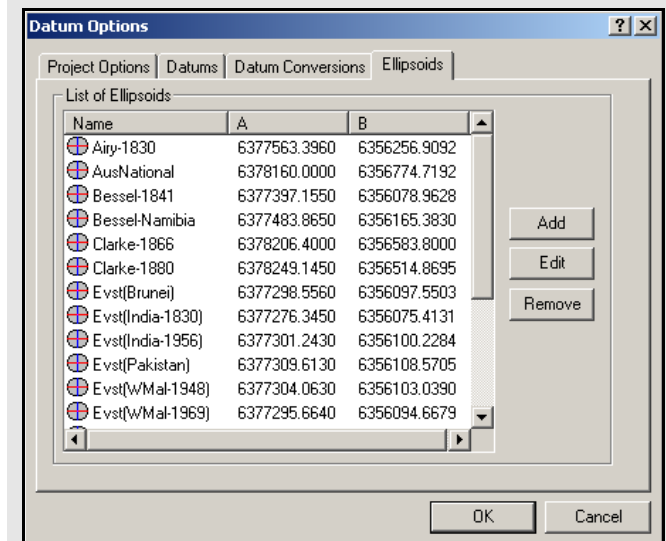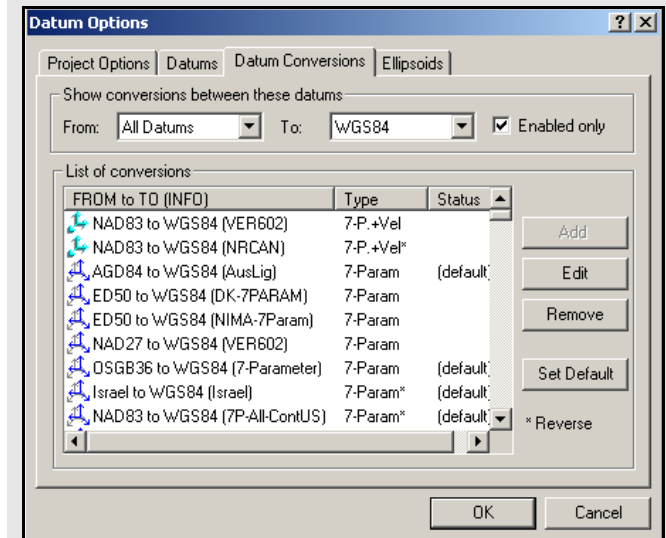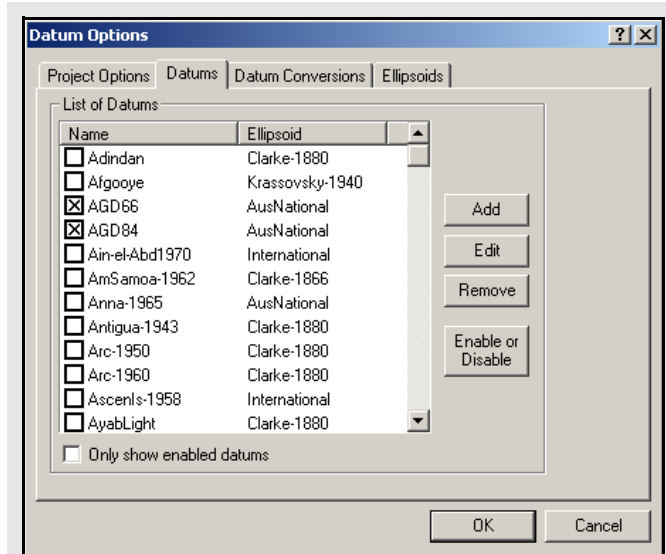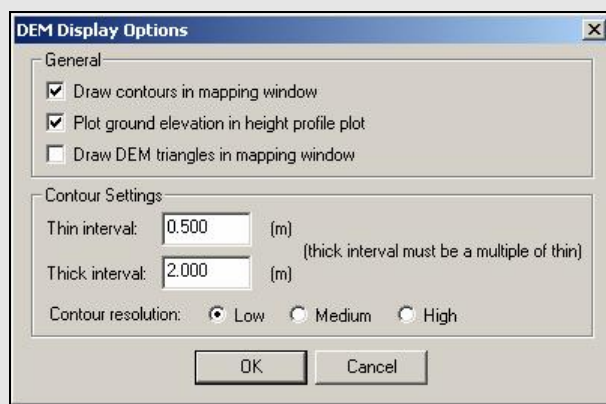
2.6.4 DEM Plotting

Using the DEM plotting options speeds up issues concerning the use of large DEMs.

General

> *Drawing contours in the Map Window*
> This shows up with the trajectory to display a topographic representation of the GPS survey. Zoom in to view the elevation of each contour.

> *Plotting the ground elevation in the height profile plot*
> Compares the ground height to the height of their trajectory. Sometimes the ground height slows down the plotting of the height profile. Turing this off allows you to only view the height of the trajectory.

> *Drawing the DEM triangles*
> Displays the TIN model of the network formed. Turning these options off reduces any sluggish response from the program when viewing the *Map Window*.

Contour Settings
You can also control the interval of the contour elevations by entering the thick and thin line intervals.

⊠   The thick interval must be a multiple of the thin.

Contour resolution
Selecting a higher resolution shows more smoothness in the contour lines and gives more details. It might also slow down CPU response and use more RAM. Having a lower contour resolution speeds up the response from GrafNav.

2.6.5   Manage Profiles

Project /Profile Tools

New from Project
Creates new CFG profile using the current project's settings.

Load into Project
Same as *Load Settings From* under *Settings* menu. This option loads the settings from the selected profile into the current project.

Update with Project
Updates the CFG profile with the current project settings.

CFG Profile Tools

Edit GNSS/PPP/IMU
Brings up the processing settings menu to allow the selected CFG profile to be modified.

Rename
Allows profile to be renamed.

Delete
Deletes the selected profile.

Copy
Creates a copy of the currently selected profile.

⊠   Modifications to pre-loaded settings are lost if software is re-installed.

2.6.6 Compare Configuration Files

This feature allows you to make a direct comparison between the settings in two different configuration files. This utility scans both of the specified CFG files and creates a report outlining all the differences found. For each setting found to be different between the two files, the report displays the values from both CFG files used for that particular setting. A total count of the number of differences appears at the bottom of the report.
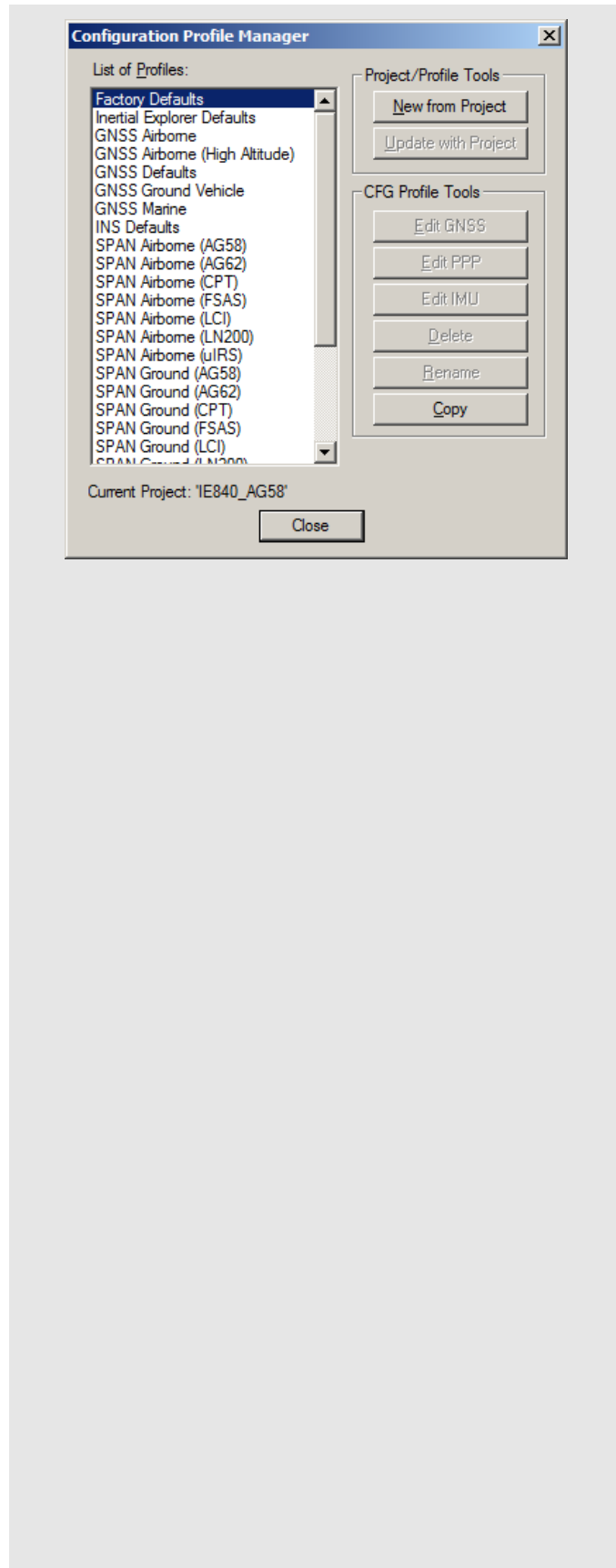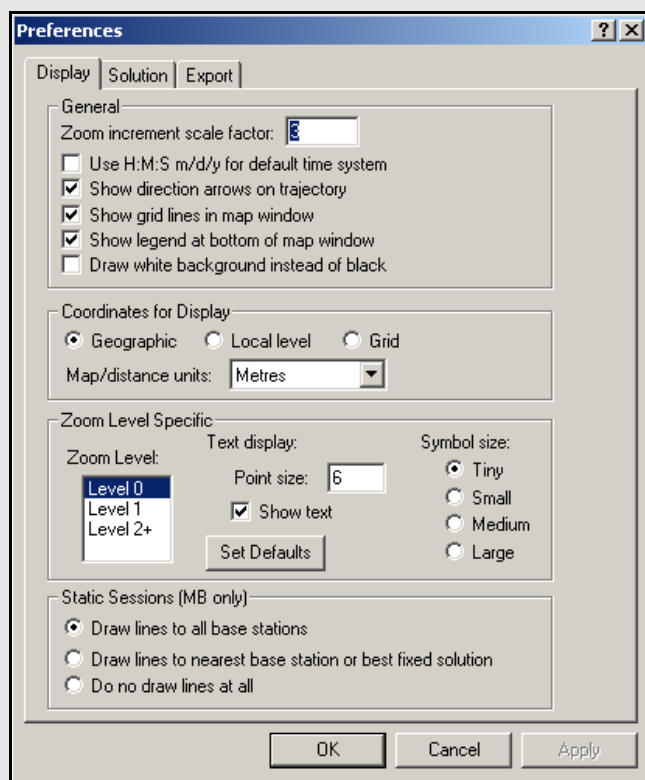
Coordinates for Display

Geographic
Displays the latitude and longitude on the screen. The orientation is such that the positive y-axis is true north.

Local level
Shows the vector difference between the master and remote. It is only available for GrafMov where you can see the relative separation rather than the absolute position, which tends to be less meaningful.

Grid
Displays the coordinates in the grid selected under *Settings | Grid*.

⊠ The UTM zone has not been set. In such a case, the display may be severely rotated. Be sure to set the zone correctly. See *Section 2.6.2,* on *Page 65* for help.

Map/distance units
Changes the units of the values being displayed for local level or grid coordinates in the *Map Window.* Changes the units displayed when using the *Distance & Azimuth* tool as well. See *Section 2.8.2,* on *Page 96* for information.

2.6.7 Preferences

Display
This option allows you to edit the *Map Window* display and other preferences.

General
The following settings are available:

> #### Zoom increment scale factor
> The default is 3, although you can change this to any positive integer.
>
> #### Show direction arrows on trajectory
> Shows arrows in the direction of travel on the map screen.
>
> #### Show grid lines in map window
> Displays grid lines.
>
> #### Show legend at bottom of map window
> Toggles the display of the color-coded quality numbers legend.
>
> #### Draw White background instead of black
> Changes the background colour of the Map Window from black to white.

Coordinates for Display
The settings are listed in the shaded box.

Zoom Level Specific
This set of options is based on the *Zoom Level* specified.

> #### Zoom Level
> **Level 0** is the main screen without being zoomed. Each level has its own set of default display options that can be changed to your preferences.
>
> #### Text Display
> Controls the font size. The *Show Text* option allows text to be seen on the screen.
>
> #### Symbol Size
> Controls the symbol display.

Static Sessions (MB only)
You can choose whether to plot the static session lines to all base stations, to the nearest base station, or not to draw any lines at all.

Solution

Combine Settings

The following settings are available:

> ***Automatically load solution on project start***
> Loads the FWD and REV files into the project once a CFG file is opened.
>
> ***Automatically write .CMB file after processing***
> Writes a CMB file after processing.
>
> ⊠   This slows down the CPU response after processing if a large project has been processed.

Processing

Enhanced processing is available with dual processors. The options are listed in the shaded box.

Verbose messaging mode

Enabling this option will result in more messages being written to the processing windows when data is being processed. If disabled, only the messages deemed important will be displayed. It should be noted that all messages will be written to the Message Log files regardless of this setting.

Enable processing profile detection

During the conversion of raw GNSS data to GPB, you have the option of having pre-processing checks performed. One of these checks includes trying to determine what type of application/environment the data was collected in. When this option is enabled, the software will use this information to automatically select the best processing profile. The profile can be overridden regardless of this setting.

Float Static Tolerance

Allows you to configure the equation used to determine whether a float static solution passes or fails. If you are a Seismic use, you might want to raise this tolerance to limit the number of failing sessions.
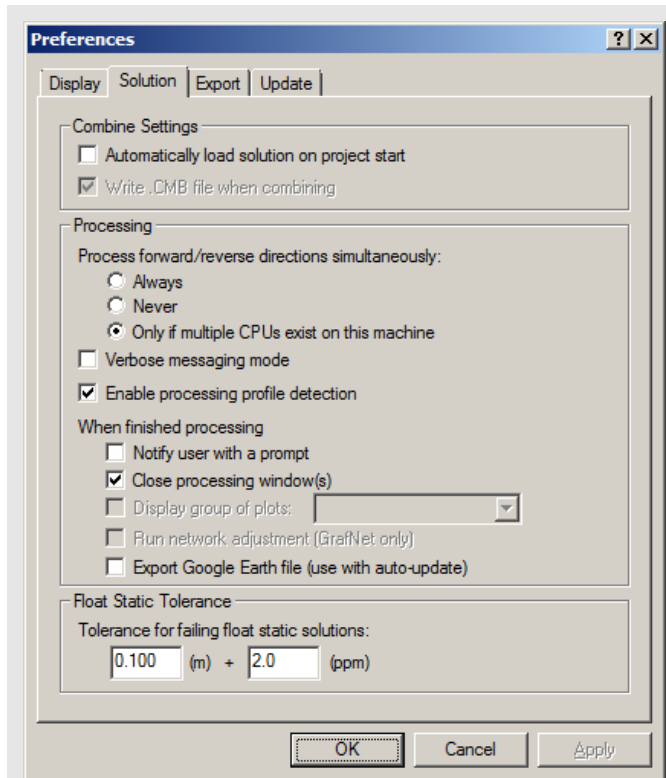
Processing Options

Process forward/reverse directions simultaneously
This feature cuts dual CPU processing time in half and improves dual core machine processing by roughly 20-30% because the software processes the forward and reverse directions at the same time. With one processor, avoid using this option because it is faster to process each direction sequentially.

> When finished processing

Notify user with a prompt: Displays a message at the center of the screen once processing is complete. When disabled, you will hear a beep after processing, unless an error occurs.

Close processing window(s): Closes all processing windows after completion.

Display group of plots: If you have defined a group of plots under *Output | Plot Results*, then you may select it here for automatic display. See *Section 2.7.1,* on *Page 73* for help creating a group of plots.

Export Google Earth file: The software writes a KML/KMZ file to the *HTML* folder, which is located in the project folder. If the *Output | Export to Google Earth | Create Auto-Update Entry* option has been used, then Google Earth updates the new trajectory.

Export

Hold epochs and events to ground
This option plots the trajectory on the ground in Google Earth. This option is recommended for ground surveys.

Limit epoch output to interval
You can reduce the density of the output trajectory by specifying an interval here. This helps reduce file size and loading times in Google Earth.

Compress KML to KMZ file
Due to their ASCII nature, KML files can be quite large. The KMZ format allows for a much smaller file without losing any information.

Optimize output for trajectory comparison in GE
By default, the software overwrites the same project KML/KMZ file, while using the Quality Number to determine the color of the epochs used for display purposes. However, if you wish to compare multiple solutions for the same trajectory, enable this option to ensure that a new output file is written. To make it easier to distinguish between each solution in Google Earth, each new output file will be assigned its own specific colour. That is, the Quality Number is ignored. In addition, a new folder is created if the *Run* descriptor has changed.

Use concise epoch description for lower memory usage
The default output files written by the software contain a lot of additional information, which can really slow down Google Earth. If this information is not needed in the output file, a more concise output file can be written.

Output MSL height for better compatibility with GE elevation data, using
Google Earth is expecting orthometric (mean-sea-level, MSL) height values. As such, if *Hold epochs and events to ground* is disabled, the plotted height may be below ground level (if the geoid undulation is negative) and the object is at ground level. Use the *Browse* button to locate the Waypoint Geoid (WPG) file. Other geoid formats are not supported. The EGM96 geoid, which covers the entire world, has sufficient accuracy for this purpose.

Maximum Memory Allocation for Plotting/Export Wizard

Change Memory Allocation

The software allocates memory up to the specified maximum based on the number of epochs in the project. This value is dependent on the length of the data collection as well as the data rate. If the software cannot allocate enough memory to accomodate the entire trajectory, it pages to disk when plotting or exporting and may degrade performance. Do not lower this value unless your computer lacks memory.
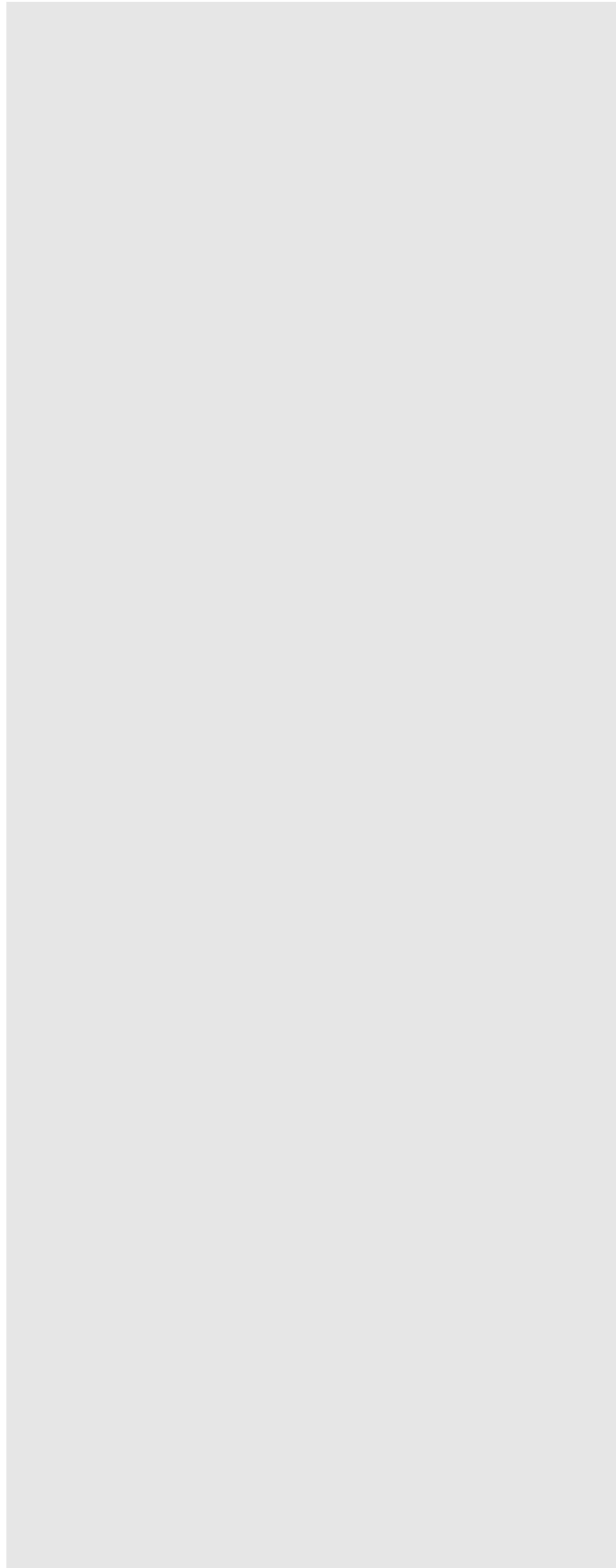
2.7 Output Menu

2.7.1 Plot Results

This feature is very useful for analyzing GNSS data and processed results. The plots are divided into eight groups, and the *Build Custom List* button allows you to form their own list of plots that will show up under the *Custom* group.

Along with selecting the plot type, you can define *X-Axis* and *Y-Axis* information. Changes made to these pages are retained for future plots. For example, if a time range is entered in the *X-Axis*, the same time range is used for future plots in this project. This is very useful for inspecting a narrow time slice. You can still make changes to axes information after the plot has been displayed by right-clicking on the plot.

If you want to change plot units, use the *Y-axis* tab. The units available depend on the plot that is selected under the *Select Plot* tab. The units must be set before you open the plot. If features are loaded, then vertical red bars appear along the top of the plot. Click the feature to show solution status information.

Add Group
Defines a set of plots for easy viewing access. Once a group has been created, it appears under the *Grouped Plots* branch on the main window. This facilitates the task of opening plots for those users who are continually analyzing the same ones after every run of processing. Any user-defined group of plots can also be automatically opened after completion of processing via *Settings | Preferences*. See *Section 2.6.7,* on *Page 69* .

The following plot features are available by right-clicking on the plots:

Properties
Allows access to many settings, like X and Y axes ranges and the display format for the latter. The plot titles, along with the X and Y axes labels, can all be edited here. Other options regarding the displaying of camera marks and the usage of thick plotting lines are available too.

X -Axis (Time)...
The option are listed in the shaded box.

Y-Axis (Value)...
The option are listed in the shaded box.

Copy
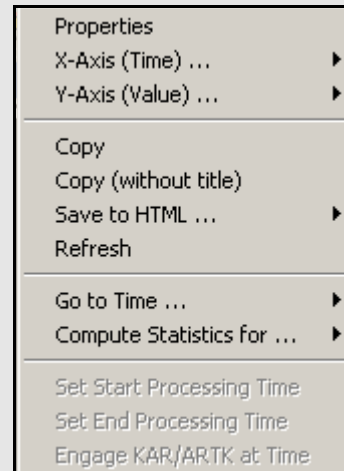
X -Axis (Time)...

Select X-Range
Previously used settings of the X-axis are stored here.

Apply to All
Scales the X axis of the other opened plots to facilitate analysis.

Auto-scale
Shows the entire time range of the data.

Set Minimum
Makes the current time the X-axis minimum.

Set Maximum
Makes the current time the X-axis maximum.

Y-Axis (Value)...

Select Y-Range
Previously used settings of the time range are stored here.

Apply to All
Scales the Y axis of the other opened plots to facilitate analysis.

⊠ In order to apply the Y axis to all plots, the maximum and minimum values must be manually specified, that is, not auto-scaled.

Auto-scale
Shows the entire value range of the data.

Set Minimum
Makes the current time the X-axis minimum.

Set Maximum
Makes the current value the Y-axis maximum.

Copies the plot onto the clipboard as a bitmap (BMP), allowing you to paste the image into other application such as MS Word or Paint.
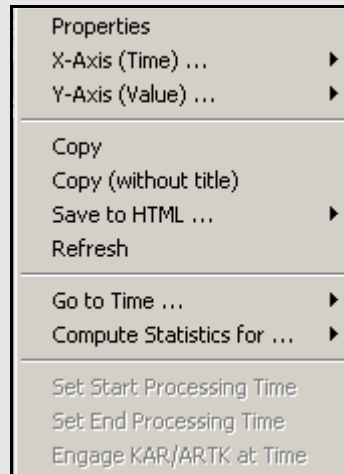
Copy (without title)
Copies the plot onto the clipboard as a bitmap (BMP) without the plot title.

Save to HTML
Copies a BMP version of the plot into an HTML file, which opens upon completion. The HTML and BMP files are saved to the project folder under a directory called *HTML*.

Refresh
Reloads the selected plot.

Go to Time…
Gives you the option of finding the nearest available time in the forward or reverse message logs, or finding the nearest epoch on the *Map Window*.

Compute Statistics for…
Calculates many useful statistics for either the entire valid processed time range, or, if it has been adjusted, only the time range being plotted. Statistics include RMS, average, maximum and minimum. Note that this feature is only available for appropriate plots.

Set Start Processing Time
Makes the selected time the start time for processing.

Set End Processing Time
Makes the selected time the end time for processing.

Engage ARTK at Time
Engages ARTK at the selected time.

Common Plots

Table 4 contains a list of common plots that are available through the *Plot GPS* window.

Table 4: Common Plots

Plot	Description
Accuracy	
Estimated Position Accuracy	Plots the standard deviations of the east, north and up directions versus time for the solution. The total standard deviation with a distance dependent component is also plotted. View this plot for individual forward or reverse solutions and losses of lock.
Estimated Velocity Accuracy	Velocity is the local level component (easting, northing, up) computed by the Kalman filter. These are mostly derived from the Doppler measurements. Plotting the Doppler RMS is a good way to check the actual accuracy based on real data. Plotting the estimated standard deviation shows the theoretical accuracy based on the Kalman filter error estimates.
Measurement	
RMS – C/A Code	Plots the root mean square combination of the code residuals. This is a good indicator of receiver code measurement accuracy and of multi-path for carrier phase processing. Large jumps can be induced by missed carrier phase cycle slips.
RMS – Carrier Phase	Plots the root mean square of the L1 phase or L1/L2 iono-free phase combination residuals. This is a good indicator of carrier phase measurement accuracy. If the signal is affected by the ionosphere and other error sources, the RMS will be greater than the few centimeter range and can be as large as 10 cm or more for single frequency. Since the code and carrier phase are combined, some noise from the C/A code can seep into the carrier phase.
RMS-L1 Doppler	The Doppler is used for velocity determination. When using GrafNav in conjunction with inertial (INS) integration, pay close attention to this plot. It gives a good indication of what standard deviation to give velocity data in the inertial Kalman filter.
RMS-P2 Code	If the option *Use P-Code in Kalman Filter* is enabled, then this feature can be used to plot the P-Code RMS. See *Fixed Static* on *page 61* for information.
Satellite Lock – Cycle Slips	Use this plot to view the quality of the data contained in a GPB file. The plot shows four data characteristics including the following: • The cycle slips in the data for each satellite, indicated by vertical bars. This information is useful for detecting poor tracking. • The available time range for each satellite in the GPB file. • The third characteristic shown is the elevation angle for each of the satellites. The different colours represent different elevation ranges. • The final characteristic shown is data that will not be used for processing as the options stand, shown in red. This means that either the C/A range or phase data (L1 or L2) is invalid, or the locktime of the satellite is less than the locktime cut-off. Black lines indicate missing ephemerides.
Individual Satellite Statistics	Shows satellite code residuals, phase residuals, elevation angles and C/NO values for individual PRNs.

Table 4: Common Plots cont.

Plot	Description
Separation	
Combined Separation	Requires forward and reverse solutions to be combined and displays the difference between the two trajectories.
Combined Separation with Fixed Ambiguity	Displays the separation between forward and reverse solutions only where they are both fixed. This plot is useful to find incorrect ARTK fixes.
Combined Number of Solutions	Shows the number of baselines that are used to form a combined baseline. This is useful for multi-base processing.
Quality Control	
PDOP	Indicates satellite geometry relating to position. Small values indicate better geometry. These values should be similar to other PDOP computations, but differences can be visible due to different base satellite selection (double differencing).
DOP-DD_DOP	Indicates satellite geometry relating to position. Small values indicate better geometry. This value is the double difference DOP and is approximately PDOP, it can be lowered due to the differential modeling. The DD_DOP is used for all internal checks and DOP related options in the software. Epochs with extremely poor DD_DOP (>100) are skipped and are not plotted.
Float/Fixed Ambiguity Status	This plot shows whether an epoch has a fixed or float ambiguity status. Fixed integer ambiguities generally have better accuracies. This plot also shows if there are zero, one or more fixed ambiguities used to determine a combined solution.
Number of Satellites (BAR)	Number of satellites for epochs. This plot gives an overview of how many satellites there are. Use this graph for large data sets because it shows every time the number of satellites drops to a minimum. Epochs with less than 4 satellites are not displayed.
Number of Satellites (LINE)	This plot shows the number of GPS, GLONASS and total satellites. Epochs with less than 4 satellites are not displayed. This plot contains more information than the bar plot.
File Data Coverage	This plot shows if and when GPB files are static and kinematic. It can overlay multiple GPB files to see if they overlap in time and to indicate weak periods of the data that could result in a loss of lock. Since it does not examine processed data, this plot is not as reliable as other indicators. If you have Inertial Explorer, you can plot IMU coverage and use this plot to show IMU data time gaps.

Continued on the following page.

Table 4:Common Plots cont.

Plot	Description
Quality Control	
Satellite Sky Plot	This plot is centered at the receiver and displays satellite elevation and azimuth. The time-line at the bottom can be used to "replay" the movement of the constellation.
Trajectory Status	For NovAtel receivers only. Displays the status flag from the real-time logs (as found in the FSP file created during raw data conversion). Refer to the NovAtel receiver manual for information regarding the status flags.
Coordinate Values	
Distance Separation	This plot shows the distance between the master and remote in kilometers. For multi-base distance separation, See the multi-base plotting tools.
Height Profile	Height over the processing time period. This can be a very good quality control measure in areas where the height is very stable.
Static Session Convergence	This plot assumes that the last epoch in the static session is the correct one. A float solution convergence plot is then formed. This gives an indicator of how well a static solution is stabilizing.
Velocity Profile	Plot shows north, east and up velocities, which can be used to determine when the antenna is moving. This plot also shows horizontal speed.
Acceleration Profile	This plot shows the approximate acceleration computed by the baseline processor. For this plot to be shown, enable the *Extended* trajectory output.
Height Above Ground	This plot is to be used in conjunction with a DEM to display the remote's height above the ground.
Local Level Vector	This is the vector between base and remote centered about the main base station. It is useful for moving baseline processing. For absolute positioning applications, the distance separation combined with the height profile is usually a better diagnostic tool.
Miscellaneous	
Estimated Clock Accuracy	This plot shows the estimated standard deviation computed by the least-squares single point processor. In general, it matches position accuracies.
GPS/GLONASS Time Offset	The time offset shown here is the computed difference between the GPS system time and the GLONASS system time.
Receiver Clock Offset	The single point processor computes a clock correction on an epoch-by-epoch basis. This value is the difference between the receiver's clock and the GPS time system. For some applications, you may wish to plot and monitor this value.
User Selected File - Plot data from	This feature can be used to plot data from a comma or space separated file. This spares you from having to use a program such as Microsoft Excel or MatLab to plot the data. It can also be used to plot the results of the Compare utility.
Tropospheric Bias Estimate	Plots the tropospheric correction value as determined by the Kalman filter

Table 5: Multi-base Plots

Plot	Description
Measurement	
C/A Code Residual RMS and Weighting	Shows root mean square (RMS) of C/A code residuals for each baseline. The measurement standard deviations are also plotted on the same (or separate plot). This plot is useful for identifying if one base station has better or worse code residuals than another.
Carrier Phase Residual RMS and Weighting	Shows the carrier RMS for each baseline. Viewing this separated value is better than the combined value shown from the RMS Carrier Phase plot. This plot shows incorrect base station coordinates.
Doppler Residual RMS and Weighting	If you require accurate velocity, use this plot to identify problematic Doppler data from one of the base stations.
Distance to Base Stations	Shows the difference between the masters and remote in kilometers. There is a separate line plotted for each baseline.
Separation	
Carrier Separation	Large base station position errors can be observed here. this is also an effective way of spotting poor quality code measurements from one of the bases. Consider using larger standard deviations for this problematic base.
Code Separation	The Doppler is used for velocity determination. When using GrafNav in conjunction with inertial (INS) integration, pay close attention to this plot. It gives a good indication of what standard deviation to give velocity data in the inertial Kalman filter.
Effective Baseline Weighting	Indicates the approximate percentage weighting that could be assigned to each baseline if a linear combination were used. It can be a helpful indicator.
Quality Control	
DD_DOP	Indicates satellite geometry relating to position for each baseline. Ideally, each baseline should have similar values. Differences can be due to a different base station or the tracking of a different number of satellites.
PDOP,HDOP, VDOP	Indicates satellite geometry relating to position. Small values indicate better geometry. Lines are displayed for position DOP (PDOP), horizontal position DOP (HDOP) and vertical position DOP (VDOP). These values should be similar to other PDOP computations, but differences can be visible due to different base satellite selection (double differencing).
Number of Satellites	Displays a line graph of the number of satellites for each baseline. Epochs with less than 4 satellites are not displayed. Gives an overview of how many satellites are visible from each baseline.
Number of Baselines	Shows the number of base stations uses for processing each epoch. It is an important means of assessing if certain bases are being rejected or not lined up during processing.

2.7.2 Plot Multi-Base

If you process more than one baseline, additional plotting tools display measurements and separations of multi-baselines. This tool plots values present in the FBV and RBV files. *Table 5* contains a list of the plots available for multi-base processing projects.

2.7.3 Plot Master /Remote Satellite Lock

This option displays the *Satellite Lock –Cycle Slips* plot for all the master and remote files in the project. See *Common Plots* on *page 76* for more information regarding this plot.

2.7.4 Export Wizard

The *Export Wizard* allows you to customize the output text format to suit your needs. It also has more features for controlling offsets, datums and corrections than the *Write Coordinates* method for exporting coordinates. You can select from 150+ data variables reproduce an existing format or create your own with exactly the information that you need.

Export coordinates Wizard

The *Export Wizard* features a user-friendly graphical interface that create different output profiles. Export profiles can be moved from one machine to another by copying the PRF files to the installation directory for the software. This means that profiles need only be created once.

Define Profile

Source Variables
All of the output variables are categorized. This pull-down menu allows you to switch between the categories, whose variables are then displayed in the window.

> *Add*
> Adds the selected variable to the end of the *Export Variables* list.

> *Insert*
> Insert the selected variable above the one selected in the *Export Variables* list.

> *Info*
> Gives a brief description of the selected variable.

Export Variables
The variables listed in this window are included in the output files that are created using this profile.

> *Remove*
> Remove any variables from the list.

> *Format*
> Customizes the output settings of the selected variable including the fixed width, the number of decimal places and the justification.

> *Info*
> Gives a brief description of the variable. The order in which the variables are outputted can be changed via the *Up* and *Down* buttons.
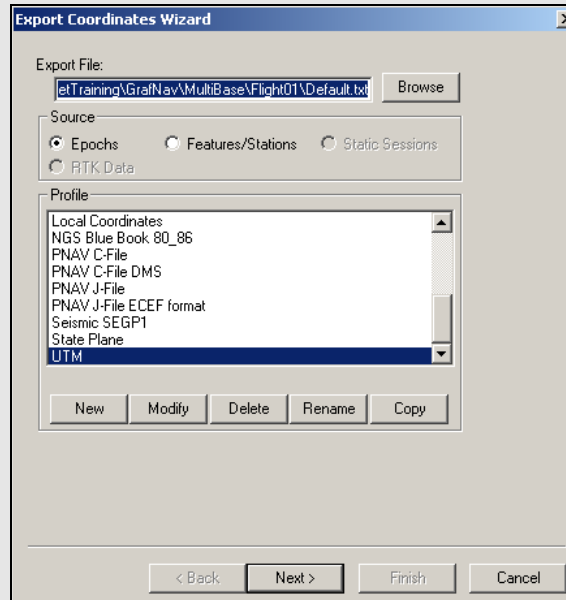
How to create a customized output file

1. Click the *New* button and type in a unique name for the profile.

2. In the *Define Profile* window, highlight the desired variable and either click *Add to* add to bottom of list or *Insert* to add the variable above highlighted variable in list. See *Table 1* on *Page 211* for a list of variables available for output.

3. Once you are finished adding all the necessary components of the profile, click *OK* to save the profile.

4. in the output file.
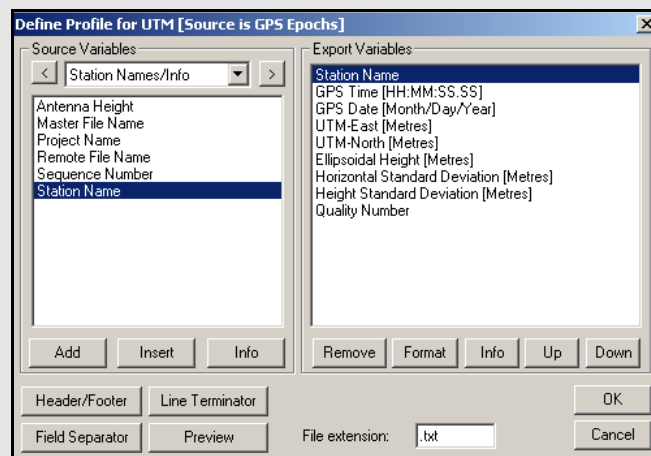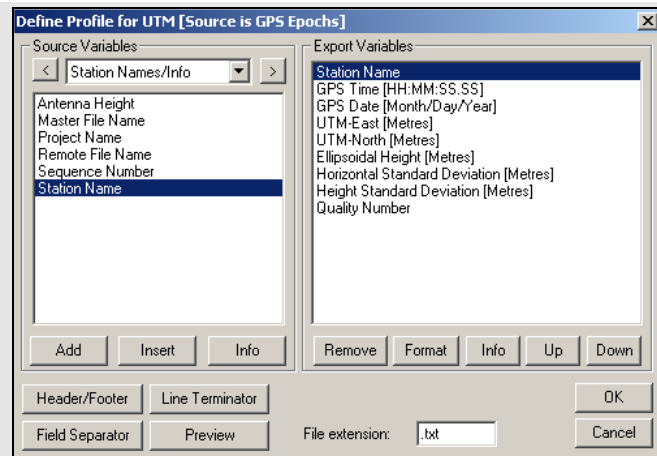
Header/Footer

The following settings are available for the header:

File
Allows you to select a file that is inserted at the top of the output file as a header.

Datum, Geoid and Projection Information
Inserts details about the datums, geoid, and projections used to create the desired output. Lists the coordinates of the master station as well.

Column Variable Contents, Units and Description
Inserts an information record for each variable selected. It shows the column header including variable name, units and a description.

String
Adds a string of user-defined text.

Variable/Field Titles
Allows *Export Wizard* to adjust the titles in field width, while also allowing the use of special characters.

Variable/Field Units
Allows *Export Wizard* to adjust the units in field width.

The following settings are available for the footer:

String
Inserts a user-defined string immediately after the data output.

Errors and warnings encountered
Adds error and warning messages to the end of the data output to alert you of any problems.

Processing summary information
Shows the summary file found under *View | Processing Summary*. See *Section 2.4.5,* on *Page 43* for more details.

File
Allows you to select a file to be added to the end of the output file.

Line Termination
Allows you to choose how to change the line termination of each record written to the file.

Field Separator
Allows for the selection of the character to be used to separate each variable in a record

Preview
Displays what the output file will look like with the current settings.

If you want to create your own export profile, you should keep the tips in the shaded box in mind.

Tips for creating an export profile

- To create a profile that does not have spaces between variable entries and the record based on column width, follow these steps:

    1. Go to the *Define Profile* window

    2. Click the *Field Separator* button

    3. Select *None* under *Separation Character* to remove any field separators in the file.

✉ The same procedure can be used to have the output be space or comma delimited.

- To change the file by adding a header/footer of a specific format, the *Header/Footer* button in the *Define Profile* window allows you to add headers/footers from a predefined text file. If specific characters are needed to designate the start and end of a text file, strings of characters can also be added to the beginning and end of the file.

- For formats that require no decimal points to be shown in the file, like SEGP1 and Blue Book, the decimal points can be removed by going into the chosen variable, clicking the *Format* button in the *Define Profile* window, and enabling the *Do not print decimal point* option.

- If you need a text string label to designate the type of record being printed/read that is, $--GLL, *81*, open up the *Miscellaneous* variable category and add user *Text String* variable. Change the format of the string by entering the text needed for the label and select the *Fixed Width* option if the format is dependent on column width.

- Review the *Header/Footer* button. You can put in your own header file and display datum/projections information, column descriptions and titles. A special character can also be inserted at the start of each header line making it easier for other software to skip past the header. At the bottom of the file, you can add errors/warnings of any problems that were encountered and processing summary information.

✉ *Table 1* on *Page 211* describes the many variables that you can include your output profiles. Not all variables are available for use with each source.
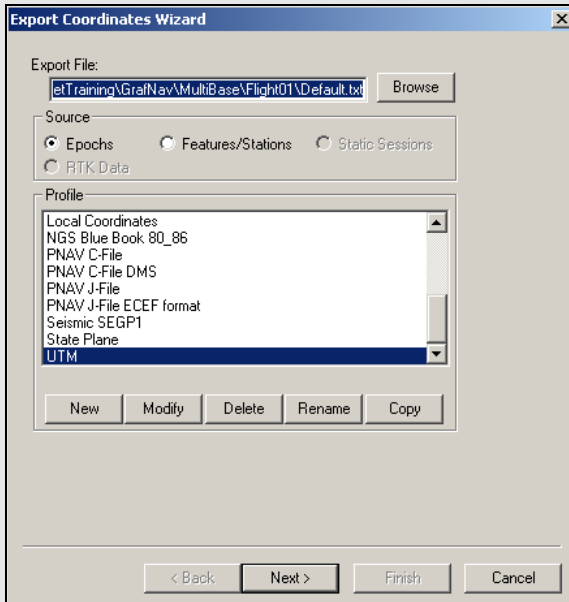
How to create an output file

1. In the *Export Coordinates Wizard* window, type in a name for the output file in the *Export File* field.

2. After a profile has been selected, click *Next* to start creating the output file.

3. Fill in the *Export Wizard* option windows in accordance with the settings needed.

4. Click *Preview t*o view the file before saving it to the file path name specified.

5. Click *Finish* to save the output file to disk.
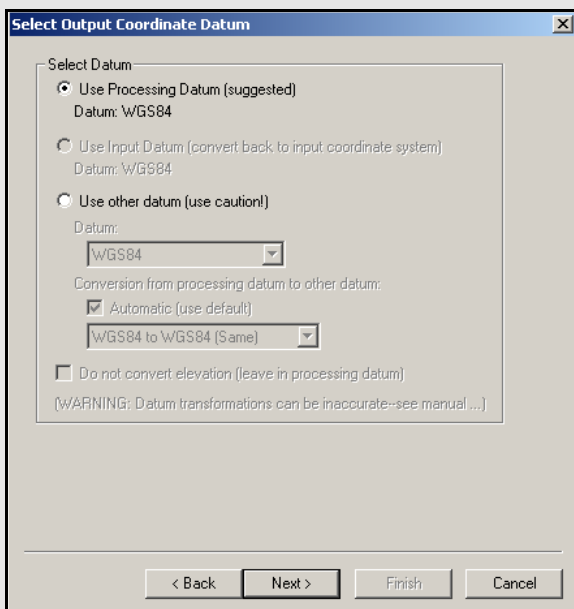
Creating an Output File

To create an output file, follow the instructions in the shaded box.

During the *Export Wizard* process, there are several different windows, depending on the variables present within the selected profile. These windows are described on this page and the following 7 pages.

Select Output Coordinate Datum

This window allows you to select a datum to output the final coordinates. Care should be taken when any datum other than the processing datum is used.

> *Use Input Datum*
> Converts coordinates back into the input datum. This option applies if the input datum is different from the processing datum.

> *Use other datum*
> Converts to a different datum. Be cautious because this results in an absolute conversion and then datum conversion errors may be present in the final coordinate output. Many meters of additional error may result, so be sure to select the closest appropriate conversion. The default *Automatic* conversion selection might not always be best.

> *Do not convert elevation values*
> Applies if the geoid model is meant for the processing datum, but the final horizontal coordinates output is in another datum.

Select Epoch Sampling Model
Prints out the variables for every epoch in the solution file.

> *Reduce to lower sampling rate*
> Prints out the variables for every *Interval* number of seconds at a lower sampling rate For example, every 10th epoch.

> *Interpolate to higher sampling rate*
> Prints out the variables for every *Interval* number of seconds at a higher sampling rate. For example every ½ epoch. This option can also fill in missing epochs where a linear interpolation is used.

> *Use distance dependent sampling*
> Only exports an epoch every *Distance* meters.

Distance and Azimuth Options
> *Horizontal Distance Scale*
> Reduces distances to the ground. For example, you can enter the inverse of the combined scale factor. See *Section 2.8.2,* on *Page 96* .

> *Azimuth Correction*
> Allows you to enter a correction to be applied to the azimuth. In GrafMov, this applies when the two antennas are not perfectly aligned with the longitudinal axis of the body to which they are fixed. Without applying a correction, the output azimuth does not represent the true azimuth of the vehicle.

Select Grid System and Settings

Select Grid to use for Transformation
The *Grid* pull-down menu features most of the commonly used grids and any grids that you have defined. The *Datum* pull-down menu is for reference and cannot be adjusted.

Enter Zone Number
Only for appropriate grids, like UTM and Gauss-Kruger.

Select State Plane Zone
Applies if you choose *US State Plane* as your grid. The zones are listed with name and zone numbers.

⊠ Be sure to include the *Selectable Grid* variables in the export profile.

Transverse Mercator Window

Central Meridian
Defines the central meridian of the Transverse Mercator projection.

Central Meridian Scale Factor
Specifies the scale factor along the central meridian.

False Easting/Northing
If the coordinates in the TM projection are negative values, entering enough large values here forces positive values.

⊠ If a latitude origin exists for the desired Transverse Mercator coordinate system, create a new grid under *Settings | Grid* using the information.

Lambert Conformal Window

Origin
Defines the central meridian and parallel for the Lambert Conformal projection.

Standard Parallels
Specifies which lower and upper parallels are standard and of constant scale factor.

Central meridian scale factor
Initializes the scale factor along the central meridian. This is usually 1.0.

False Easting/Northing
If the coordinates in the Lambert Conformal projection are negative values, the false easting and northing force positive values.

Enter Time Options Window
Use this correction when converting GPS time to UTC time.

This window also sets the time zone offset for local time output. This is the number of hours that the local time is offset from GMT.

Apply 3-D Offset Window
This page appears if camera event marks are exported. It allows you to apply a 3-dimensional offset from the antenna to the measurement device (entry nodal point on aerial camera). The offset is defined in the local body system of the aircraft, and not the camera. The right handed coordinate system is defined in the shaded box.

In order to transform this body from vector to local level, aircraft attitude is required. This is supplied when the camera event marks are imported. If no attitude is present, then the heading is assumed to be the course-over-ground (direction of travel). This can have errors of many degrees due to the aircraft's crab angle. You can also supply a crab/drift angle in the *Feature Editor* using the *Global Edit* button.

⊠   The *Export Wizard* has variables for the offsets after they have been rotated to local level. Export them to check the offset vector.

X-axis - positive axis through the front nose of the aircraft

Y-axis - positive axis through the left wing

Z-axis - positive axis through the roof

⊠   This vector is from camera to antenna, meaning that the Z-axis value is usually positive.
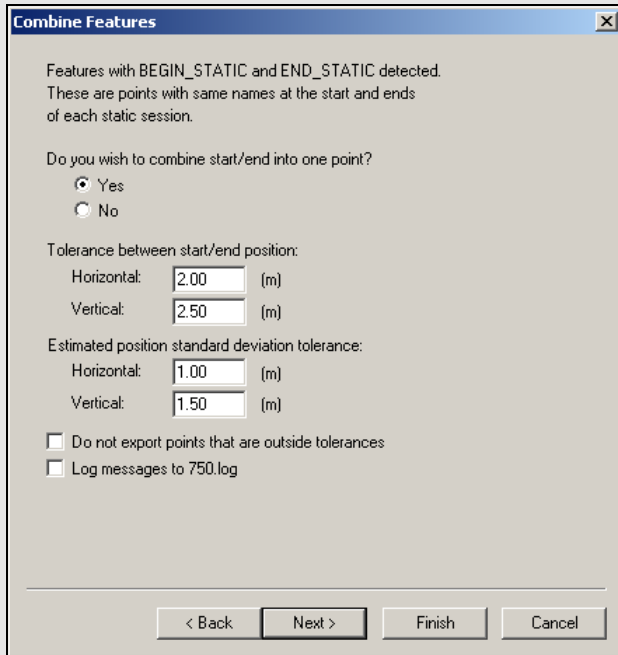
Parameters for combining features

- Select *Features/Stations* as the *Source* from the *Export Coordinates Wizard* window.

- Each static session should have a station at the start and end.

- The remarks field for such stations should be "BEGIN_STATIC" at the start and "END_STATIC" at the end.

⊠ The Ashtech Download decoder automatically inserts these fields if the *Extract station information from Ashtech D-File* setting is used along with the Seismark data collector software.

Features can be moved to static session start and end using the *Move to Static* button in the *Feature Editor*.

Combine Features Window

Use solutions from the start and end of each static period to form a combined solution for data sets with static sessions separated by kinematic. This produces coordinates in a more optimum fashion. For this type of data, it is important to process both forward and reverse, and to load a combined solution. This method works well because in applications like high tree cover, the first and last epochs of a given static session can be significantly different. This feature flags these points and puts more weight on the solution with the best estimated standard deviation.

The parameters for combining features are listed in the shaded box. The program creates a LOG file that shows statistics about each combination when this feature is used. With this option, the remarks field are also replaced with a status message. The *KinSurveyStations* export profile is well suited for use with this method.

> *Tolerance between start/end position*
> Defines the minimum difference between start/end positions necessary to generate an error message. If the difference is less than the specified tolerances, then the combination is deemed to be OK and combined solutions are exported regardless of this.

> *Do not export points that are outside tolerances*
> If this option is enabled, the combined solutions that are not okay are not exported.

> *Estimated position standard deviation tolerance*
> Field are used to flag points with very poor estimated standard deviations.

> *Log messages to file.log*
> Allows messages to be logged to a separate file. This is a good quality control feature.

Vertical Scale Factor Window

This correction is used by photogrammetrists. When performing photogrammetric aerial triangulations these algorithms, known as block adjustments, assume the scale factor for the horizontal and vertical coordinates. The block adjustments are contained in softcopy systems. When map projection coordinates, like UTM, Gauss-Kruger, State Plane and Lambert, are used in the adjustment, the horizontal coordinates are then scaled by the map projection scale factor. The vertical coordinates, if uncorrected, has a scale factor equal to 1. Adjustment software that works in a geocentric frame, like PC-GIANT, are unaffected. These adjustments are not very compatible with soft-copy systems.

To counter-act this problem, GrafNav applies a correction to the vertical component that corrects for scale error. Currently, GrafNav assumes a constant terrain height, and this correction is most accurate in flat areas. It is less accurate in areas with high relief because the constant height model no longer holds true. Aircraft height variations are taken into account. GrafNav prompts you for the average height of the ground. If you output height in feet, then this height should also be in feet.
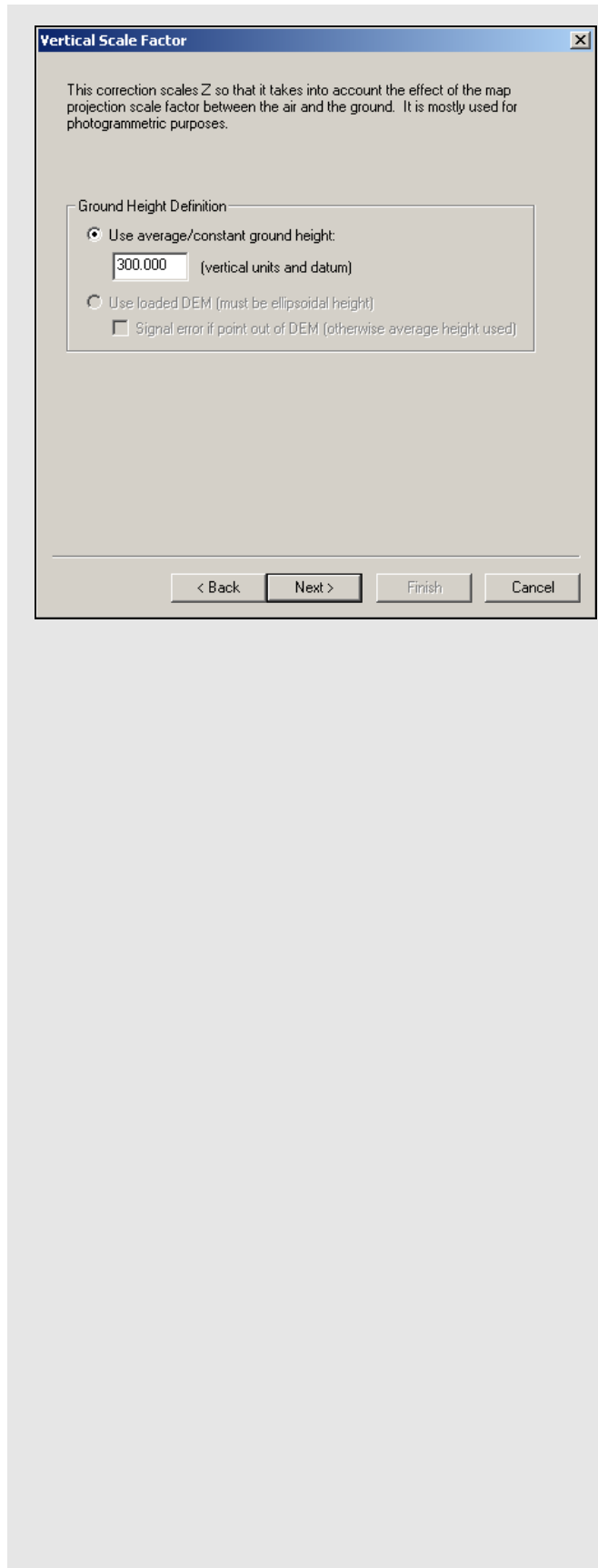
Table 6: Transformation Parameters

Transformations	Parameters
1-D Shift	Z-shift
2-D Shift	X-shift, Y-shift
2-D Similarity	X-shift, Y-shift, scale, rotation
2-D Affine	X-shift, Y-shift, X-scale,Y-scale rotation, sheer
3-D Similarity	X-shift, Y-shift, Z-shift, X-rotation, Y-rotation, Z-rotation, scale
3-D Shift	X-shift, Y-shift, Z-shift
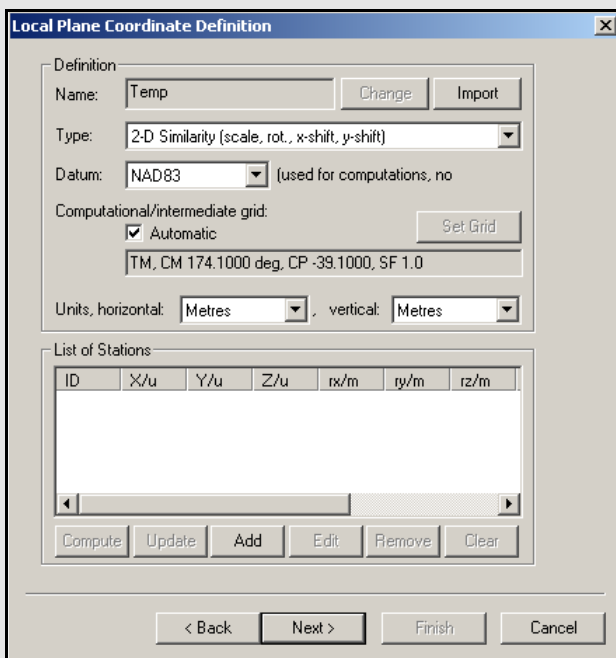
Local Plane Coordinates Definition Window

This feature reproduces localized coordinate systems. It rotates and scales processed coordinates for features or epochs into a local coordinate frame.

⊠   The Z coordinate are a differential ellipsoidal height, and not a Cartesian coordinate.

There are six types of local transformations supported. The parameters that are solved by each transformation are shown in *Table 6*.

The local frame transforms the processed output coordinates and is defined by the number of surveyed points. The minimum number of points required for the transformation depends on the number of parameters that need to be solved for. The minimum number of individual X, Y, Z coordinates defined for any specific transformation is equal to the number of parameters being solved for. Each coordinate must be given in either meters or feet.

For the 4-parameter 2D transformation, the northings and eastings of at least two points are required. For the 6-parameter 2D transformation, the northings and eastings of three points are required. Performing a 7-parameter 3D transformation requires seven known coordinates. Six of these coordinates must define two X, Y, Z points completely. A height for a third point must be entered or another horizontal pair of coordinates to solve for the final parameter.

Using the 6-parameter 2D transformation or the 7-parameter 3D transformation can be very risky. The horizontal X and Y-axis will no longer be perpendicular to one another when using the 6-parameter 2D since the transformation allows for a skew between these axes. Coordinates transformed using the 7-parameter 3D transformation are not necessarily in a local-level frame any more, which can cause severe problems in many applications.

To show which type of transformation is desired and which points are known points, GrafNav offers the *Local Plane Coordinate Definition* window. The default computational grid is a Transverse Mercator grid with the central meridian down the centre of the project area. This grid system should match the one used to create the local system. For example, UTM.

Add, Remove, and Edit
Define the reference points in the transformation. When adding a station, use the computed coordinates from station features to define points for the transformation. Otherwise, select a station from *Favourites* or you can manually define the point coordinates. The name given to a known point must be the same as the name of the station it corresponds to. The *Find Point* button searches the list of the points that have GPS coordinates, including any loaded station features, base stations, or stations with known coordinates.

Update
Replaces existing geographic coordinates for points with those present in the processing software.

The *Favorite* points are points that you can use as known points in many different projects. *Favourites Manager* saves the coordinates of these points so that they can be used at any time without having to be re-entered. To use one of these points in the transformation, its name must be the same as its corresponding point in GrafNav.

Geoid Correction Window
GPS works in the ellipsoidal height system. However, many maps and vertical datums are defined in the orthometric system (height above mean sea level). GrafNav can make use of the BIN/SLV and GEO geoid files produced by the Canadian and American governments. GrafNav also supports various geoids in the WPG (Waypoint Geoid Format). This includes files for the US (Geoid03, Geoid99 and Geoid96), Australia (AusGeoid93), and the world (EGM96). These files are found on the distribution CD or via Waypoint's FTP site. Using these files, GrafNav produces orthometric heights as output.

Filter Output/Estimated Accuracy Scaling Window
This window filters the output based on the quality number and/or standard deviation of the computed position. The standard devation value, in metres, represents the position trace.

To output standard deviation values, scale them here to meet your required confidence level.

To filter based on standard deviations, the filter will be applied to the unscaled values.
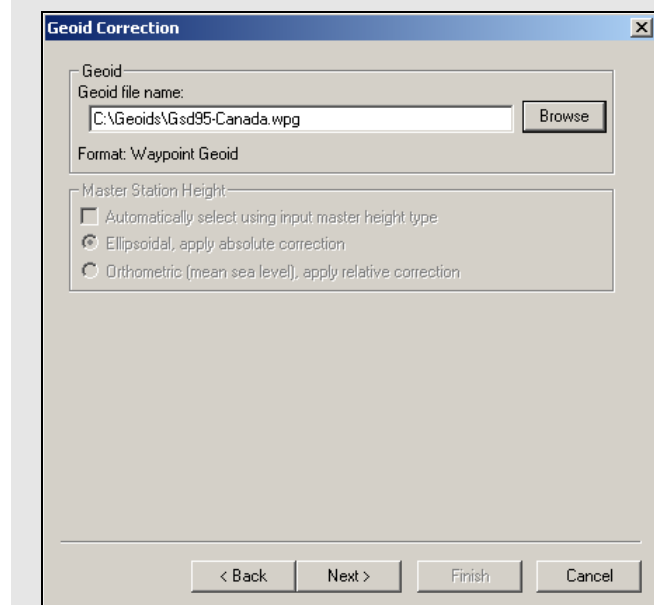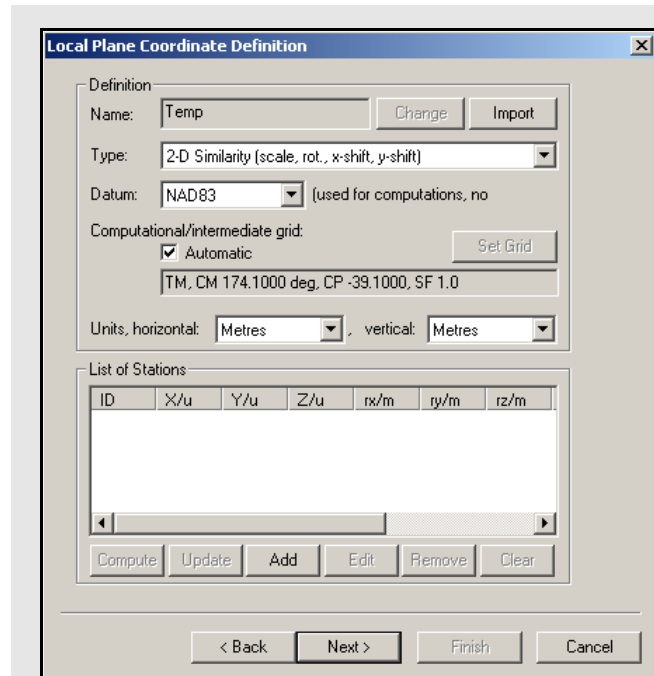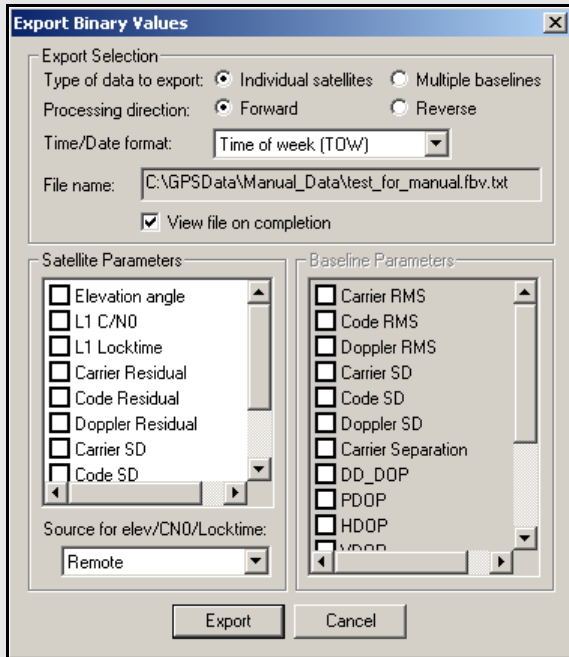
Export Selection options

Type of data to export: Select whether values for each satellite should be exported or for each baseline (MB processing only).

Processing direction: For processing values, forward or reverse values can be exported. For GPB values, forward or reverse produce the same result.

Time/Date format: A number of time outputs are possible. See *Section 2.7.4,* on *Page 80* for more information on each format

File name: Displays the name of the file.

For GPB based values like *L1 C/N0* and *L1 Locktime*, select whether to export the data from the base or rover files.

See *Section 2.7.4,* on *Page 80* for a description of the available individual export values.

2.7.5 View Coordinates

This allows you to view the coordinate files created by the *Export Wizard* features. If several output files have been created, this feature loads the most recent.

2.7.6 Export Binary Values

For GPS processing, the binary value (FBV/RBV) files contain additional statistics about each satellite and/or baseline. For MB processing, these files are automatically created. For single baseline processing, their creation requires that the *Write MB binary value/satellite residuals* option be enabled under the *Advanced 1* tab of the processing options. See *Ionosphere/Troposphere (Differential GNSS processing)* on *page 60* for more information. Plot these values with the *Multi-Base Statistics* and *Individual Satellite Statistics* plots under *Output | Plot GPS Data*. To work further with these values, use this option to convert FBV/RBV files to ASCII. Satellite locktime and C/N0 values can also be exported from a GPB file in this way.

✉ A solution must be loaded.

Export Selection
The options available are listed in the shaded box.

2.7.7 Write Combined File

This feature writes the combined trajectory to disk in a format similar to that described in *Section 5.4.3,* on *Page 165* . This combined file represents the weighted combination of the two solutions currently loaded in the project, usually the forward and reverse. It can, in turn, be loaded directly by the software, allowing for the comparison of solution files obtained using varying processing options.

Export DXF

DXF is a file format read by various CAD packages. This utility outputs your project into DXF format.

Output File Name

Specify the name and path of the DXF to be created.

Output Components and Options

The following options are available:

> *Stations/Features*
> Outputs any stations or features loaded.
>
> *Baselines/Static Sessions*
> Outputs baselines between all the static sessions. The colour of the baselines will be the same as it appears in GrafNav and is determined by the quality factor.
>
> *Epochs*
> Outputs the trajectory and is only useful for kinematic data. Colour is determined by the quality factor.
>
> *Join Epochs*
> Joins a line between epochs.

Symbol Sizes

These settings govern the size of the features and stations in the DXF file. *Automatic* is suggested for a trial.

Datum

Allows you to choose between the processing datum or the input datum.

The grid options are available under the *Select Grid System* tab. For UTM, State Plane or any other zone-dependent grid, check that the zone number is correct because the default is likely wrong.

2.7.8   Build HTML Report

Creates an HTML file containing a bitmap version of any plot that is currently open, including the Map Window. These HTML and BMP files are saved to the *HTML* folder contained within the project folder. The HTML file also contains information regarding the processing run(s) used to generate the plots.

2.7.9   Export to Google Earth

These options are listed in the shaded box.
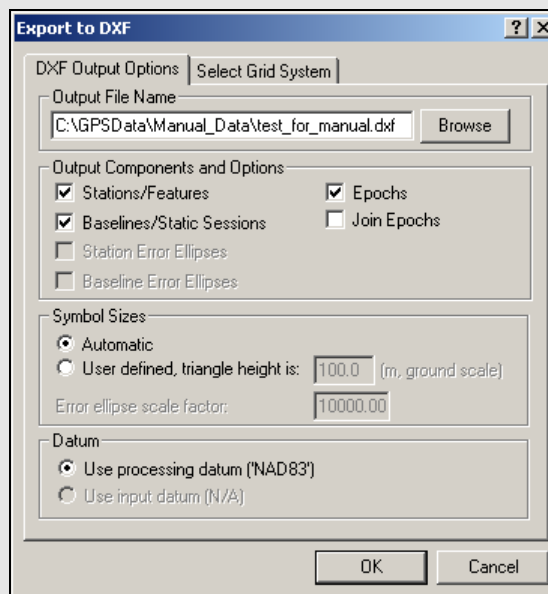
Export to Google Earth Options

Export and View

Writes out a KML/KMZ file and loads it into Google Earth. This feature opens Google Earth.

Export Only

Writes out a KML/KMZ file to disk, but does not load it into Google Earth. If an auto-update entry has been previously created, then the newly written KML/KMZ records are updated in Google Earth.

Create Auto-Update Entry

Creates a network link within Google Earth which scans the project KML/KMZ file every 15 seconds for changes. This option can be used along with the *Export Google Earth file* option under *Settings | Preferences* to completely automate the writing and loading of KML/KMZ files. See *Section 2.6.7,* on *Page 69* for more information.

For additional customizing of the Google Earth output files produced by the software, please see *Section 2.6.7,* on *Page 69* .

Table 7: Quality Number Description

Quality	Colour	Description	3D Accuracy (m)
1	Green	Fixed integer	0.00 – 0.15
2	Cyan	Converged float or noisy fixed integer	0.05 – 0.40
3	Blue	Converging float	0.20 – 1.00
4	Purple	Converging float	0.50 – 2.00
5	Magenta	DGPS	1.00 – 5.00
6	Red	DGPS	2.00 – 10.00
Unprocessed	Grey	Has not been processed	N/A
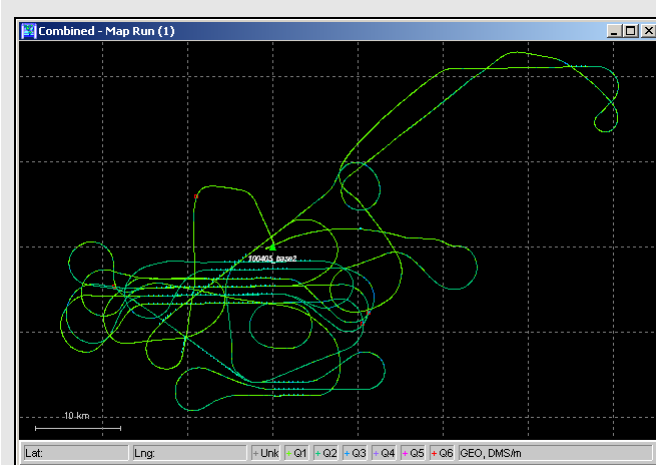
2.7.10 Show Map Window

This screen is a graphical representation of the project area. It shows the master stations, the location of the remote station at each epoch, and station or event marks.

The master stations are represented by solid green triangles. Event marks are shown as cyan circles, while station marks are shown as yellow triangles. See *Section 2.6.7,* on *Page 69* for help enabling or disabling certain features of this display.

Remote locations are shown as small crosses. The colour of the crosses depends on the quality of the solution. The colours displayed are listed in *Table 7*.

> ⊠ The accuracies given are only guidelines. The actual accuracies might be different and, in fact, much worse. Check the standard deviation values, which are also a guideline.

Mouse Usage in Map Window

Positioning the cursor on a station or epoch mark and clicking with the left mouse button brings up the *Station Information* or *Epoch Information* message box. Clicking the right mouse button brings up the *Object Menu*. See *Section 2.4.7,* on *Page 46* for additional information.

If you have a scroll-wheel on your mouse, you can use it to zoom in and out by scrolling forwards and backwards over the area of interest.

Right-clicking on the Map Window provides you with several options, including the ability to load a specific solution and to open the Feature Editor.

The *Save to HTML* option generates an HTML file containing a bitmap version of the Map Window. These HTML and BMP files are saved to the *HTML* folder contained within the project folder.

See *Section 2.8,* on *Page 96* for additional interactive mapping tools.

2.7.11 Processing Window

This window appears during processing and shows position, status, satellite and message information originating from the processing engine. This screen is updated every 500 milliseconds.

Status
This window displays a graphical quality bar in the *Status* box. The first icon on the left shows the quality factor. This number ranges from 1 to 6 and is most sensitive to solution stability. Stable solutions are usually 1 or 2 for carrier phase processing. For code-only processing, the quality ranges from 3 to 6. See *Table 7* on *Page 93* for a description of quality factors. If this factor jumps from 1 to 6, either a serious loss of lock has occurred, or unfixable bad measurements have incurred a Kalman filter reset.

The right-most icon of the *Status* box displays a *K* during kinematic processing and an *S* for static processing.
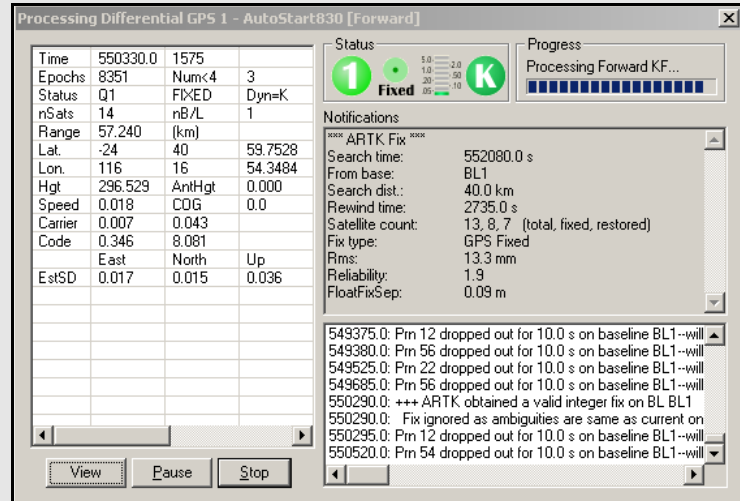
Table 8: Notifications Window Messages

Message	Description
Search time	Time at which ARTK engaged.
From base	Specifies which baseline was fixed. This is useful in multi-base projects.
Search distance	This is the distance when the ambiguity search was performed. This is not the distance when ARTK was restored.
Rewind time	The number of seconds before the Search time that ARTK was able to restore the ambiguities.
Satellite Count	The number of satellites used by ARTK.
Fix Type	Solution type used.
RMS	This is the RMS fit of the ARTK search, in cycles. Values better than 0.04 usually mean a correct solution.
Reliability	This is the ratio between the second best RMS and the best RMS. Ratios above 3 or 4 are usually a pass for dual frequency. The tolerance is variable depending on the float-fixed separation.
FloatFixSep	This is the distance between the solved fixed integer solution and the float solution at time of search. Low numbers mean a good correspondence between the two solutions.

Table 9: Processing Window Parameters

Parameter	Description
Acceleration Vector	Acceleration components in Local Level frame.
Baseline Data (MB)	Displays distance, carrier phase RMS, and number of satellites information for each baseline.
Baseline Distance	Distance separation for projects containing only one base station.
Channel (Ambiguity)	Displays the ambiguities, as well as their standard deviation, for each satellite being tracked.
Channel (Az/Elev)	Displays elevation and azimuth for each satellite being tracked, in degrees.
Channel (Flag/Locktime)	Displays status flag and locktime count for each satellite being tracked.
DOPs	Displays DD_DOP, PDOP, HDOP and VDOP.
Estimated Accuracy	Standard deviation of the position components in the Local Level frame.
Geographic Position	Displays position and antenna height of remote at current epoch.
Local Level Vector	Local Level vector in metres.
Measurement RMS	RMS and standard deviation of the L1 carrier phase and C/A code measurements.
Speed/COG	Vehicle instantaneous velocity vector in m/s, and course-over-ground. These values may be inaccurate for code-only processing.
Status Flags	Solution quality information such as number of satellites, quality factor and ambiguity status.
Time/Epochs	Displays time in seconds of the week, as well as a continuous count of epochs processed. The GPS week number is also shown.
Velocity Vector	Components of velocity in the Local Level frame.
Channel Data B/L	Allows for selection of baseline for which to display channel information.

Table 10: Notifications for Static Processing

Message	Information
RMS	RMS value computed by fixed solution (should be less than 0.02), in metres
Reliability	This is the ratio between the second best RMS and the best RMS. Ratios above 3 or 4 are usually always a pass for dual frequency. The tolerance is 1.5. For single frequency, ratios are lower, but greater than 2 is usually correct. The tolerance for single frequency is 1.35.
Frequency	This means the data type used. If a fixed solution fails on a short baseline using dual frequency data, the software tries again using only single frequency.
Time	Amount of time used in the solution, in *hh*:*mm*:*ss* format
Type	Fixed static solution type used. *Continuous* looks for the best "continuous" overall time period/block of data. *NewFixed* (multi-sat) uses all of the data, although it may reject some satellite arcs.

Progress

The *Progress* box shows whether the engine is processing in the forward or reverse direction, and how far along it is.

View

In the left-hand window, various parameters are available for display via the *View* button. The list of available parameters is given in *Table 9*.

Notifications

For kinematic processing, the *Notifications* window displays all information pertaining to the last ARK solution. Descriptions of the messages that are in *Table 10*.

For static processing, the *Notifications* window displays all information pertaining to the fixed solution. Descriptions of the messages that are displayed are in *Table 8*. Messages included in the *Notification Window* for static processing are in *Table 10.*

2.8 Tools Menu

2.8.1 Zoom In & Zoom Out

The *Zoom In* and *Zoom Out* tools adjusts the viewing scope of the map, while the *Zoom Reset* brings the map back into the default view.

If you have a scroll-wheel on your mouse, you can use it to zoom in and out by scrolling forwards and backwards over the area of interest.

Right-clicking on the Map Window provides you with several options, including the ability to load a specific solution and to open the Feature Editor.

The *Save to HTML* option generates an HTML file containing a bitmap version of the Map Window. These HTML and BMP files are saved to the HTML folder contained within the project folder.

2.8.2 Distance & Azimuth Tool

The first six options available all pertain to the *Map Window*. The *Distance & Azimuth* tool allows for certain calculations to be made between epochs or stations. Click on the feature or epoch that you wish to measure *from* and then right-click on the feature or epoch that you want to measure *to*. The *Distance and Azimuth* window appears and shows the horizontal, surface, grid and spatial distances between the selected points. The azimuth and scale factor information are also displayed.

2.8.3 Move Pane

This tool is only accessible once the map zooms in. This tool allows you to scroll the different parts of the map. To use this tool, click on the map and drag it in the desired direction.

2.8.4 Find Epoch Time

This feature allows you to search the map for the epoch corresponding to a GPS time. Once found, the map zooms in and the epoch time is circled in red.
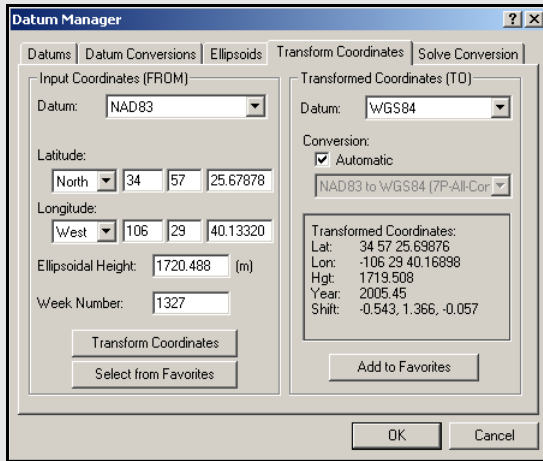
How to solve for a transformation or datum conversion

1. Isolate the *ToDatum* and the *FromDatum* to be used. Normally, one of the two will be WGS84, but ITRF is also common. This feature can be used to convert between any two datums and it does not matter which datum is which (*From* or *To*), as long as the coordinate files correspond.

2. Create a text file that contains the geographic coordinates of the points in the *FromDatum*. Examples include NAD83 and ED50. Coordinate systems other than geographic (degrees minutes seconds) are not supported. The format for the coordinate file is as follows:

   PointID [Ref Year] Lat_deg Lat_min Lat_sec Lon_deg Lon_min Lon_sec EllHgt Flag

   Continued on the following page.

⊠ The *PointID* may not contain any spaces. The *Lat_deg* (latitude) term is positive for the Northern hemisphere and negative for the Southern. The *Lon_deg* (longitude) is positive for the Eastern hemisphere and negative for the Western. The *EllHgt* is in meters and is the height above the ellipsoid.

The *Flag* term is optional and indicates whether this point should be used for computing the transformation. Valid values are either 1 or 0, with 1 being assigned if the *Flag* is not present. Use the *Flag* to either prevent suspect points from corrupting the solution or to use some points as an independent check.

2.8.5   Datum Manager

See *Section 2.6.2,* on *Page 65* for information regarding the first three tabs. The two remaining tabs are discussed here.

Transform Coordinates
This tool transforms point coordinates from one datum to another. This is often used to transform base station coordinates of a project to another processing datum. You can select a point that is stored in the *Favourites Manager* to be converted and save any transformed point to *Favourites*.

⊠ Specifying the week number of the coordinate effects the final result if the conversion 14-parameter.

Solve Conversion
GrafNav can solve for a 3-, 7-, or 14- parameter transformation. The 7-parameter can have the scale constrained to unity resulting in a 6-parameter transformation with 3 translations and 3 rotations. The 14-parameter transformation allows scale, scale rate, translation, velocity, rotation, and rotational rate to be solved. You can enable or disable individual parameters. Use this if you have a list of control points with coordinates in both datums. From these point pairs, a locally best-fitting datum transformation can be computed for the region or project area. The two lists must be in ASCII format and all points in each file must be common to both files, with identical point names. The order the points appear in each file is not important and ellipsoidal height values are required.

⊠ 7 and 14-parameter transformations should only be used for areas greater than 300 km across because solving transformations over small areas makes the parameters very sensitive to coordinate errors.

14-parameter transformations require coordinates from the epochs in time, which is specified as epoch year in the second parameter.

In some cases, 7-parameter transformations are necessary due to a slope in the local datum. This is considered a very localized datum.

Advanced Settings

Add computed conversion to Datum Conversion List

Adds the computed conversion to the list under the *Datum Conversions* tab. This allows the conversion to be used by the software.

Force scale factor to 1.0

Constrains the PPM scale to zero (scale factor = 1). This is only applicable for the 7-.

Compare against existing conversion

Computes residuals for an another existing conversion in the *Datum Conversions* list. This is useful for determining if the newly computed conversion fits better than the existing one.

Processing Report

The following are contained in this report:

Parameters

The input options used for the computation.

Raw Differences

These are the raw differences between the ECEF coordinates of the matched points in the two files. Only points that have a match found are processed. The *USED* column indicates if points are to be used in the solution or not and refers to the *Flag* in the *FromDatum* file.

Transformation Parameters

Shows the parameters computed by the solve process. If a comparison is made, then this shows the parameters from the datum conversion. If the transformation needs to be inverted due to opposite *From* and *To* datums, then the reversed values are shown.

Residuals using …

Shows difference between raw *FromDatum* coordinates and the *ToDatum* coordinates transformed into the *FromDatum*. Root-mean-square values are shown at the bottom. Note that the residual values are oriented to local level (east, north and up).

Raw Differences

These are the raw differences between the ECEF coordinates of the matched points in the two files. Only points that have a match found are processed. The *USED* column shows if points are to be used in the solution or not and refers to the *Flag* in the *FromDatum* file.

How to solve for a transformation or datum conversion (cont.)

3. Create a text file corresponding to the *ToDatum*. The format for this file is the same as for the *FromDatum*, except that the *Flag* term is ignored. Be sure that the *PointID*s match those in the *ToDatum* file that was created in the previous step.

4. Select *Tools | Datum Manager*. Click on the *Solve Conversion* tab

5. Press *Browse* to select the coordinates file corresponding to the *FromDatum*.

6. Select the datum from the list. If the datum is not present, enable or add it. See *Section 2.6.2,* on *Page 65* for more information.

7. Browse for the file corresponding to the *ToDatum*.

8. Select the corresponding datum.

9. Select the transformation parameter type. Enter a meaningful *Info* string to appear in the datum conversion. It is helpful to put a comment in order to be able to distinguish this transformation from others later one.

10. Select an output file name. This file is a report that is generated from the computation process. It contains the computed transformation parameters along with the residuals.

11. (Optional) Click the *Advanced Settings* button. parameter transformation and effectively causes a 6-parameter transformation to be solved.

12. Select the *Compute Transformation* button. A message proclaiming success should appear afterwards. If not, act on the message. For some failures, a partial report file may be created.

13. Press the *View* button to view the processing report.
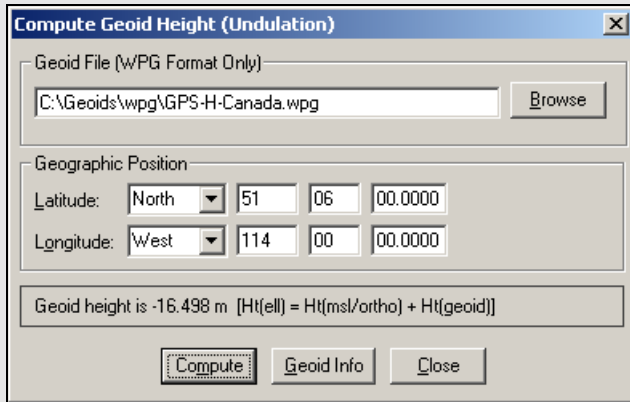
2.8.6 Geoid

Waypoint software supports the use of geoid files for orthometric heights.

When correcting ellipsoidal heights to produce orthometric heights, it is very important that the geoid and processing datums match. For example, if EGM2008 is used, then the base station coordinates should be in WGS84.

The geographic boundaries are displayed within the applicable geoid. The number of rows and columns present in the grid used to define the geoid are also shown.

In some cases, you might want to process in a datum different than the one the geoid uses. To do this, use the geoid model in a relative fashion. The slope should be roughly the same between ellipsoids. Between NAD27 and NAD83, there is up to 200-metre difference in geographic coordinates. In areas with very high relief, this might result in a few centimeters of orthometric height error. The same can be said for other datums with large shifts like TOKYO and ED50.

In GrafNav, conversion to ellipsoidal height can be performed when entering the master coordinates. When exporting with *Export Wizard*, the geoid undulation is subtracted.

For GrafNet, the process is similar. This is because you can convert orthometric heights to ellipsoidal as you enter the control/check point coordinates. Be sure to set the ellipsoidal/orthometric height flag correctly.

⊠ Elevations are always stored as ellipsoidal inside GrafNet. Conversion to orthometric only take place at time of coordinate export. In many cases, the default output is ellipsoidal height, so care should be taken when exporting elevation values.

The Geoid Information tool gives you details concerning the selected geoid. This tool will only read WPG files.

The Compute Geoid Height tool calculates the geoid height for any given point. Be sure that the horizontal coordinates entered correspond to the datum upon which the geoid is based. If you are uncertain, click the *Geoid Info* button.

2.8.7 Grid/Map Projection

GrafNav supports grid/map projections in several ways including the following:

- You can enter their horizontal master station coordinates using any grid definition.

- You can output final coordinates in a map projection of your choice. See *Section 2.6.7,* on *Page 69* and *Section 2.7.10,* on *Page 93* for additional information.

- Several grids, like UTM, TM, Gauss Kruger, US State Plane and Lamber, have been pre-defined in the software but you can also add your own. The directions to do this are in the shaded box.

- Use the *Transform Coordinates* tool under *Tools | Grid/Map Projection* to convert between geographic coordinates and grid coordinates.

Transform Coordinates

This tool quickly transforms coordinates for a single point from geographic to grid, or vice versa. When transforming TM projections, make note of the *Point is in Southern Hemisphere* option; it is disabled by default.

⊠ After a conversion from grid coordinates to geographic coordinates has been made, you may add them to your *Favourites*.
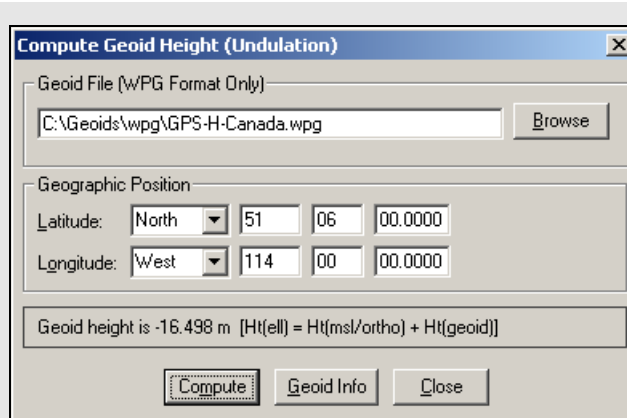
How to define a new grid

1. Go to *Tools | Grid/Map Projection | Define*.

2. Click on the *New* button.

3. Choose a grid from the many types including Transverse Mercator and Lambert Conformal.
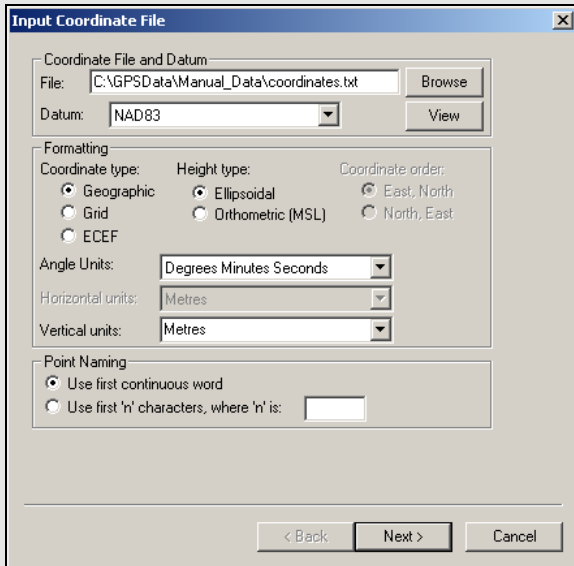
How to convert a coordinate file

1. Identify the name, datum and format of the input file.

✉ Each line of the input file should be formatted to contain the station name followed by the coordinates.

2. Press *Next.* You are prompted for grid definition settings if grid coordinates were selected earlier. If not, the next step is to specify the name, datum and format desired for the output file. The *Point Naming* options are disabled as the program simply copies the names as read in from the input file.

3. Specify the datum transformation to be used if the input and output datums are different. You can also specify a geoid file if orthometric height is required. This is useful if you output orthometric heights because datum transformations are not applied.

2.8.8 Convert Coordinate File

This tool converts large lists of coordinates. If you already have the list of coordinates in ASCII, use it because all the files can be converted easily. It can be used for converting datums, changing the height system used (ellipsoidal, orthometric) or changing to grid or ECEF coordinates. This tool can also be used to change a list of coordinates to another format, for example, from decimal degrees to DMS.

The *Use first continuous word* option is the default. If the station names do contain spaces, select *Use first 'n' characters* to specify a width of *n* characters. The software reads the first *n* characters as the station name, including any spaces that may be present. Geographic coordinates use positive/negative signs to show the hemisphere. For example, latitude is positive in the Northern hemisphere and negative in the Southern, while longitude is positive for East and negative for West.

Additional options include the following:

Include column header
Conserves the header information from the input file.

View output files after conversion
Automatically opens the output file after pressing *Finish*.

Input grid coordinates in southern hemisphere
Only necessary if the input data has grid coordinates from a project area that is in the southern hemisphere.

Do not apply datum transformation to height
This option is useful for outputting orthometric heights because no datum transformation are applied in this case.

2.8.9   Time Conversion

This tool converts GPS into HMS (hours, minutes, seconds) and vice versa.

2.8.10   Favourites Manager

Use this feature to avoid retyping coordinates that are used often. Access it via the *Tools* menu in all Waypoint software.

Upon loading the *Favourites Manager*, a list of favourite groups appears. If this feature has never been used before, nine or, possibly, ten groups should appear as shown in the screen shot in the shaded box.

These groups contain a list of control points that continuously collect GPS data that can be downloaded free of charge via the download program (*Tools | Download Service Data*).

During the installation of the software, you are prompted to find the directory where any previous version of the software was installed. This automatically copies all of your files (including any previously stored *Favourites*) into the new version.
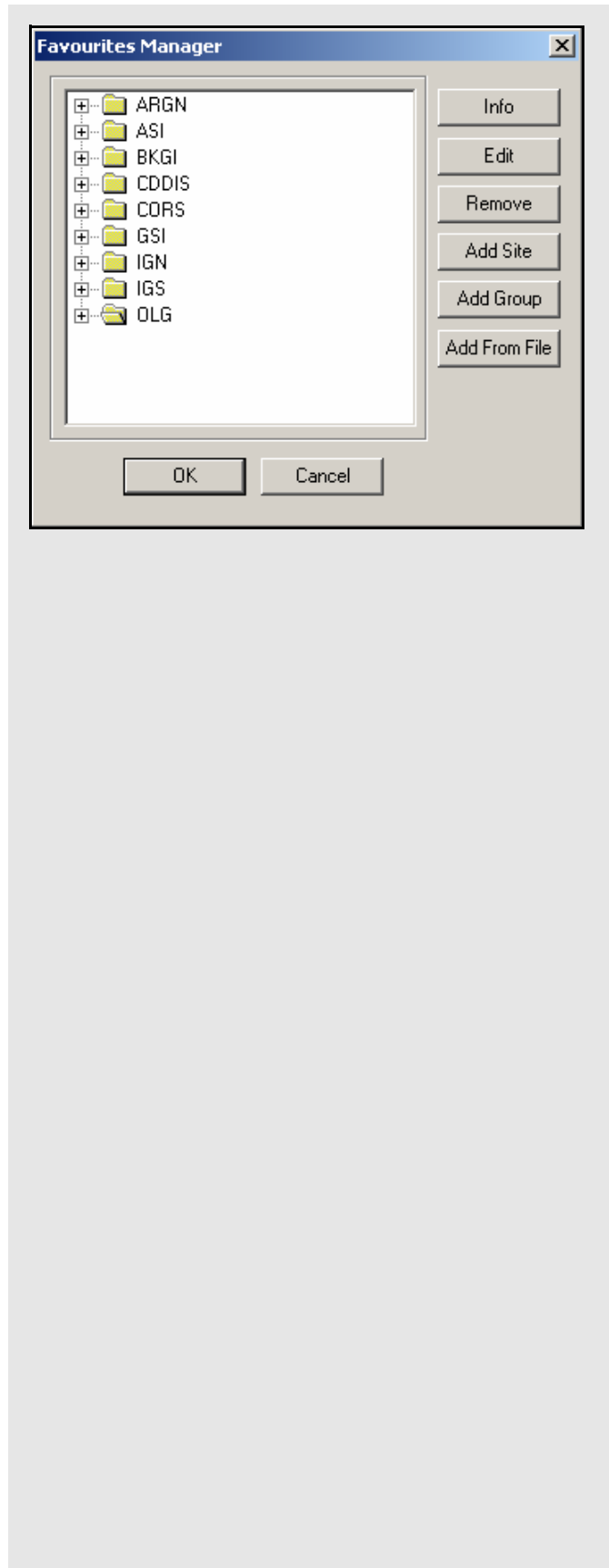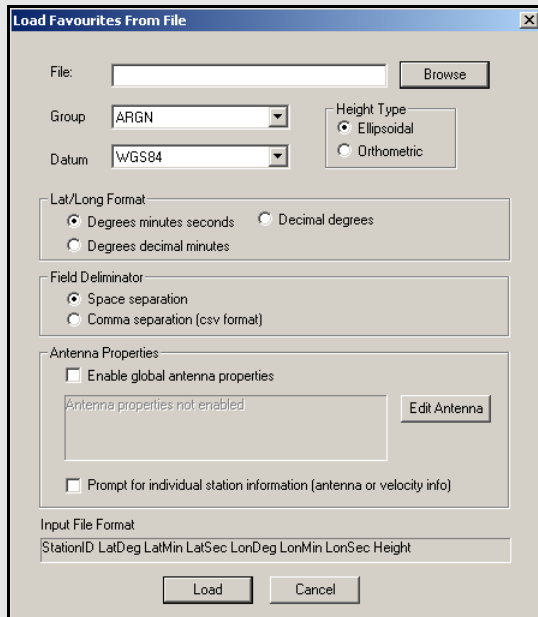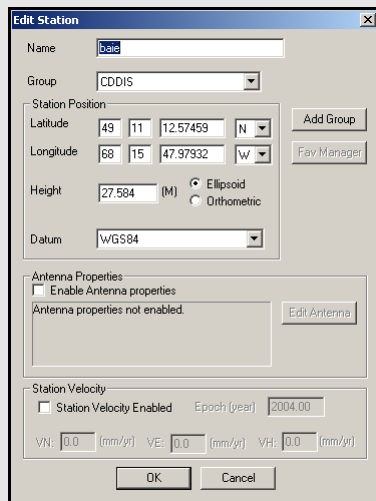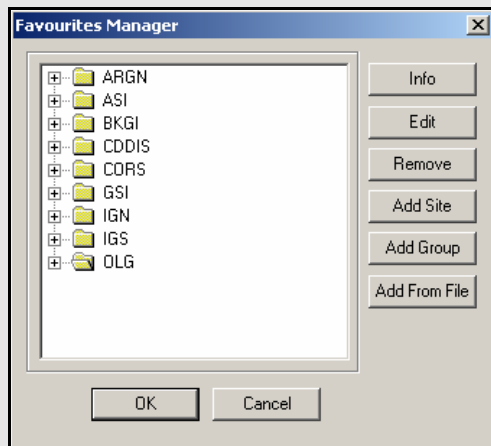
The following options are available in the *Favourites Manager* via the buttons on the right-hand side:

Info
If clicked while a group is highlighted, this returns the total number of sites contained within the group. If clicked while an individual site is highlighted, the position, velocity and datum are displayed.

Edit
You can modify the information related to a station through this option, including coordinates, antenna information, and station velocities.

Remove
May be used to removed an individual site or an entire group.

Add Site
Allows for the addition of a new site into any group.

Add Group
Allows for the addition of a new group.

Add from File
Using this feature, a list of station coordinates can be directly loaded from an ASCII file, eliminating the need for manual entry. The file must contain the station names and coordinates in a comma- or space-delimited format. *The Input File Format* box at the bottom of the window provides a useful reference for those users who are unsure as to what their input file should look like.

> ✉   Southern latitudes and Western longitudes should be denoted by a negative sign. You should also take care to properly flag the inputs heights as being "Ellipsoidal" or "Orthometric".

Information regarding the stations' antennas can also be specified here. If the antenna model and/or heights are common to all the stations being added, then the *Enable global antenna properties* setting can be enabled to specify this information. If the information varies from station to station, then the *Prompt for individual station information* option should be enabled. This latter option is also needed if you wish to specify station velocities.

2.8.11 Mission Planner

This utility is available in all of Waypoint's programs. It provides you with a method of investigating satellite geometry, satellite count, and dilution of precision values for the GPS constellation. Mission planning is normally performed prior to the mission, but it can also be used to compare the theoretical constellation to that observed during processing.

Settings

Mode
Selecting *Single Point* provides results for the area immediately surrounding the point chosen under *Point of Operation*. *Differential* displays results for the area between the two defined points and should be used for long baselines.

Point of Operation
Indicates the location for which the information is being sought. Click *Define* to select a file with a list of geographic coordinates for numerous cities. In the window, click *Change List File* to select which list to choose the location from.

Two default files (MPF) are provided with the software. The first is *north_am.mpf*, which contains an extensive list of North American cities. The second is *world.mpf*, which includes cities from around the world. There is third file available, *MissPlan.mpf*, for users who wish to create their own list of geographic locations.

Base Station
Only available if *Differential* has been selected under *Mode*. Click the *Define* button to view the list of locations available. You might have to load a coordinate list via the *Change List File* button on the window that appears.

Almanac File(s)
An almanac file is required for *Mission Planner* to access the orbital parameters of each satellite needed for its computations. This information is available from two sources. The first is via the Internet. Both GPS and GLONASS almanacs are updated on a daily basis and can be downloaded free of charge. The second source is a Waypoint ephemeris (EPP) file containing almanac data. This option only applies to users of NovAtel receivers, as they are the only manufacturer whose almanac records are supported.
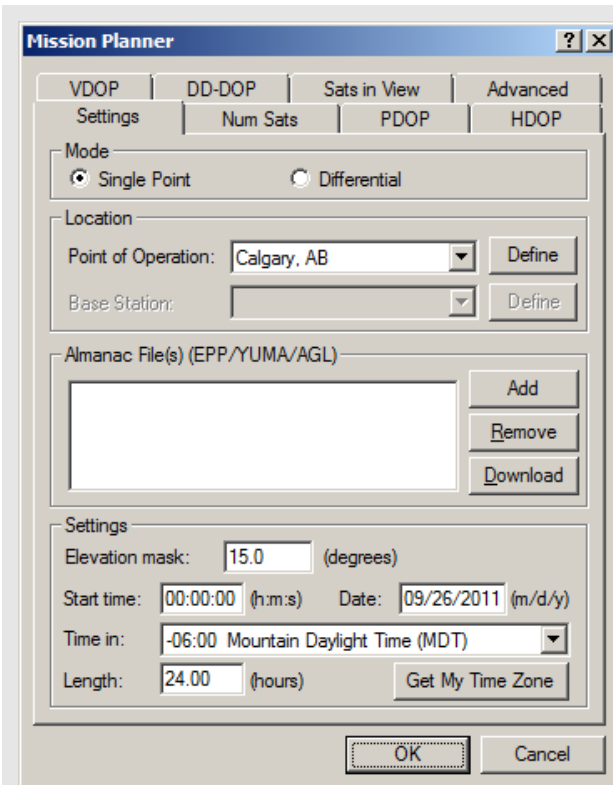
If you already have a valid almanac source, use the *Add* button to locate it on your hard drive. Otherwise, use the *Download* button to bring up the *Download Almanac Files* window, from which you can specify the date and constellation for which the almanac data is needed. For typical mission planning, enter today's date to ensure the most recent almanac files are downloaded.

Settings

The following settings are available:

> *Elevation mask*
> This option sets the cut-off elevation. The default value for the mission planner is 15 degrees. Use larger values to simulate typical conditions of satellite blockage lower on the horizon.

> *Start time*
> The start time of the mission. Used as the starting point for all displayed plots.

✉   Ensure that the time entered is in GMT time, not local time.

> *Date*
> The date of the mission.

> *Time in*
> Use the *Get My Time Zone* button to specify your local time offset from GMT. If you are mission planning for a project outside your time zone, use the drop-down list to make a manual selection. Note that all plots will display *H:M:S* time in the local time frame.

> *Length*
> Length of the mission and determines the time span that is covered by the displayed plots.

Num Sats PDOP, HDOP, VDOP, and DD-DOP

The following descriptions are applicable to the *Num Sats*, *PDOP*, *HDOP*, *VDOP*, and *DD_DOP* tabs.

Chart Type
Select *None* to tell the utility not to plot the values associated with the current tab. You view the data in *Line graph* or *Bar chart* format. The *Bar graph* gives you access to the *Bar Colors* box. Bar charts allow for easier interpretation of the results because the values are classified according to their quality level.

Bar Color
Available only if you request that the values are plotted in bar chart format. These settings allow you to modify the range of values associated with each quality level. If there are less then six defined categories, you can also add one.

Y-axis Range
Select *Automatic* forces *Mission Planner* to automatically scale the Y-axis for each plot. Manually enter the boundaries by selecting *Manual*.

Satellites in View

Chart Type
Select *None* if you do not want to view this plot. Otherwise, you can select *Satellite lock plot*, which allows you to view an elevation plot of the satellites in view.

Satellite Sky View Plot
Displays plot that shows elevation and azimuth of all satellites over time.

Advanced Tab

Log File
You can choose to save an ASCII output of the mission planning information. Enable *View LOG file after processing* to open this output file when plotting is finished.

Data Interval
Select *Automatic* to force the *Mission Planner* to compute a data interval suitable for most recent plot window size. Select *Manual* to define a data interval to improve the resolution.

Options
The options that are available are listed in the shaded box.

Num Sats PDOP, HDOP, VDOP, and DD-DOP Options

Ignore satellites with bad health
Mission Planner checks the almanac file for any sick satellites if this option is selected. Any satellites confirmed as being so are removed from plotting and output.

Ignore these satellites
If certain satellites are causing problems, but are not identified as being sick in the almanac file, they can be manually specified here for removal from plotting and output.

Plot all DOPs on one graph
If multiple DOP plots were requested for viewing in line graph format, enabling this option forces them to be displayed on the same plot.

Display seconds of the GPS week instead of H:M:S
Toggles the format of the X-axis labeling between GPS seconds of the week or Local *H*:*M*:*S*.

⊠   If any changes were mistakenly saved in *Mission Planner*, the defaults can be restored by deleting the *WPMissPlan.ini* file in the *C:\Windows* directory.

System Usage:
GPS only -restrict to GPS satellites
GPS + GLONASS - both systems if both almanacs are loaded

Satellite systems to use
Specifies the constellation(s) for which you need the predictions made.

GLONASS PRN offset
GLONASS PRN numbers will vary depending on the receiver. An offset can be entered here to match that used by your receivers.

UTC time offset
Specifies the difference, in seconds, between the UTC and GPS time frames.
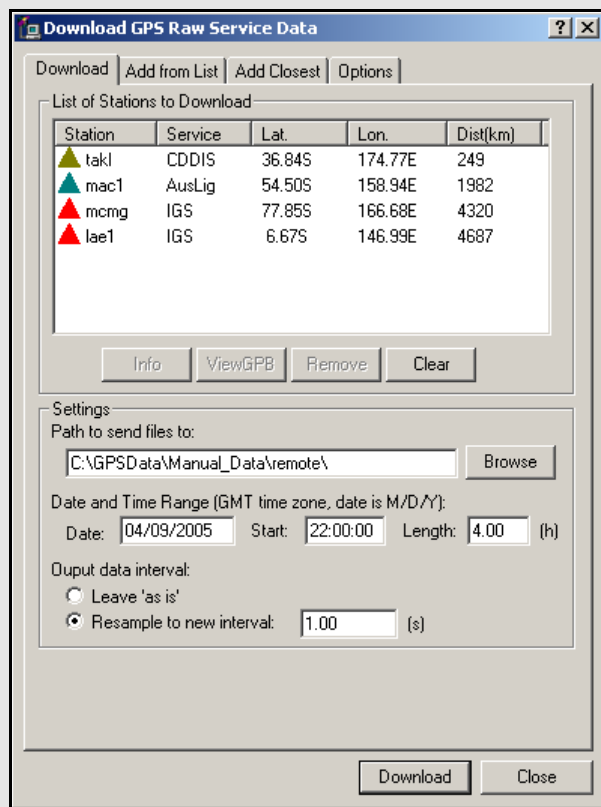
2.8.12 Download Service Data

This utility is available via the *Tools* menu in all of Waypoint's programs. It downloads free RINEX data from different services and converts it into GPB format. The option to resample the data to a higher interval is also available. The accessible services are websites and FTP sites that store data from a number of GPS sites. You are also free to add your own services.

Download

List of Stations to Download

This displays a list of the stations that have been selected for download. The list is empty until you add to it using the *Add from List* or *Add Closest* tabs.

Settings

The *Path to send files to* field specifies where to save the downloaded RINEX and converted GPB files. The *Date and Time Range* parameters indicates the date and time range of the data to be downloaded.

> ✉ A maximum of 168 hours can be downloaded at once.

Selecting *Leave 'as is'* will not perform any type of resampling on the downloaded data. Select this option if you are planning to use the data only in GrafNet. The interval for most data files is anywhere between 1 to 30 seconds and is dependent on the service that the data is downloaded from. For kinematic applications, resample the downloaded data using the *Resample to new interval* option.

Add From List

List of Stations

This window provides a listing of all the data downloading services. Click on them to expand the branch and reveals the list of stations that are obtained through this service. The *Info* button provides rough coordinates for the station of interest. The *Add button* places the station on the *List of Stations to Download* under the *Download* tab.

Download Latest List
This connects to the Waypoint Products Group's (Waypoint) FTP site and downloads the most recently updated manufacturer's files. Waypoint updates the list of stations on a monthly basis. The complete list of stations is in the *manufact.dn1* file. In order to download the entire set of manufacturer files, click the *About Download* button under the *Options* tab.

Add Closest

This tab finds stations that are close to the project area to download data from.

Position
The position is a reference point from which all stations are measured.

The two options available to choose this position include the following:

- It can be entered manually if you know the coordinates for the point of interest.

- Click the *Position* from the *GPB File* button to select a GPB file from the project in which the downloaded data is to be used. The utility uses the computed average coordinates from the position records in the GPB file for the search. To use this feature, the selected GPB file must contain valid positions. See *Section 6.2.3.2,* on *Page 170* for help.

Settings
The two settings that constrain the station search are listed in the shaded box.

Once the position and the searching parameters are defined, click the *Find Stations* button to obtain the list of stations found. They are listed in ascending order based on their distance from the point used for the search. You can choose to download data from all the stations using the *Add All* button, or only from those specifically chosen with the *Add Selected* button. In both cases, the *List of Stations to Download* is updated under the *Download* tab.
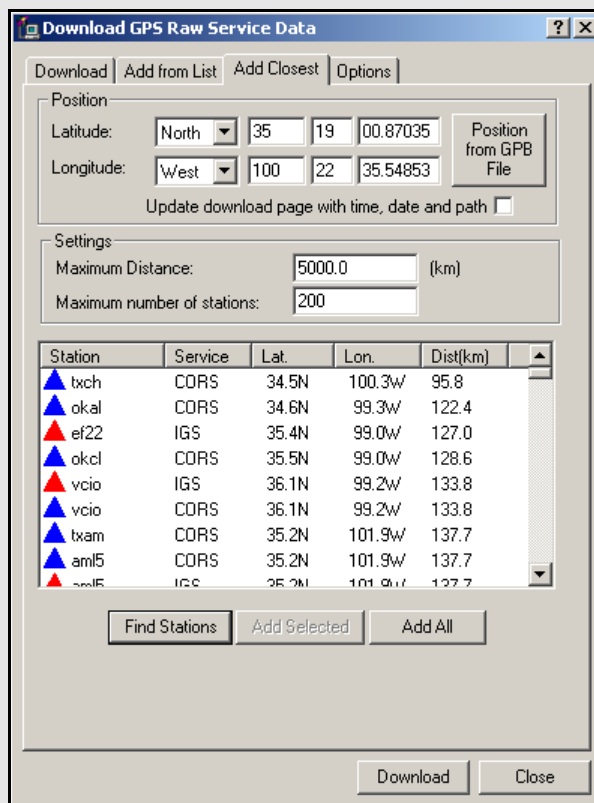
Two settings that constrain the station search include the following

Maximum Distance
The maximum distance that a station can be from the position used for the search in order to be included in the output list.

Maximum number of stations
The maximum number of stations to be displayed in the output list. This setting comes with the option to *Update download page with time, date and path*. Enabling this adjusts the date and time range parameters under the *Download* tab. This ensures that the data downloaded overlaps with the GPB file used for the search.
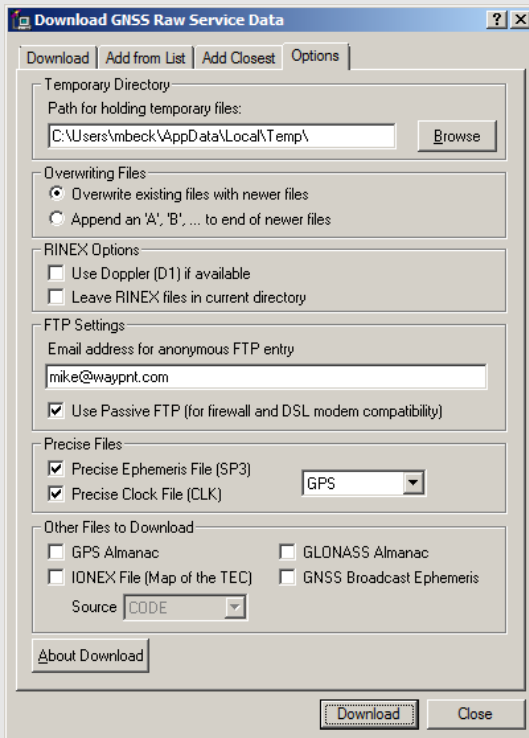
Specified correction files

Precise Ephemeris File
Final precise ephemerides are prioritized. If it is unavailable, the rapid orbit is used instead.

Precise Clock File
Contains information regarding clock biases in all GPS satellites. It is required for precise point processing.

IONEX File
Contains information regarding the total electron count of the ionosphere. This is useful in single frequency/point processing to help the process modeling of the ionosphere.

GPS Almanac
Contains information that will allow the *Mission Planner* to estimate the future whereabouts of the GPS constellation.

GLONASS Almanac
Same as above, but with respect to the GLONASS constellation. This almanac file is supported by the *Mission Planner*.

GNSS Broadcast Ephemeris
Generates an EPP file with all of the GPS and GLONASS ephemerides for the given day.

Options

There are several settings under this tab which require proper configuration in order for the *Download Service Data* utility to function properly.

Temporary Directory
The directory specified here temporarily stores RINEX files while they are being converted into GPB format.

> ✉ This directory cannot be the same as specified under the *Download* tab.

Overwriting Files
If a file already exists in the destination directory with the same name as the file being downloaded, this setting determines which action to take. *Overwrite existing files with newer files* replaces the file with the one being downloaded. *Append an 'A', 'B' to end of newer files* renames the new file to avoid conflict.

RINEX **Options**

> **Use D1 in observation file if available**
> The Doppler measurements in the RINEX file is written as-is to the GPB file.

> **Leave raw RINEX files in Current directory**
> May be selected if you do not wish to have the RINEX files deleted after conversion to GPB is complete.

> **Use New GPB format**
> Disabling this option converts the RINEX files into the old GPB format. Disable this if the data will be used in Version 6.03 or older.

FTP Settings
The FTP sites accessed with this utility are public and accepts anonymous login. To do this, provide an email address to be used as a password for login. Users with a DSL connection, or behind a firewall, might have to enable *Use Passive FTP* for this utility to connect properly.

Other Files to Download
Any files selected here are downloaded for the day specified on the *Download* tab. You can specify any of the correction files listed in the shaded box for download.

Add Stations and Services

In the event that the *manufact.dn1* file does not contain stations recently added to one of the services, add them manually. You can also add a service to use in the utility.

To add a station or service, open *user.dn1* file in the software's installation directory. If the file does not exist, then create it. You can add service or station records.

Station records must conform to the format in the shaded boxes on this page and the next page.

⊠ You might find it easiest to copy a station record from the *manufact.dn1* file and paste it into *user.dn1* file for modifying.

Adding a service requires knowledge of the FTP address at which the data is stored. The directory structure and file type must be known.

Station record format

Station {	sName:	*Four-character station name as saved on FTP server. See Note 1 Page 111.*
	lat:	*Latitude, in DMS, followed by N or S to designate hemisphere.*
	lon:	*Longitude, in DMS, followed by E or W to designate hemisphere.*
	ht:	*Ellipsoidal height, in metres.*
	serv:	*Name of service to which station belongs. See Note 1 and Note 3 Page 111.*
}		

Service record format

Service {	ServId:	*Name of service, up to a maximum of 8 characters. See Note 1 Page 111.*
	ftpAd:	*Address of the FTP server.*
	User Name:	*Required to log into non-public sites. See Note 1 and Note 4 Page 111.*
	Password:	*Required to log into non-public sites. See Note 1 and Note 4 Page 111.*
	oFile:	*Generic path to the observation file. See Note 6 Page 111.*
	dFile:	*Generic path to the compressed observation file. See Note 4 and Note 6 Page 111.*
	nFile:	*Generic path to the GPS navigation file. See Note 6 Page 111.*
	gFile	Generic path to the GLONASS navigation file.
	hoFile:	*Generic path to the hourly observation files. See Note 4 and Note 6 Page 111.*
	hdFile:	*Generic path to the compressed hourly observation files. See Note 4 and Note 6 Page 111.*
	Ftype:	*Type of compression used for files. See Note 2 and Note 4 Page 111.*
	Datum:	*Datum in which the station positions for this service are defined.*
	color:	*Color to use for symbols in utility's interface. See Note 4 and Note 5 Page 111.*
}		

Service record notes

☒ 1. This field is case-sensitive.

2. Only the Z, GZ, and ZIP formats of compression are supported. Field no longer required as of 7.60.

3. The service name must match the *ServID* field of a service record, as defined in the *manufact.dn1* file or, if the service is user-created, in your *user.dn1* file

4. This field is optional and, thus, does not need to be present.

5. The color defined here is used in the interface to identify the stations belonging to this service. The following colors are available: red, green, blue, magenta, cyan, gray, wine, black, gold, darkgray, darkgreen, darkblue, lightcyan, and darkmagenta.

6. This field identifies the format of the directory structure used on the FTP site to organize the data. Any folders in the structure that are common to all data must be hard-coded into this field. The rest, however, must be defined using the following case-sensitive strings:

<JJJ>	*Julian Day*
<YYYY>	*Year*
<XXXX>	*Station ID*
<week>	*GPS week*
<wkrl>	*GPS week - 1024 -* padded with leading zeroes
<wkrn>	GPS week -1024 - without padding
<yy>	*Last two digits of the year*
<d>	*Day of the week (0 – 6)*
<MN>	*Month number*
<DM>	*Day of the month*<h> hour of the day, in lower case (a-x)
<H>	hour of the day, in upper case (A-X)
<II>	hour of the day, numeric (00-23)
<mmm>	first three letters of month (Jan-Dec)

Service records must conform to the format in the shaded box. Refer to the manufact.dn1 file for examples of service and station records.

2.9 Window Menu

This menu option displays the GrafNav windows in different ways.

2.9.1 Cascade

Cascades the windows from the top left to the bottom right of the screen.

2.9.2 Tile

Gives each window a section across the screen.

2.9.3 Next and Previous

Lets you view one window at a time.

2.9.4 Close Window

Closes one window at a time.

2.9.5 Close All Windows

Closes all windows.
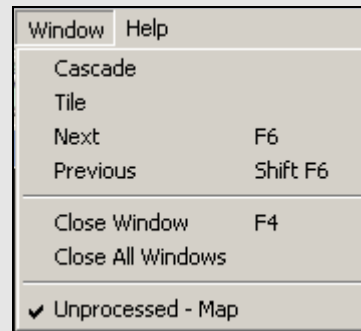
2.10 Help Menu

Files to download from Waypoint's FTP site

manufact.adf
List of antenna profiles. See *Add Master File (s)* on *page 28* for more details.

manufact.dcb.
List of the differential code biases, in nanoseconds, between the P1 and C/A code for each satellite. Used by PPP.

manufact.dn1
List of base stations available for the *Download* utility. This is usually updated monthly.

manufact.dtm
List of datums, ellipsoids, and transformations between datums.

manufact.fvt
List of *Favourites* and the groups they are contained in. These only contain coordinates for stations available with the *Download* utility. See *Section 2.8.12,* on *Page 107* for more information.

manufact.grd
List that contains available grids such as UTM, US State Plane, Gauss Kruger and so on. See *Section 2.8.7,* on *Page 100* for more details.

manufact.svi
A file that associates a PRN number with a satellite type (Block II, Block IIA and so on) for purposes of determining the center of mass of the satellite. It assists in single point processing. This file should not be modified.

2.10.1 Help Topics

Opens an HTML version of this manual. This feature can be very useful as a quick and easily accessible reference.

2.10.2www.novatel.com

This option opens a web browser to NovAtel's website. The Waypoint Products Group's section contains details on the latest versions, patches, information on GPS/INS, and technical reports can be found.

2.10.3About GrafNav

This window displays information about the software version, build dates, copyright information, hardware lock key information, and DLL information.

Access the hardware key utility from this window by clicking *Key Util (Upgrade)*. This tool is useful if an upgrade needs to be performed on the hardware lock. The *Dependent Files* window displays a list of executables and DLLs associated with GrafNav. The date and time of the files are shown, as well as a quick description of the file. Other programs have this feature as well.

With Internet an connection, use the *Download latest manufacturer files* option to connect to Waypoint's FTP site. You can download the files that are listed in the shaded box from this site.

Most of these *manufact* files have an associated user file where you enter your own information to be saved. These files are not modified when you download the latest manufacturer files. Do not directly modify the *manufact* files because they are overwritten when this option is used.

3.1 GrafNet Overview

GrafNet is a static network processing package that creates a single network by tying all the points of static GPS baselines together. Within minutes, GrafNet processes the entire project in a single operation. When the processing is completed, GrafNet color codes the baselines so irregular ones are isolated from the project and can be easily analyzed. GrafNet allows 3 types of static baseline processing solutions, including fixed static, float and ionospheric free.

This chapter tells you about the types of common networks, the different solutions and the methods to produce coordinates for each station in GrafNet. This chapter also describes how to get started with GrafNet, goes through each menu of its interface and provides step-by-step instructions for first-time users.

3.1.1 Types of Networks

Closed Loop Network

Surveyors often use this style of network because of increased reliability. Due to the closing of the loops, any baseline determination errors will show up as tie point error. Such closure values can be seen via *Process | View Traverse Solution*. If just two GPS receivers are employed, then a method called "leap-frogging" can be used to collect the data. In this procedure, starting from a known point, the lead receiver is placed on the first point to be surveyed. After the first session is complete, the trailing receiver is moved ahead of the lead receiver so that it now becomes the lead. The next baseline is observed and this procedure is repeated until small (4-6) loops are closed.

Radial Network

Also referred to as *Single Base Station*. Applications where productivity is more important, like GIS, do not need the same degree of reliability as the closed loop network. For these situations, use open loop networks. An example of this a network is in the shaded box. For this method, one receiver is left stationary over a reference or control point. One of more remote GPS receivers are moved from point to point being surveyed.
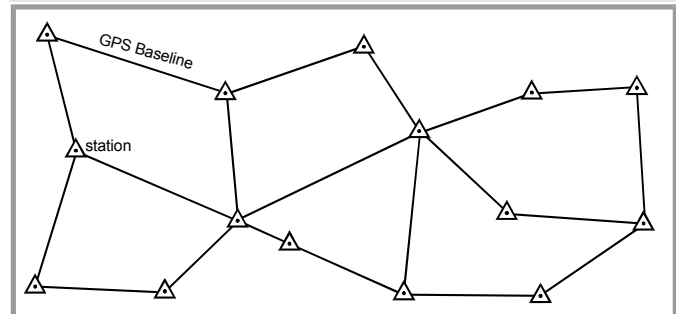
Figure 1: Closed Loop Network

⊠ Antenna height measurement errors will often cancel with this method and should therefore be double-checked. Methods involving more than two receivers become quite complex, and are past the scope of this chapter.
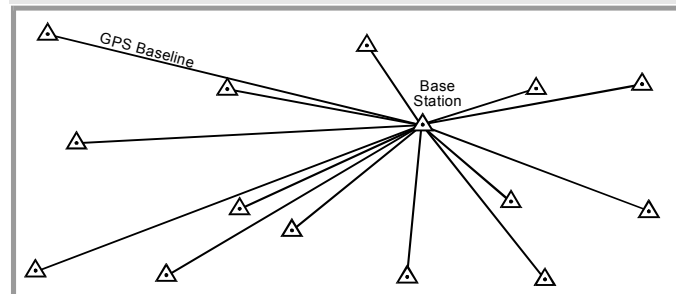
Figure 2: Radial Network

Table 11: Solution Types			
Solution Type	**Fixed integer**	**Ionospheric Correction**	**Description**
L1-Float	N	N	L1 float solution. Used most often with single frequency receivers on short occupations or long baselines.
L3-Float	N	Y	Ionospheric-free float solution. Requires dual frequency but can have very good accuracies on longer baselines if occupation is long enough.
L1-Fixed	Y	N	L1 fixed integer solution. Can be very accurate on shorter baselines. Solution is computed from one continuous period of GPS data with the most satellites covering the longest time. The *Message Log* (FML / RML) file can be viewed to determine how many satellites are used and for how long.
L1-NewFixed	Y	N	L1 fixed integer solution that uses all of the satellites tracked. Satellite tracks that is, satellite-base pair between cycle slips, that fit poorly are rejected. Look at the FSS / RSS file to view each track.
L1L2-Fixed	Y	See **Note**	Same as L1-Fixed except that dual frequency data is used. By using the wide-lane, much shorter fix times are possible. For longer baselines, the iono L2 noise model can be used to improve accuracy.

✉ Ionospheric correction is applied if the *Iono Noise* model is used, which depends on the baseline distance, or if you manually select the *L2 Noise* model. In such cases, the solution type would appear as *L1L2-IonoFixed* or *L1L2-IonoNewFixed*.

3.1.2 Solution Types

GrafNet automatically determines concurrent sessions by examining the start and end times of the observation files. GrafNet tries to form sessions using an extended time scale to resolve any conflicts stemming from differing week numbers. This requires that a valid ephemeris file (EPP) be present for each corresponding observation file (GPB). For more than two receivers simultaneously collecting data, unwanted session connections can be ignored using the *Session Menu*, under *Process | View All Sessions*. The vector for each session is resolved independently. There are three modes of static processing includes the following:

Fixed Solution
This process uses single or dual frequency data, but assumes integer ambiguities. This mode delivers the best accuracies and is also the default static processing mode. Single frequency will fix reliably on baselines less than 10 km, while dual frequency will work well up to 25 km. Longer baselines will require longer observation times.

Float Solution
This method does not solve for integer ambiguities, and therefore, has no baseline length restrictions. Regardless, long single frequency baselines will have much poorer accuracies than their dual frequency iono-free counterparts. Normally, the float solution is only used when either fixed static solutions cannot be made to pass or for long single frequency baselines of 10 km or more.

Iono-free Solution
This is a float solution with the ionospheric effect largely removed from the carrier phase by combining L1 and L2 carrier phases in the iono-free combination. This option requires dual frequency data at both stations. Iono-free should normally be used if the fixed solution fails (on longer baselines), or on very long baselines (greater than 50km) where fixed static is unreliable.

GrafNet also offers an *Automatic* mode, which chooses between the three processing modes by examining baseline lengths and the type of measurements available. *Table 11*, in the shaded box, contains a list of solution types attainable in GrafNet.

After processing, baselines will be green if they passed or red if they failed. If an error occurred and only an approximate 1-5 metre solution was extracted, the baseline will show up as purple. If the baseline shows up as blue, a serious error has occurred. See *Section 3.2.1,* on *Page 120* for steps to follow if a baseline fails.

3.1.3 Computing Coordinates

Once the processing is complete, there are two methods to produce coordinates for each station.

Traverse Solution
This solution automatically computes during processing. It starts from known stations and transfers positions to neighboring stations one baseline at a time. A tie or closure will be computed for stations that already have coordinates transferred.

Network Adjustment
This method takes all of the baselines into account into a single weighted least-squares adjustment. It spreads the errors out over the entire network and takes advantage of redundant baselines using covariance weighting to produce more accurate station coordinates. The network adjustment flags erroneous measurements in the sense that the residuals (calculated baseline vector minus observed value) will be unacceptably high. This is most obviously displayed by the PPM (parts per million) value.

3.2 Start a Project with GrafNet

The information in this section tells you how to start a project and quickly process a static network using GrafNet. The individual menu items are discussed later in this chapter.

Install Software
Verify that the installation was successful by ensuring that you have a *Waypoint GPS* program group on your computer. If this program group is not there, see *Section 1.2.2,* on *Page 16* for installation instructions.

Create a Project
Follow the instructions in the shaded box.

How to install the software

1. See *Section 1.2.2,* on *Page 16* for installation instructions.

How to create a project:

1. Select *GrafNet* from the *Waypoint GPS* program group in your start menu.

2. Select *File | New Project*.

3. Find the directory where the project files will be located. GrafNet creates many files during processing so using a new directory makes things easier.

4. Give the project a name and click *Save*.

✉ Entering the name of a project that already exists overwrites the file contents.

How to convert data

☒ If Waypoint's logging utilities were used to log directly into GPB format, then skip these steps.

1. Select *File | Convert | Raw GPS to GPB*.

2. Browse to the directory containing the raw data.

3. Click *Auto Add All* or select the appropriate GPS receiver and convert the data file.

How to add observation files

1. Select *File | Add / Remove Observations*.

2. Click *Get Folder* and select the directory containing the GPB and EPP files.

3. Select the files that you want added.

☒ You only need to select GPB files. The EPP files are assumed to have identical prefix names.

4. Verify the station ID and the antenna height when the dialogue box appears.

5. Click *OK*.

6. Select *File | Save Project*.

How to add a ground control point

1. Select *File | Add / Remove Control Point*.

2. Press the *Add* button.

3. Select the ID corresponding to the control point to be added.

4. Enter the latitude, longitude, and height for that station.

☒ These coordinates should be in the same datum as the selected under *Options | Datum*.

5. Click *OK*.

How to set the processing options

1. Select the desired static processing mode. These modes are described in *Section 3.1.2,* on *Page 116* .

2. Select the desired processing datum.

Convert Data

To be processed, raw GPS data files have to be converted into Waypoint's GPB format, including raw data from Waypoint's data-logger program. Instructions on how to convert these files are in the shaded box.

Add Observation Files to the Project

Files can be added one at a time by clicking *Add*, or all files in the directory can be added by using *Select All* followed by *Add*. A dialogue box appears requesting verification of the station ID and antenna height. With some receivers this information will be filled in automatically. Always ensure that the ID and antenna heights are correct. Steps on how to add observation files to a project are in the shaded box.

☒ If a station has been observed more than once, the station ID should be the same for each observation. Otherwise, two separate stations will be formed and solved for.

Add a Ground Control Point

Follow the steps in the shaded box to add a ground control point.

Set the Processing Options

Follow the steps in the shaded box to set the processing options.

Process All Sessions

Follow the steps in the shaded box to set the process all sessions. After these steps are completed, error ellipses on each of the single session baselines and the processing window should both appear.

Verify That All Baselines Have Passed

Passed baselines will be plotted in green, failed baselines in red, purple, or blue. Duplicate (yellow) baselines do not show the pass / fail via coloring and must be verified. To verify, follow the steps in the shaded box.

If it is a closed loop network and you feel that the solution is correct despite failing GrafNet's statistical tests, right click the baseline and select *Override Status* to override the status. The traverse will transfer coordinates using failed baselines, while the network adjustment will not.

Run Network Adjustment

Follow the steps in the shaded box to run a network adjustment. After these steps are completed, The *Network Adjustment Results* will open, while error ellipses will be plotted for each station on the *Map Window*.

Export Station Coordinates

Follow the steps in the shaded box to export station coordinates.

Clean Up processing Files (optional)

Follow the steps in the shaded box to remove some of the intermediate processing files.

How to process all sessions

1. Select *Process | Process Sessions*.

2. Select *All unprocessed* as the *Sessions to Process* under the *Process* tab.

3. Click the *Process b*utton.

How to verify that all baselines have passed

1. Right-click the failed baseline.

2. Select *View Results* or *View Information* to find out where the problem lies.

How to run a network adjustment

1. Select *Process | Network Adjustment*.

2. Press *Process*.

How to export a station coordinate

1. Select *Output | Export Wizard*.

2. Enter an output file name.

3. Select the source for the coordinates (usually *Network*).

4. Select a profile containing the desired output variables.

How to clean up processing files

1. Select *File | Remove Processing Files*.

How to fix bad baselines

Fixed Static Solutions

If fixed solution fails, then try to switch to a float solution. Remember that float solutions are not very good at achieving centimeter accuracies unless there are many hours of data.

Forward / Reverse Processing

Switch from Forward to Reverse processing. The reverse solution might pick a different base satellite and have a different solution that passes. GrafNet will pick the forward or reverse solution with the latest date so reprocess the forward solution if the reverse is unacceptable.

Changing the Elevation Mask

GrafNet by default uses a 15° elevation mask. This is because tropospheric and ionospheric errors increase significantly on low satellites. Lowering the mask to 10° allows more satellites into the solution, strengthening the geometry. This improvement might offset the atmospheric errors.

Use ARTK

Use ARTK in GrafNav for an individual baseline. Edit with GrafNav and then reprocess with GrafNav and then reprocess by enabling ARTK and engaging ARTK in static mode.

Start and End Times

The start / end times can be modified from within the *General* tab. Sometimes a data set can have parts that are unusable. A good indicator is the *L1 Phase RMS* plot. Entering the start and end times eliminates these parts by selecting the appropriate times. Another way to find good sections of data is to view the FSS or RSS files. There is a section at the start showing numerous periods of cycle slip free data for various satellites, and it also shows which period was used. You can also try entering the start / end times from another period exclusive to the one used.

Continued in the shaded box, on the following page.

3.2.1 Fix Bad Baselines

Some baselines appear red when running GrafNet and duplicated baselines will stay yellow. When examining the baseline sessions from within the *Sessions* window of the *Data Manager*, one or more sessions will have *Bad* indicators. This means that one or more tests have failed in the static solution. If a baseline is flagged as *Approximate*, then the baseline was only able to achieve an approximate (1-5 m) solution and it has failed. These baselines can also be considered *Bad*.

The purpose of this section is to help you re-process these baselines to achieve better results. There are many causes of a failed baseline, and not every solution is given. In some cases, the correct solution has been found, but the statistics just fail. This indicates that GrafNet cannot label this baseline as correct. If there are loops that are closed in this solution, then you can change the status from *Bad* to *Good* using *Override Status* from within the *Sessions* window of the *Data Manager*.

The shaded boxes on this page and the following page contain optional approaches to fix bad data.

How to fix bad baselines continued...

Doppler Usage

Bad Doppler data sometimes makes data process poorly. Detect this by plotting the L1 Doppler RMS. If there are any large spikes (5 or more times the size of the Doppler standard deviation), then this data may have problems. Try to shut the Doppler OFF for carrier phase processing from within the *Advanced* Options.

Satellite Omission

A bad satellite has many bad data warnings in the message log file (FML/RML). Omit this satellite with the *Advanced* tab options.

Measurement Standard Deviations

For a float or iono-free solution, changing the standard deviations for both the L1 carrier phase and the C/A code improves a solution. Obtain suitable standard deviations by viewing the plots for both the C/A code RMS and the L1 phase RMS. A good standard deviation value is one which about 90% of the RMS falls below. Realistic values allow the Kalman filter to perform better.

3.2.2 Unfixable Data

Sometimes data is simply bad and changing the options cannot help. This section discusses some of the possible causes of such data in the shaded box. For some cases, there is advice for improving the solution.

About unfixable data

Moving Antenna

An antenna that is not still causes havoc with static processing. This can be caused by an operator not holding the antenna still, heavy winds or a vehicle that is rocking. Theoretically, this data should be processed as kinematic and the position solutions averaged but GrafNet does not currently support this mode of processing so this data should be avoided. If it needs to be processed, a float solution will perform best.

Ionospheric Effect

Heavy ionospheric activity can cause large carrier phase noise. A single frequency receiver cannot do much to alleviate the problem. However, dual frequency data will most likely process better with an iono-free solution rather than some of the fixed integer techniques, such as the fixed solution.

Constant Loss of Lock

Antennas placed under trees or similar obstructions will often continuously lose lock, which causes the fixed static to fail and the float solution to report poor accuracy.

Poor Antenna Location

High multi-path mostly affects the C/A code but the carrier phase can also be affected and might cause a fixed solution to fail. Antennas placed near large metal structures are most affected. Locations on rooftops can also cause poor data. Avoid these locations. The only suggestion for possibly improving this data during processing is to reduce the size of the C/A code standard deviation from within the *Measurement* tab of the processing options.

Receiver Problems

Sometimes a GPS receiver just collects bad data. Low power or a poor antenna connection can cause this. If the problem is consistent with a particular GPS receiver unit, have the manufacturer check the GPS receiver.

3.3 File

3.3.1 New Project

To process a network for the first time, you must start a new project, which is done via *File | New Project*. GrafNet's project configuration files carry a GNT extension.

3.3.2 Open Project

To open an existing project, follow the steps in the shaded box.

3.3.3 Save Project

The program automatically saves the project file (GNT), the *Session Report* (REP) and *Traverse Solution* (TRV) files before processing. Any changes made to the observations like name or antenna height are also saved.

3.3.4 Save As

Use the *Save As* command under the *File* menu to create a new project that has identical processing options as the current project. This allows you to change the options in the new project and process the data without losing the solution computed by the original configuration.

3.3.5 Print

This option allows you to print different windows.

3.3.6 Add / Remove Observations

This feature adds observation files to GrafNet projects. These files must be converted to GPB files using *File | Convert | Raw GPS to GPB*. GPB files are already created if you used Waypoint's data logging software and choose to log into GPB format.

GrafNet extracts the station name and antenna height values from the STA file, which is created during the conversion process.

How to open a project

1. Choose *Open Project* from the *File* menu.

2. Choose the name of the project from the dialogue box that appears asking you to select the name of an existing project (GNT file).

3. Click *Open*.
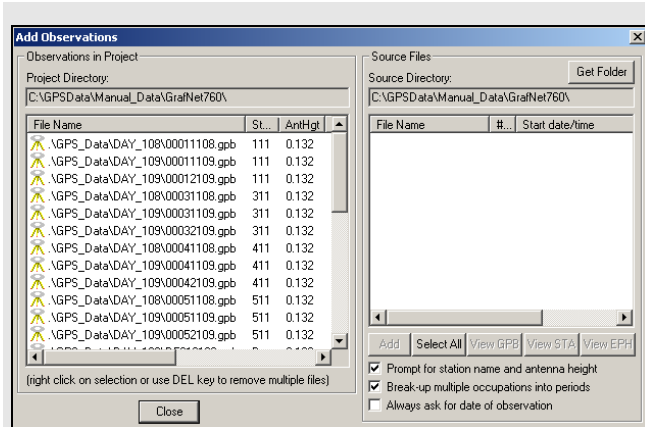
Station Name and Antenna Height

Verify that these values are correct and disable the option *Prompt for station name and antenna height* to add observations without user input. Double-check *station names* and *antenna heights* in the *Observations in Project* list. Correct errors by right-clicking the observation and selecting *Edit*.

Antenna Profiles

GrafNet lets you select an antenna profile. Because additional offsets to the L1 and L2 phase centres are added, when using profiles other than *Generic*, match up the antenna height measurement to the expected measuring mark on the antenna. See *Section 2.3.6,* on *Page 28* for help. If a slant measurement is selected, then a correction is applied based upon the size of the antenna ground plane. Be sure that the origin, know as the measuring mark, is defined.

Observation Files

Adding observations breaks observation files into multiple periods if a gap of 3 minutes or more is detected. This is controlled with *Break-up multiple occupations into periods*. Some RINEX files have gaps but are observed over the same point for the entire observation period so disable this option. For cases where the time gap is very short because the station-to-station movement is very fast, control the minimum time gap for breaking up periods with the *Solution and Session* tab, under *Options | Global Settings*. Look for the Minimum time span for breaking up observations into periods.

⊠ Station IDs must match those of all observations for a given station and those of matching ground control points. Reprocess sessions associated with an observation if the antenna height has been changed. This is performed by right-clicking on the station for that observation and selecting *Remove Processing Files*. Then, select Reprocess entire project under *Process | Process Sessions*.

3.3.7   Add / Remove Control Points

Add at least one horizontal ground control point before processing. Sessions will not be processed unless they are connected to a control point. The three types of control points include the following:

- 3D: constrained horizontally and vertically
- 2D: constrained horizontally
- 1D: constrained vertically

After selecting *Add / Remove Control Points* from the *File* menu, click *Add* to enter a new control point or *Edit* to adjust the station, position or Datum of a control point. The station ID should match that of the corresponding station.

Standard deviations can be entered at this stage. The default values are 5mm for horizontal and 5mm for vertical. You can change them to more realistic values. Standard deviations are only taken into account in the network adjustment. They are useful for combining high and low accuracy control points.

3.3.8   Add / Remove Check Points

Check points are useful for gauging how well the network fits the existing control fabric. They are added in the same manner as control points, except that standard deviations cannot be defined. It is important that the processing datum matches the coordinates' datum.

3.3.9   Alternate Ephemeris / Correction Files

Adds additional precise or broadcast ephemeris files (SP3 / SP3c and EPP files). See *Section 2.3.8,* on *Page 30* for more information.

⊠   Be sure that the entire span is covered.
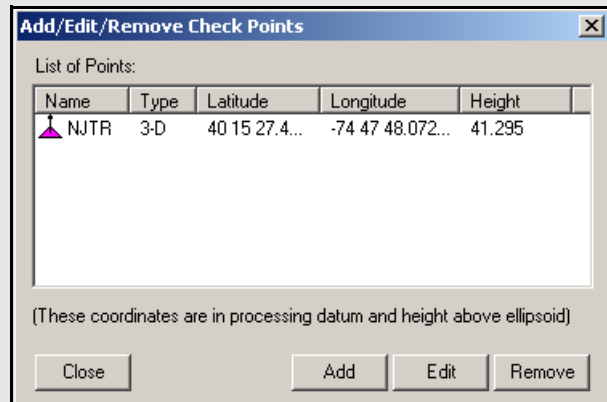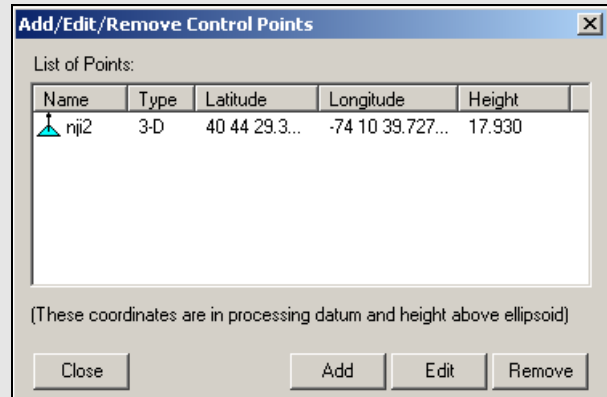
⊠   The latitude and longitude coordinates should be in the same datum as the selected datum. The height can be entered as meters above the ellipsoid or above mean sea level. If height above mean sea level is used, you will have to select a geoid file. If a mean sea level, or orthometric, height is entered here, then only an approximate geoid correction is applied. As stations become more distant from the control point, orthometric height errors will increase. If more than one control point is present, and orthometric heights are entered, the height ties may be poorer as well.

Two conversion utilities available with *File | Convert*

Raw GPS to GPB

Users who have logged their data without using Waypoint's logging software will have to convert their files to GPB format in order to process them with the software. More information on this utility is available in Chapter 7.

GPB to RINEX

Users who wish to produce a RINEX file from their GPB files may do so using this utility. This utility supports the creation of Version 2.0 and 2.1 of the RINEX format. For additional information, see *Chapter 5* on *Page 153*.

3.3.10 Remove Processing Files

This feature can be used to clean up a directory by removing the session-dependent files. Solutions for static sessions are stored in the FSS for forward and RSS for reverse processed files. The FWD / REV and FML / RML files are unnecessary and can be removed. Selecting *All Files* removes all files including the solution files. You must reprocess for further analysis. See *Section 2.3.12,* on *Page 40* for details.

3.3.11 Import Project Files

This feature does the following:

- Reads all configuration file settings from the selected CFG
- Copies the processing files associated with the CFG
- Loads the new solution into memory.

3.3.12 View

ASCII File

See *Section 2.4.8,* on *Page 49* for information regarding this feature.

Raw GPS Data

See *Section 2.4.9,* on *Page 49* for information regarding this feature.

3.3.13 Convert

The two conversion utilities that are available with this option are listed in the shaded box.

3.3.14 GPB Utilities

A number of utilities are available for use with GPB files. See *Chapter 6* on *Page 167* for information regarding any of these utilities.

3.3.15 Recent projects

Displays recent projects.

3.3.16 Exit

Exits program.

3.4 Process Menu

3.4.1 Processing Sessions

This option brings up the *Process Sessions* window, where a number of options pertaining to processing are available.

Process
Sessions to Process
Allows you to decide which session to process. The options are listed in the shaded box.

Processing Settings
Determines which processing settings to use for each baseline. The options are listed in the shaded box.l

On Completion
Defines actions to be taken when processing is completed. The following two settings are available:

> ***Show sessions being processed in data window***
> Displays all processed sessions in the *Data Manager* window.

> ***Run network adjustment on completion***
> Will automatically bring up the *Network Adjustment* window. See *Section 3.4.6,* on *Page 133* for more information.

General Options
Process Direction
The direction can be set to *Forward, Reverse*, or *Both directions*. GrafNet uses the most recently created solution file. The forward and reverse solution should provide roughly the same solution but in some circumstances, a reverse solution passes when a forward has failed, or solutions may differ because of different base satellite selections. If both directions are selected, the combination of the two solutions will be used. See *Section 2.5.2,* on *Page 63* for more information.
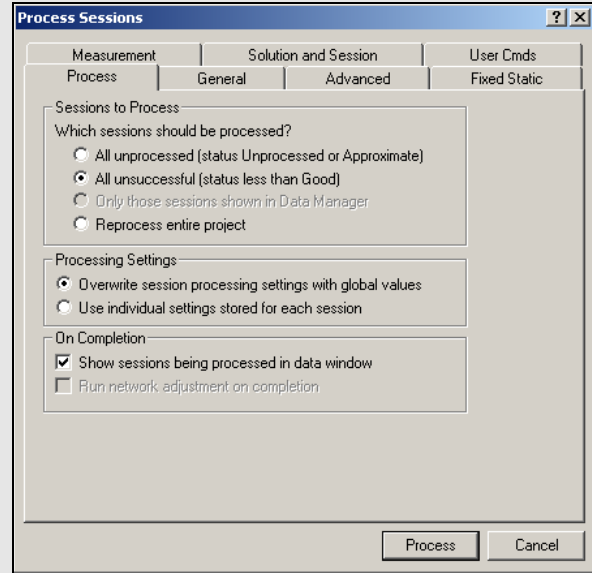
Sessions to process

All unprocessed
Processes all session listed as either *Unprocessed* or *Approximate* that is, blue or purple in *Map Window.*

All unsuccessful
Processes sessions that do not have a *Good* status that is, not green in the *Map Window.* Processing will start nearest to the control points and move outward. For processing problem sessions, it may be better to process through GrafNav.

Only those session shown in Data Manager
Will only process the sessions that are presently listed in the *Data Manager* window.

Reprocess entire project
Reprocesses all solutions, regardless of status. It is a good idea to reprocess all sessions after changing the global options.

Processing settings

Overwrite session processing settings with global values
Will apply the options set under *Options | Global Settings* to all baselines being processed. Any individual baselines whose settings were changed will have their settings overwritten.

Use individual settings stored for each session.
Will use the options as individually set for each baseline for processing.

Table 12: Processing Modes

Mode	Freq.	Minimum Observation Time (min)	Maximum Distance (km)	Approximate Accuracy
Fixed	Single Dual	15 5	15 50	5mm + 1ppm 5mm + 1ppm
Float	Single	*See Note 2*	*See Note 3*	10mm + 2ppm
Iono-free	Dual	*See Note 2*	*See Note 3*	10mm + 0.5ppm
Auto	Single Dual	Chooses between **Fixed** and **Float** depending on baseline distance. Chooses between **Fixed** and **Iono-free** depending on baseline distance.		

✉ 1. Observation times should be increased for longer baselines. For single frequency, a good rule of thumb is 10 min + 1 min / km. For dual frequency, these times can be halved. Observation times should also be increased during poor satellite geometries that is, high PDOP.

2. No minimum time is given, but accuracy improves with observed time. A few minutes of observation will only achieve sub-metre accuracies under very good operating conditions.

3. For dual frequency receivers, use fixed or float solutions for baselines less than 50 km, and iono-free solutions for more than 50 km.

4. Accuracies are given for average occupation time. Accuracies will increase for longer times, and degrade with poor geometry or bad measurement quality.

5. Use precise ephemeris for baselines longer than 150 km. See *Section 3.3.9,* on *Page 125* for information.

Static Solution Type
See *Table 11* on *Page 116* for information

Frequency
Defines the type of data used for processing. The following settings are available:

Single frequency
Forces single frequency (L1 only) processing

Dual frequency
Forces dual frequency processing. L1 / L2 data must be present in all observation files.

Automatic
Auto-detects single or dual frequency processing for each baseline. This is the default mode and should be used under most circumstances.

GPS / GLONASS Mode
Applies to data logged using GLONASS-enabled receivers. The following settings are available:

Automatic
Enables the use of GLONASS data.

GPS only
Disables GLONASS processing. This option may be useful if GLONASS data is causing problems.

GPS+GLONASS
Forces the use of available GLONASS data. Should be used if automatic detection fails.

Elevation Mask
Satellites below this mask angle will be ignored. The default value is 15°. Lowering this value will allow more satellites to be used, possibly improving a solution with poor geometry.

Time Range
This option is only available for individual baselines by right-clicking on the session in the *Data Manager* and selecting *Options*.

Interval
Allows you to choose the processing interval. The default interval is the interval at which the data was logged. If the logged data rate is high (1 Hz), override this interval with 15 seconds. Processing static data at intervals shorter than 15 seconds is not beneficial, will not improve accuracies and could result in overly optimistic accuracy estimates due to the high time correlation of carrier phase data.

Advanced Options

Satellite Omissions
See *Satellite / Baseline Omissions* in the *Advanced Tab* on *Page 52* for more information.

Cycle Slip Settings
The settings are listed in the shaded box.

GrafNav / GrafNet Interface Settings
If you export baselines to GrafNav, the choices in the shaded box are available to specify how changes made to the processing settings in GrafNav affect those in GrafNet.

⊠   If you decide to have the processing settings in GrafNet updated to match those used in GrafNav, they will only be stored for the individual baseline that was exported. The global processing options for the GrafNet project are unaffected.

Fixed Static Options
See *Section 2.5,* on *Page 50* for information regarding all the settings on this tab.

Measurement Options
See *Section 2.5,* on *Page 50* for information regarding all the settings on this tab.
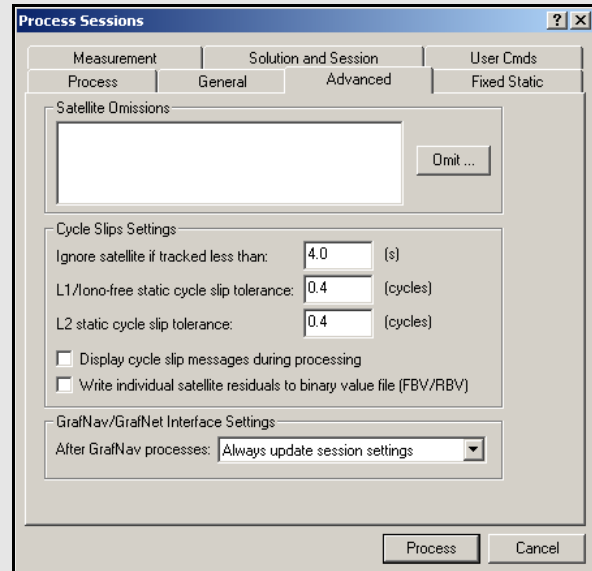
Cycle slip settings

Ignore satellite if tracked less than
See *L1 carrier locktime cut-off* in the *Advance 1* options tab on on *Page 60* for more information.

L1 / Iono-free static cycle slip tolerance
See *Static cycle slip tolerance* in the *Advance 1* options tab on on *Page 60* for more information.

L2 static cycle slip tolerance
See *Small L2 cycle slip tolerance* in the *Advance 1* options tab on on *Page 60* for more information.

Display cycle slip messages during processing
See *Write cycle slips to message log* in the *Advance 1* options tab on on *Page 60* for more information.

Write individual satellite residuals to binary value file
See *Write MB binary values / satellite residuals* in the *Advance 1* options tab on on *Page 60* for more information.

GrafNav / GrafNet Interface Settings

Always update session settings
Any changes made to the processing settings in GrafNav will be saved to that baseline's processing settings in GrafNet.

Never update
Any changes made in GrafNav will not be saved in GrafNet. As such, GrafNet will retain the settings that were used at the time of export.

Prompt user before update
You will be prompted after every processing run in GrafNav as to whether or not the processing settings used should be saved to GrafNet.
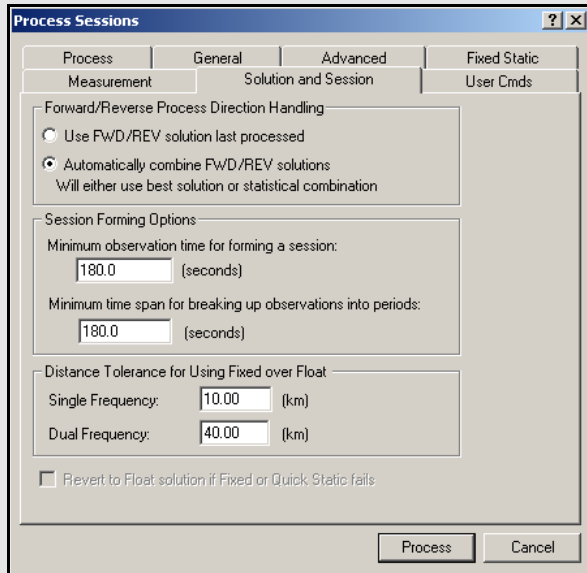
Session Forming Options

Minimum observation time for forming a session

Controls the minimum number of seconds necessary to declare concurrent observation files as a session. The default value is three minutes. For dual frequency data, this time can be reduced, while for single frequency data, this value may have to be lengthened to avoid short / low accuracy baselines.

Minimum time span for breaking up observations into periods

Controls the time required between sessions in order to have them recognized as two separate sessions. The default is three minutes. This gets used when observations are added to the project with the *Break-up multiple occupations into periods* option enabled in the *Add Observations* window. See *Section 3.3.6,* on *Page 123* for more information.

Solution and Session Options

Forward / Reverse Process Direction Handling

Allows you to change the way forward and reverse solutions are chosen for use in the network. By default, GrafNet will load the latest solution (most recently processed). However, if you want to use a combined solution, select the *Automatically combine FWD / REV solutions* option.

Session Forming Options

The two settings available are listed in the shaded box.

Distance Tolerance for Using Fixed Over Float

This tolerance is used when you select *Automatic* for the *Static Solution Type* under the *General* tab. If the baseline distance is longer than the tolerance, then a float solution will be used for single frequency, while an iono-free solution will be used for dual frequency. Otherwise, the fixed static solution is used.

User Command Options

See *User Cmds* on *Page 62* for more information on this tab. The list of available commands can be found in *Appendix A* on *Page 216*.

3.4.2 Rescanning Solution Files

This option rescans the FSS (forward static solution) or RSS (reverse static solution) files. When deciding between the forward or reverse, it will use the one most recently created. Under normal circumstances, solution scanning is automatic, but there are a few instances when you may want to rescan manually, such as when using GrafNav in conjunction with GrafNet.

3.4.3 Ignore Trivial Sessions

GrafNet defines trivial baselines as those that are unnecessary and result from multiple receivers simultaneously running. The problem with this is that the baseline solutions computed by GrafNet are correlated, and so they are dependent. Removing trivial baseline reduces these dependencies, while still maintaining a closed loop. It also creates a network where the standard deviations reflect the actual errors more accurately.

Consider the network in *Figure 3*. The six stations are surveyed with four receivers during two one-hour sessions. During the first session, stations A, B, C, and D are observed. During the second session, the points C, D, E, and F are observed.

This network can be divided in two sub-networks, formed by the first and second time periods. Before the trivial baseline removal, every baseline in these two sub-networks is dependent on the other baselines. These dependencies cause the loop ties to be low.

With four receivers or more collecting data at the same time, a sub-network is very over-determined. Using three GPS receivers, the network is still over-determined, but all baselines need to be included to form a closed loop. GrafNet removes these dependent or trivial baselines by creating a single loop that connects all of the points in the sub-network. *Figure 5*, in the shaded box, illustrates that it is easy to remove these baselines.

With four receivers, there are two dependent baselines in each sub-network. GrafNet removes these trivial baselines for each sub-network. *Figure 4* shows two possibilities of what GrafNet might do with the first sub-network.

GrafNet removes the trivial baseline by setting their session status to *Ignore*. It is possible to un-ignore any session by simply changing its status back to *Unprocessed*. GrafNet tries to keep the sessions that are of best quality. The following criteria is considered:

- The amount of time the baseline was surveyed
- The frequencies used in the surveying of the session
- The length of the baseline
- The number of connecting baselines to the two end-points

As shown in *Figure 5*, GrafNet automatically excluded AC, BD, CE, and DF. It then forms a single loop for each of the time periods. DC is a baseline with a duplicate session.
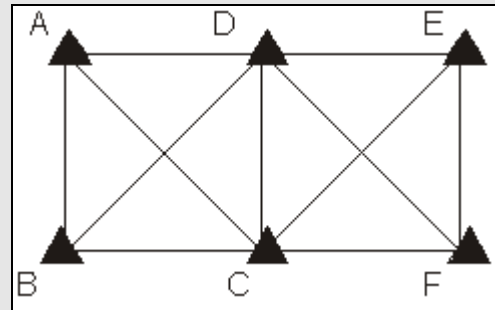
Figure 3: Trivial Baselines
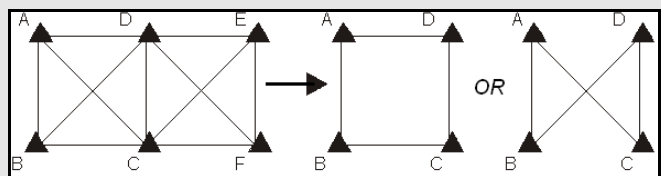
Figure 4: Removal of Trivial Baselines
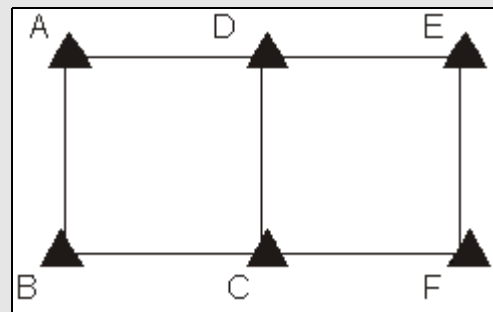
Figure 5: Network with Trivial Baselines Removed

```
Compute Loop Tie                                    [X]

  Stations: 111, D50211, D50311
  Sessions: 111 to D50211 (1), D50211 to D50311 (1), 111 to D50311 (1)

  dEast:    -0.001 m
  dNorth:   -0.001 m
  dHeight:  -0.012 m

  NumGood:       3
  NumBad:        0
  NumApprox:     0
  NumTotal:      3

  TotalLength:   43.124 km
  MinLength:     8.710 km
  MaxLength:     17.458 km
  AvgLength:     14.375 km

              [     OK     ]
```
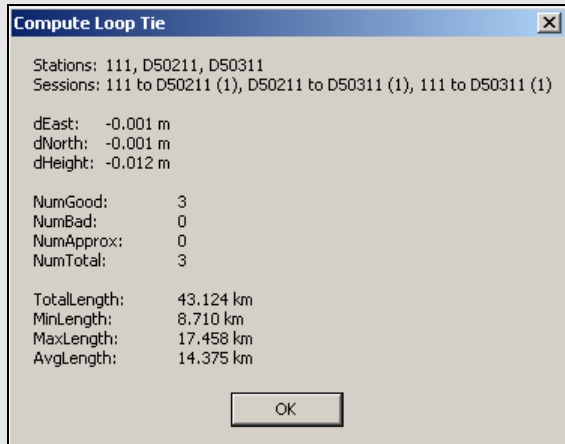
3.4.4 Unignore All Sessions

This feature changes the status of all ignored sessions from *Ignore* to the status they had previously.

3.4.5 Compute Loop Ties

In some cases, the Traverse or Network residuals shows a poor fit. The first step is to ensure that the network is minimally constrained, which means that there should only be one 3-D control point, or one horizontal and one vertical point. Convert any additional control points to check points. See *Section 3.3.8,* on *Page 125* or *Section 3.6.5,* on *Page 140* for help.

For a constrained network, the poor fit indicated by large residuals can be caused by the following two issues:

- •   Incorrect antenna heights used for multiple occupations of a point

- •   Baseline solution is incorrect (by far the most common cause)

In some cases, it is obvious from the traverse output which baseline is the culprit, but often, further investigation is required. The Compute Loop Tie feature makes such examinations much easier. By adding the vectors of a loop within the network, discrepancy values are formed in the east, north and height directions. For a loop without problems, these values should be near zero. If not, then one of the baselines forming the loop has an error. Loops can be formed in the following two ways:

- •   Selecting stations of vertices

- •   Selecting baselines forming legs of loop

Make the selections on the map or by selecting stations or sessions in the *Data Manager* window. After selecting the first station or session, hold down the *Ctrl* key while selecting the remaining ones. Selection must be continuous, but it does not matter if the loop is formed in the clockwise or counter-clockwise direction. Once a complete loop is formed, select *Process | Compute Loop Tie* or right-click on one of the selections in the *Data Manager* window and select *Compute Loop Tie*. A window containing various statistics for the closed loop will be displayed.

3.4.6   Network Adjustment

This option invokes the network adjustment contained within GrafNet. External network adjustment programs, such as GeoLab, also support GrafNet's output format.

The network adjustment is only available within GrafNet, and it is a means to more accurately compute each station's coordinates given the solution vectors computed for each session / baseline. Such an adjustment uses the X, Y and Z vector components, and also utilizes the 3 x 3 covariance matrix which is the standard deviation values + coordinate-to-coordinate correlation. Using least squares, the errors are distributed based on a session's estimated accuracy. More weight is placed on sessions with lower standard deviations.

Advantages

In the traverse solution, each station's coordinates are determined using one session from one previous station. For networks with redundant measurements, which is usually the case, this can lead to a sub-optimal or even erroneous determination of a station's coordinates. The network adjustment does a much better job of distributing errors than the traverse solution. This makes it less sensitive to errors as long as a session's estimated accuracy is representative of actual errors. Thus, the network adjustment generally produces more accurate station coordinates.

Another advantage of the network adjustment over the traverse solution is that it assigns a standard deviation to each point. Estimated standard deviations should be used with caution, but they are a good tool for locating outliers. See *Section 3.4.2,* on *Page 130* for more information on scaling standard deviations to match the data accuracy.

Before running the network adjustment, all baselines must have already been processed. Only good (green) baselines will be used, unless otherwise specified with the *Utilize sessions labeled 'BAD' in network adjustment* option.
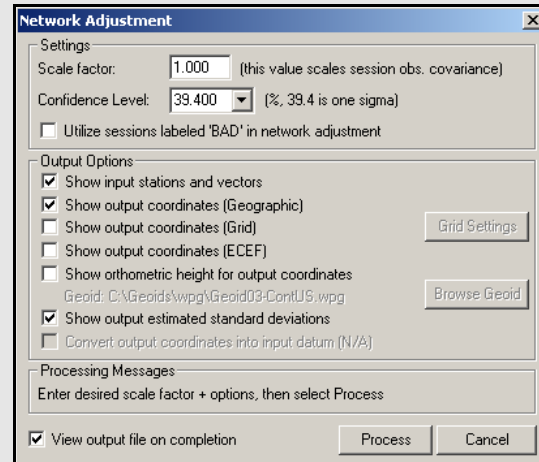
How to process with the Network Adjustment

1. After successfully processing all of the baselines within GrafNet, access the network adjustment via *Process | Network Adjustment*.

✉ The network adjustment will only accept session data flagged as *Good*. Other baselines will be ignored unless otherwise specified with the *Utilize sessions labeled 'BAD' in network adjustment* option.

For the initial few runs of the network adjustment, the scale factor should be set to 1.0. This will not scale the final standard deviations to match observed session vector residuals. See *Page 135* for more information.

2. Click *Process* to compute a network adjustment solution. This will display any errors encountered.

3. If there are any "hanging stations", which are stations that are not attached to the network or are attached by a *Bad* baseline, the adjustment will fail. It is possible to change the status of the baseline to *Good* from the *Sessions* window in *Data Manager*.

4. A .net file is created, which can viewed via *Process | View Network Adjustment Results*.

✉ The network adjustment must be re-run if you have reprocessed sessions or changed the station configuration.

How to interpret the output

The network adjustment output is an ASCII file, which can be printed from GrafNet.

Input Stations
This is a list of the control (GCP) and check (CHK) points in the project. Their associated geographic coordinates and standard deviations are also shown.

Input Vectors
This is the ECEF vector components for each session that has a *Good* status. The lower triangular of the ECEF covariance matrix is shown next to the vector components. The value in brackets is the standard deviation of the ECEF X, Y or Z axis in meters. The covariance values are not scaled by the Scale Factor entered at the start.

Output Vector Residuals
This is the most important section of the network adjustment output. It indicates how well the session vectors fit in the network. The residual values are shown in local level, where RE is the east axis residual, RN is the north axis residual and RH is the Z axis residual. These values are expressed in meters and should ideally be a few centimeters or less. Larger values may be acceptable for larger networks.

In addition to the residual values, a parts-per-million (PPM) value is shown. This indicates the size of the residuals as a function of distance. 1 PPM corresponds to a 1 cm error at a distance of 10 km. The baseline length is also shown in kilometers. Baselines less than 1 km can have large PPM values. This is because other errors such as antenna centering become an influencing issue. This might not indicate an erroneous session solution. The last value is the combined (east, north and up) standard deviation (STD). This indicates sessions that have one or a combination of the following:

- float solution
- poor satellite geometry (that is, high PDOP)
- short occupations

Settings

Scale Factor
Error ellipses should appear on the stations in the *Map Window*. These ellipses are scaled by this option.

Confidence Level
The level of confidence (in percent) of the error ellipse can also be adjusted. This uses a statistical 2-D normal distribution. Changing this value does not alter the final coordinates, but it will scale the final standard deviations and covariance values. For example, 95% results in a standard deviation scale factor of 2.44.

Output Options
Controls what is output from the network solution.

Show input stations and vectors
Outputs all the control and check points and their vectors. The coordinates are output in geographic form.

Show orthometric height for output coordinates
Requires that you provide a geoid file, which can be selected with the *Browse Geoid* button.

Other output options include outputting the estimated standard deviations.

To process the network adjustment, press the *Process* button. This step must be performed each time a project is re-loaded.

View output file on completion option.
Lets you view the ASCII solution file once the adjustment has been made.

Using Multiple Control Points

When multiple control points are present, it is important to initially only use one. This will prevent errors in the existing control from causing otherwise correct session vectors not to fit. Therefore, large tie errors in the traverse solution or large residuals in the network adjustment are attributed to GPS errors.

The variance factor is only truly valid as a scale factor for a minimally constrained adjustment. See *How to interpret the output* in the shaded box. Once satisfied with the quality of the GPS data and the fit of the session vectors, you can add additional control points with *File | Add / remove Control Points* or by right-clicking on a station in the *Map Window* and selecting *Add as Control Point*.

Since the network adjustment is a least-squares adjustment, it attempts to move control point coordinates to make the network fit better. This is an undesirable effect for many applications. To avoid it, give control points very low standard deviations. The default value is 5 mm, which might have to be lowered if the network fit is poor. Lowering the standard deviation to 0.0001 m forces the control point to "stay put". A standard deviation of zero is not allowed. Change the standard deviation for control points via *File | Add and Remove Control Points*. Select the desired control point and click *Edit*.

Using Horizontal and Vertical Controls

GrafNet supports horizontal and vertical control points in addition to full 3-D control. To utilize this control, you must have available 1-10 m accurate coordinates for the unknown axes (that is, Z for horizontal points and latitude and longitude for vertical points). These coordinates can be obtained from the single point solution (in the absence of SA) or from an initial network adjustment run using just one 3-D control point. The latter method is normally used.

When the vertical and horizontal control points are added, it is important to de-weight the unknown axes. For vertical control points, the horizontal standard deviation is set to 100+ m. For horizontal control points, the vertical standard deviation is set to 100+ m.

Obtain Orthometric Heights

Orthometric heights are available in the network adjustment output.

How to interpret the output cont.

Check Point Residuals

If check points have been added, this section shows how well the known coordinates compare to those computed by the network adjustment.

Control Point Residuals

This section shows the adjustment made to control point residuals. When just one control point is used, then the adjustment will always be zero. With two or more points, the adjustment depends on the input control point standard deviation and the session vector standard deviations.

Output Station Coordinates

This shows the computed coordinates for each of the stations both in geographic and ECEF coordinate systems. The output datum is indicated by the *Datum* parameter at the top of this file.

✉ The geographic height should be ellipsoidal. However, this is only true if you enter an ellipsoidal height for the control point elevation.

Output Variance / Covariance

This section shows the local level (SE, SN and SZ) standard deviations along with ECEF covariance values. The standard deviation values are scaled by both the input scale factor and the statistical (confidence) scale factor and the covariance values are only scaled by the input scale factor. If error ellipse parameters are desired, then the *Write Coordinates* feature should be used.

Variance factor

See *Page 135* for information.

Variance Factor and Input Scale Factor

The variance factor is at the bottom of the network adjustment output. It is the ratio between the observed residuals errors and the estimated session (baseline) accuracies. Ideally, the variance factor should be 1.0. This indicates that the estimated errors correspond well to observed errors. A variance factor less than 1.0 indicates that the estimated errors are larger than the observed errors (that is, session standard deviations are pessimistic). Most often, value greater than 1.0 denotes that observed errors are larger than estimated accuracies (that is, session standard deviations are optimistic) exists unless the GPS data is very clean. Thus, low variance factors are normally desired. Very large variance factors 100+ normally indicate abnormally large session errors (that is, a very poor network fit), and you should try and investigate the source of the problem before using the coordinates produced.

The variance factor can also be used to scale the station standard deviations to more realistic values. The network adjustment is initially run with a unity scale factor. The resulting variance factor can then be inserted in the scale factor field from the first screen. After running the network adjustment with this new scale factor, you will notice larger or smaller standard deviations and that the new variance factor should now be ~1.0. This procedure will only work for a minimally constrained adjustment (that is, one 3-D control point, or one 2-D and one 1-D control point).

3.4.7 View Traverse Solution

GrafNet computes a traverse solution automatically after processing each session. This feature can be used to view traverse solution files (TRV).

Traverse Solution

Once all of the baselines have been successfully processed, meaning that they are green in the *Map Window*, you will wish to produce coordinates for each of the stations. Accomplish this by using the traverse technique from known station to unknown stations. Using *File | Add / remove Control Points*, additional known (fixed) control points can be specified.

At least one GCP is needed per project before GrafNet will process any data, but others can be added later. These known control stations are used to transfer coordinates to unknown stations in the network.

In some ways, this is very similar to a conventional traverse survey but instead of instrument, backsight and foresight stations, this traverse technique only has an instrument and foresight station. Starting from the known stations, coordinates are transferred to the nearest stations. Then, the next nearest stations receive coordinates. This procedure is repeated until all connected stations have coordinates transferred. The arrow marker on the baseline shows which direction this transfer takes place.

The coordinates for a given station are transferred from the minimum number of legs. The lengths of the legs are not taken into account which, in some cases, results in an unfavorable transfer of position. In this case, the network adjustment produces more accurate coordinates.

For stations that have more than two baselines connecting, a loop tie can be computed. This means that there is more than one possible transfer of coordinates to this point. The first transfer is used for coordinate generation. Subsequent transfers are used to compute loop ties. The loop ties are good for locating erroneous baselines but they are an accumulated error of many baselines to that point. This means that the last baseline in that traverse leg may not be the erroneous one. These ties also give a good indication of the accuracy of the network, but the magnitude of the errors will be larger than the network adjustment residuals. The network adjustment method is not that much more accurate than the traverse method. Rather, the traverse method accumulates errors (closures) while the network adjustment spreads these errors across the whole network.
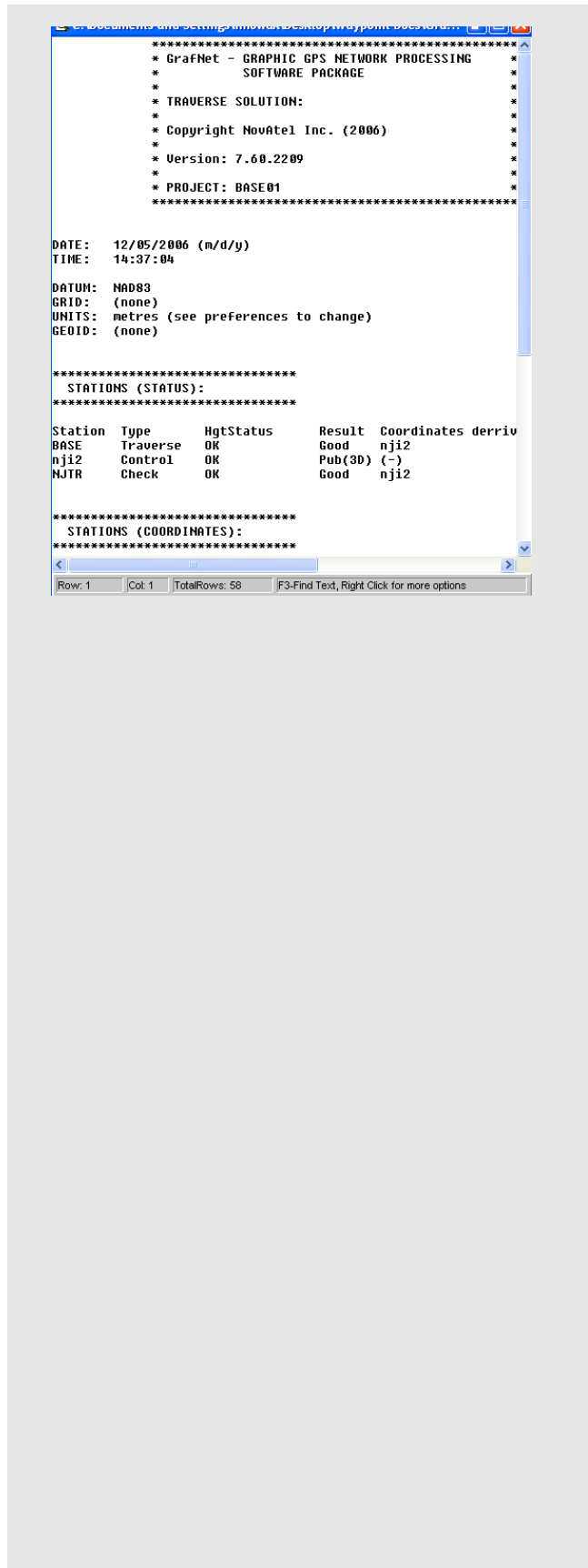
3.4.8 View Processing Report

This option displays the RPT file containing information about the stations, sessions, baselines, observations and gives a summary for each session processed.

3.4.9 View All Sessions

View the *Session* window of the *Data Manager* for all baselines with this feature. It can also be invoked for individual sessions by clicking on a baseline in the *Map Window*. This is a useful way of ensuring all sessions have a *Good* status.

3.4.10 View All Observations

This option displays information about each observation in the *Data Manager*. Right-click on the observations and select *View* to bring up a message box that shows the file name, station name, antenna height, time range and data interval, among other things. Selecting *View GPB File* will access the *GPB Viewer*.

3.4.11 View All Stations

This feature displays the *Stations* window in the *Data Manager*. The window lists all stations in the project, as well as their traverse solution coordinates.

3.5 Options Menu

3.5.1 Global Settings

This feature accesses the global processing options. The options set here are applied to all baselines in the project, overriding any settings that may have been customized for individual baselines. The processing settings for individual sessions can be customized by right-clicking on the session in the *Data Manager* and selecting *Options*.

3.5.2 Sessions Settings (Shown in Data Manager)

This feature allows you to set the processing options only for the sessions currently appearing in the *Data Manager*. In order to use this feature, the *Sessions* window of the *Data Manager* must be open.

3.5.3   Datum Options

See *Section 2.6.2,* on *Page 65* for help with this feature.

3.5.4   Grid Options

See *Page 100* for information regarding this feature.

3.5.5   Geoid Options

This feature lets you select the geoid for the project. The geoid selected is used as a reference when outputting orthometric heights in the *Traverse Solution* (TRV) file. It will also be used as a default for orthometric height output when running the network adjustment.

3.5.6   Preferences

GrafNet Display

See *Page 69* for information regarding any options not described here.

Zoom Display Settings
The *Ellipse scale* field changes the size of the error ellipses. Projects covering large areas might have large ellipses and decreasing the values for all three zoom scales (0, 1, and 2) will make the ellipses smaller.

Error EllipseDisplay
Controls whether relative or absolute error ellipses are displayed. First, error ellipses can be displayed for session solutions. Second, ellipses can be displayed for the stations after a network adjustment is run. The crosses on the ellipse option merely shows the axes of the error ellipses.

Solution

In addition to the options described in *Section 2.6.7,* on *Page 69* , the solution tab offers GrafNet users the ability to automatically run a network adjustment after processing has completed.

3.6   Output Menu

3.6.1   Export Wizard

See *Page 80* for information regarding this feature.
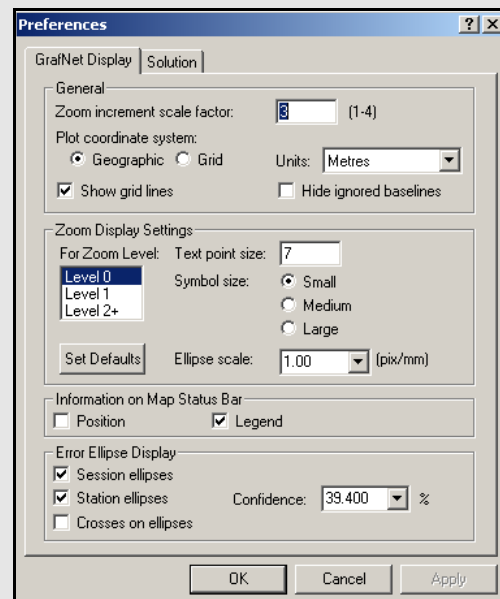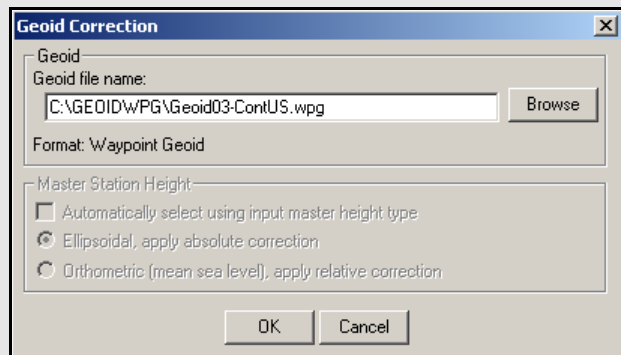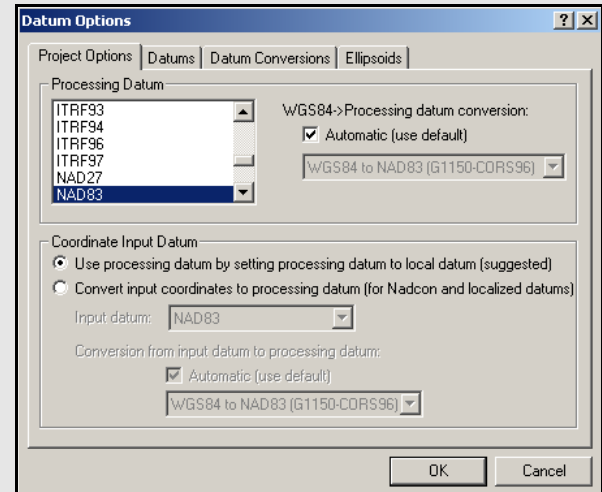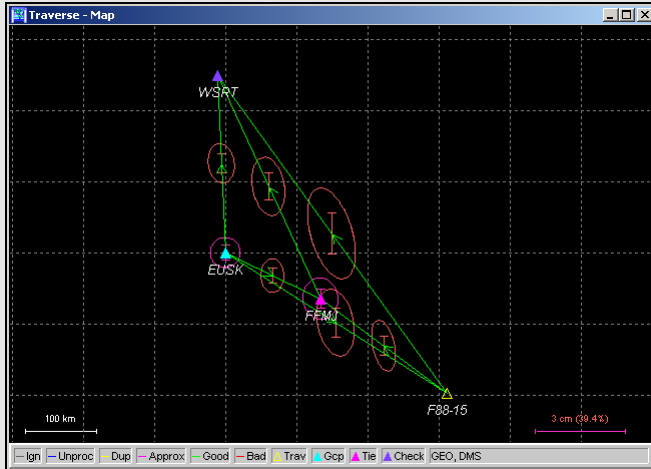
Table 13: Station Colour Legend

Colour	Description
Cyan	**Control point –** A reference station with known coordinates
Dark Purple	**Check point –** Station has known coordinates available, but they will only be used as a check. Comparisons are found in the TRV file. The network adjustment output file (NET) will also show check point residuals.
Light Purple	**Tie point** – Two or more sessions are connected as remotes to this station via the traverse solution. The TRV file will show traverse ties.
Yellow	**Traverse point –** No tie information can be computed for traverse solution.

3.6.2 View Coordinates

See *Page 91* for information regarding this feature.

3.6.3 Export DXF

See *Page 91* for information regarding any feature not described below. Only the options specific to GrafNet are discussed here.

Station Error Ellipses
Display around each station and are only available if a network adjustment has been completed.

Baseline Error Ellipses
Only the baselines need to be processed**.**

Error ellipse scale factor
The ellipse scale factor scales the ellipses so they will be visible if you do not see them in the DXF file.

3.6.4 Show Map Window

Map Window
This window displays a graphical representation of the project area. It shows the stations and connecting baselines.

Mouse Usage in Map Window
Either double-clicking or right-clicking on a station, gives you access to several options, which are described in *Section 3.6.5,* on *Page 140* .

⊠   Clicking on a station displays the station in the Stations window of the Data Manager, while clicking on a baseline will display that baseline and any duplicates in the Sessions window. See *Section 3.6.5,* on *Page 140* for more information.

3.6.5 Show Data Window

Data Manager
This interactive window allows for easy display and organization of the project components. The *Data Manager* gives statistical information regarding all observations and baselines, among other things.

Observations Window
The *Observations* window displays information regarding all the observation files (GPB) that are included in the project. The columns that are in the shaded box are displayed in the *Observations* window. The following options are available by right-clicking on an observation:

> *View*
> Displays *Information* window for the observation file.

> *Edit*
> Opens the *Add / Edit Observation* window, in which the station name and antenna information can be corrected.

> *Delete Observation*
> Removes the observation period from the project.

> *View GPB File*
> Opens observation file in *GPB Viewer*.

> *View STA File*
> Opens the station file for the associated GPB file.

> *View Ephemeris File*
> Opens ephemeris file (EPP) for the associate GPB file.

> *Plot Coverage*
> Opens the *File Data Coverage* plot for all observations in the project. See *Table 4* on *Page 76* for information regarding this plot.

> *Plot L1 Satellite Lock*
> Launches the *L1 Satellite Lock / Elevation* plot. See *Table 4* on *Page 76* .

> *Plot L2 Satellite Lock*
> Launches the *L2 Satellite Lock / Elevation* plot.

> ***Show Sessions using Observation***
> Displays all sessions involving the observation period in the *Sessions* window.

Expanding the *Observations* branch in the *Data Objects* window on the left-hand side of the *Data Manager* allows the observations to be displayed individually in the *Observations* window. Expanding each observation in the *Data Objects* window displays the station that was observed.

Columns in the Observation Window

Name
Name of the station at which the observations were made.

AntHgt
Antenna height for the period at which the observations were made.

AntType
Type of antenna used at the station

File
File, path and name of the GPB observation file.

#
If multiple observations periods are contained within one GPB file, this column indicates which of those observation periods is being referred to. Observation periods are numbered sequentially in the order they appear in the GPB file.

Length
Length of the observation period.

Start Date
Date of which the observation period started.

Start Time
Time of day at which the observation period started.

Receiver
Type of receiver used to log observations.

Freq
Indicates whether data is single or dual frequency.

Int(s)
Interval, in seconds, at which the data was logged.

Columns in the stations window (

Name
Name of station.

Type
See *Table 13* on *Page 140* for information on station types.

Latitude
Latitude coordinate of the station.

Longitude
Longitude coordinate of the station.

EllHgt
Ellipsoidal height of the station.

Source
Indicates whether the station coordinates are from the traverse solution or the network adjustment.

#Files
Number of observations periods for that station.

TotalLen
Total observation time made at that station.

A(mm)
Semi-major axis of error ellipse at that station, as defined from the network adjustment.

B(mm)
Semi-minor axis of error ellipse at that station, as defined from the network adjustment.

DH(mm)
Estimated height standard deviation.

Stations Window
The *Stations* window displays information regarding all the points observed in the network. The columns listed in the shaded box are displayed in the *Stations* window. The following options are available by right-clicking on a station:

View Solution
Displays solution from traverse computation and network adjustment, if valid.

Add as Control Point
Allows you to define station as a control point.

Add as Check Point
Allows you to define station as check point.

Edit Control / Check Point
Allows for editing of the input coordinates of stations already defined as check or control points.

Toggle between Control / Check Point
Switches status between control point and check point.

Add to Favourites
Adds station to *Favourites* list, using the computed coordinates.

Remove Processing Files
Removes all observation files logged at that station from project.

Show Observations
Displays all observation periods for that station in the *Observations* window.

Show Connecting Sessions
Displays all sessions involving that station in the *Sessions* window.

Expanding the *Stations* branch in the *Data Objects* window on the left-hand side of the *Data Manager* will allow for the stations to be displayed individually in the *Stations* window. Further expanding each station in the *Data Objects* window will display all observation files in which the station was observed.

Sessions Window

The *Sessions* window displays information regarding all the sessions in the network. The columns listed in the shaded box are displayed in this window. The following options are available by right-clicking on a session:

View Results
Allows you to view results of forward or reverse processing, or view the combined solution.

View Information
Displays *Information* box for the session.

View File
Allows access to message log, static summary, trajectory output, or configuration files.

Plot
Allows access the plots discussed in *Table 4* on *Page 76* .

Options
Allows access to the processing settings so that they can be set individually for this session. See *Section 3.4,* on *Page 127* for additional information.

Override Status
Manually sets the status of the session. See *Table 11* on *Page 116* for information. Ignore redundant or troublesome sessions. You can assign a *Good* status to a failed baseline if the solution is, in fact, correct. Only do this on closed loop networks.

Process
Processes the session independently of all others.

GrafNav
Launches the baseline into GrafNav. See *Section 2.5,* on *Page 50* for additional information.

Delete
Deletes of all processing files related to that session, or for the deletion of either the forward or reverse solutions.

Compute Azimuth / Distance
Displays the *Distance and Azimuth* box for the session. See *Section 2.8.2,* on *Page 96* for help.

Show To / From Stations
Displays both stations in the *Stations* window. See on *Page 142* for information.

Show To / From Observations
Displays both station *Observations* window. See *Observation Window* on on *Page 141* for information.

Expand the *Sessions* branch in *Data Objects* of the *Data Manager* to display individual in the *Sessions* window.

Columns in the Sessions Window

Name
Name of session, which serves to indicate direction of coordinate transfer.

SD
Standard deviation, in mm, of baseline, as calculated by the Kalman filter.

Reliability
Reliability of the fixed static solution, if available.

RMS
RMS of the fixed static solution. Applies only to fixed baselines.

SolType
Indicates solution type. See *Table 11* on *Page 116* for a full description.

Time
Length of session, in *hh:mm* format.

Dist
Baseline distance, in km.

Status
Solution status. See *Table 11* on *Page 116* for descriptions.

From
Indicates the *FromStation*.

To
Indicates the *ToStation*.

#
If multiple sessions exist for same baseline, indicates which session is being referred to.

Columns in the Control / Check Points Window

Name
Name of the station.

Type
Type of control or check point, which can be 3D, horizontal or vertical.

Latitude
Known latitude coordinate of the station.

Longitude
Known longitude coordinate of the station.

EllHgt
Known ellipsoidal height of the station.

HzSD
Standard deviation of the known horizontal coordinates. Applies only to control points.

VtSD
Standard deviation of the known vertical coordinate. Applies only to control points.

dE
Easting residual between input coordinate and traverse solution at check point.

dN
Northing residual between input coordinate and traverse solution at check point

dH
Height residual between input coordinate and traverse solution at check point

Control / Check Points
The *Control / Check Points* window displays information regarding all the stations assigned known coordinates in the network. The columns listed in the shaded box are displayed in the *Control / Check Points* window.

The following options are available by right-clicking on a control or check point:

View Info
Displays *Information* box for the point.

Edit
Allows for editing of known coordinates via the *Add / Edit Control Point* window.

Toggle between Control / Check
Switches status between control point and check point.

Show Station
Displays station in the *Stations* window. See *Stations Window* on on *Page 142* for information.

Expanding the *Control* or *Check Points* branches in the *Data Objects* window on the left-hand side of the *Data Manager* allows for the points to be displayed individually in the *Control / Check Points* window.

3.6.6 Baselines Window

The *Baselines Window* displays information regarding all the sessions in the network. See *Columns in the Sessions Window* on *Page 143* for a description of the columns displayed and the options available by right-clicking on a session.

Expanding the *Baselines* branch in the *Data Objects* window on the left-hand side of the *Data Manager* allows for the sessions to be displayed individually according to the baseline they are expanded from. Expanding each baseline in the *Data Objects* window will allow for the display of any individual session in the *Sessions* window.

3.6.7 Processing Window

See the *Process* menu on *Page 50* for information regarding this window.

3.7 Tools Menu

See *Section 2.8,* on *Page 96* for information regarding the features available through this menu.

3.8 Help Menu

See *Section 2.10,* on *Page 113* for information about these features.

Table 14: Baseline Colour Legend

Colour	Description
Blue	**Unprocessed** – Normally represents an unprocessed baseline. In some cases when processing quits prematurely, the colour may remain blue. The return error message can be viewed by right-clicking the baseline in the *Sessions* window of the *Data Manager* and selecting *View Information*.
Grey	**Ignored** – Indicates a session that is to be ignored.
Yellow	**Duplicate –** Indicates a duplicate baseline, meaning that it has more than one session. Such baselines are plotted with two colours, with one being yellow. The second colour will represent the best solution among all the sessions for the duplicate baseline.
Purple	**Approximate** – Indicates that an error has occurred during the processing and only an approximate (1 to 5 metres) solution was extracted. Such a solution is only useful for transferring an approximate position from base to remote, and this session should either be reprocessed or ignored.
Red	**Bad / Failed** – Represents a baseline where processing failed one or more tests and is thus deemed to be bad. Right-click the baseline in the *Sessions* window of the *Data Manager* and select *View Information* to determine the problem. If you are confident that the solution is okay, the status can be changed from the *Sessions* window as well. You can control when float solutions pass via the *Solution* tab under *Options	Preferences*.

4.1   Overview of GrafMov

GrafMov is a moving baseline upgrade that can be added on to Waypoint's GrafNav / GrafNet GPS post-processing software package. GrafMov software is for relative processing between two moving GNSS antennas.

This optional processing module allows for relative position and velocity determination between two moving antennas. Accuracies can be much higher than those achieved when processing from a fixed base station because relative distances tend to be much shorter. If the two antennas are fixed on the same craft, a post-mission heading determination system is formed.

This chapter describes how to get started with GrafMov, goes through each menu of its interface and provides step-by-step instructions for first-time users.

4.2   Getting Started with GrafMov

Before you start a project in GrafMov, verify installation and convert data. This section provides a quick tutorial on how to get started with GrafMov.

Install Software

Verify that the installation was successful by ensuring that you have a *Waypoint GPS* program group on your computer. If this program group is not there, see *Section 1.2.2,* on *Page 16* for installation instructions.

Convert Data

To be processed, raw GPS data files have to be converted into Waypoint's GPB format, including raw data from Waypoint's data-logger program. Instructions on how to convert these files are in the shaded box.

The *GPBView* utility can be used to switch between static and kinematic mode. See *Chapter 3* on *Page 167* for a complete description of the *Convert* utility.

Create a New Project

The steps to create a new project are listed in the shaded box. The *Auto Start* feature can also be used to automatically bring up all the pertinent dialogue boxes. See *Section 2.2,* on *Page 24* for more information on the *Auto Start* feature.

How to install software

1. See *Section 1.2.2,* on *Page 16* for installation instructions.

How to convert data

1. Select *File | Convert | Raw GPS to GPB* to access the converter.

2. Navigate to the directory that contains the data.

3. Select *Auto | Add All* to auto-detect GPS formats.

4. If you want to change the conversion options, click on *Options* or *Global Options* to set the rover to kinematic mode.

How to create a new project

1. In GrafMov, select *File | New Project | File Name*.

2. Enter the name of the new project.

3. Click *Open*.

✉   Entering the name of a project that already exists overwrites the file contents.

How to load master file (s)

1. After creating a new project, the screen appears empty. Select *File | Add Master GPB File(s)*.

2. Select one of the moving stations as the base station and click *OK*. The program will load the GPB file and then a dialogue box will appear asking for the appropriate master station coordinates

3. Click on the *Datum Options* button to select the processing datum.

4. Select the desired datum from the list in the *Processing Datum* box. Be sure that the radio button labeled *Use processing datum by setting processing datum to local datum* is selected. If the datum has changed, GrafMov will warn you.

How to load the remote file

1. Go to *File | Add Remote GPS File* to select the remote station and click *OK*.

2. Enter the height of the antenna or range pole (height of phase centre above ground) when you are prompted to enter the remote station antenna height.

3. Press *OK*.

How to process

1. Select *Process | Process Differential*.

2. Click on the **Process** button to begin post-processing the GPS data.

3. For the *Static Initialization* mode, select *Float* for kinematic initialization or *Fixed Static* if there is a sufficiently long static period at the start.

4. Click on the *Process* button to begin post-processing the GPS data.

How to export final coordinates

1. Select *Output | Export Wizard*. Select the source for the solution. *Epochs* will output the trajectory, while *Features/Stations* will export any loaded features

2. Choose a profile and select *Next*.

Load Master File(s)

The steps for loading master file (s) are in the shaded box. When loading master files, make sure that the data from both moving stations must have been logged simultaneously. When loading, remember that base station coordinates are irrelevant in because the base station is moving but try to enter the appropriate antenna information.

Load Remote File

The steps on how to load a remote file is in the shaded box.

Select Moving Baseline Options

To successfully process moving baseline data, go to *Settings | Moving Baseline Options*. The *Enable moving baseline processing* options must be enabled. If you are interested in attitude determination, indicate so with the options under *Azimuth Determination*. See on *Page 150* for more information on the options available.

Process

The steps for processing are in the shaded box. For this tutorial, the defaults associated with the software will be accepted. See *Chapter 3* on *Page 50* for more information.

While the program is processing, pay attention to the quality bar. Ideally, it should settle down to a level of 1 or 2 if the GPS data is reasonably good. See *Section 2.7.11,* on *Page 94* for a description of the quality factor.

If this bar spikes, it will probably coincide with a loss of lock or large phase and pseudorange RMS values, and possibly unstable ambiguity numbers and corresponding solutions. For slower computers, view the values during processing but faster units process epochs at such a high speed that visual inspection is likely impossible. This should not cause concern since all statistics will be available upon processing completion.

Plotting and Quality Control

Select *Output | Plot GPS Data*. From the list of options, several plots can be viewed. See *Table 4* on *Page 76* for a description of these plots.

Export Final Coordinates

The steps for exporting coordinate files are in the shaded box. For the *Select Output Coordinate Datum* screen, using the processing datum is recommended. You might also be prompted for the geoid undulation file, which are provided on the distribution CD. *Section 2.7.4,* on *Page 80* for help.

4.3   File Menu

See *Section 2.3,* on *Page 25* for information regarding all of the features available via this menu. This section provides only a few points relevant to GrafMov.

4.3.1   Add Master File

⊠   It is strongly recommended for differential processing with a static base station that you use GrafNav. GrafMov is meant for processing between moving antennas and will only allow for one base station to be defined.

When designating a GPB file as the master, you are prompted to enter its coordinates. These coordinates have no effect on processing. GrafMov extracts the position from the master's GPB file. Normally, the receiver computes this position in real-time but some of the decoders re-compute positions during conversion, so it is important to ensure that the master GPB file has proper coordinates. Do this with the *Re-compute position and clock offset* option when converting the raw data, depending on the type of receiver used. See *Section 6.2,* on *Page 167* for help.

Positions can be calculated after conversion with the *GPB Viewer*, which can be accessed through *File | GPB Utilities | View Raw GPS Data*. Once the appropriate GPB file has been opened, select *Edit | Recalculate Position*. See *Section 6.2,* on *Page 167* for additional information regarding this feature.

It also important that the static/kinematic flags have been properly set. Failure to do so will lead to the development of large errors. In the absence of flags in the raw data, the *Raw GPS to GPB* converter will decode the entire file as being either static or kinematic, depending what you specify. If you are not sure when the data is static or kinematic, it is better to make the entire file kinematic.

4.4   View Menu

See *Section 2.4,* on *Page 41* for information regarding all of the options in this menu.
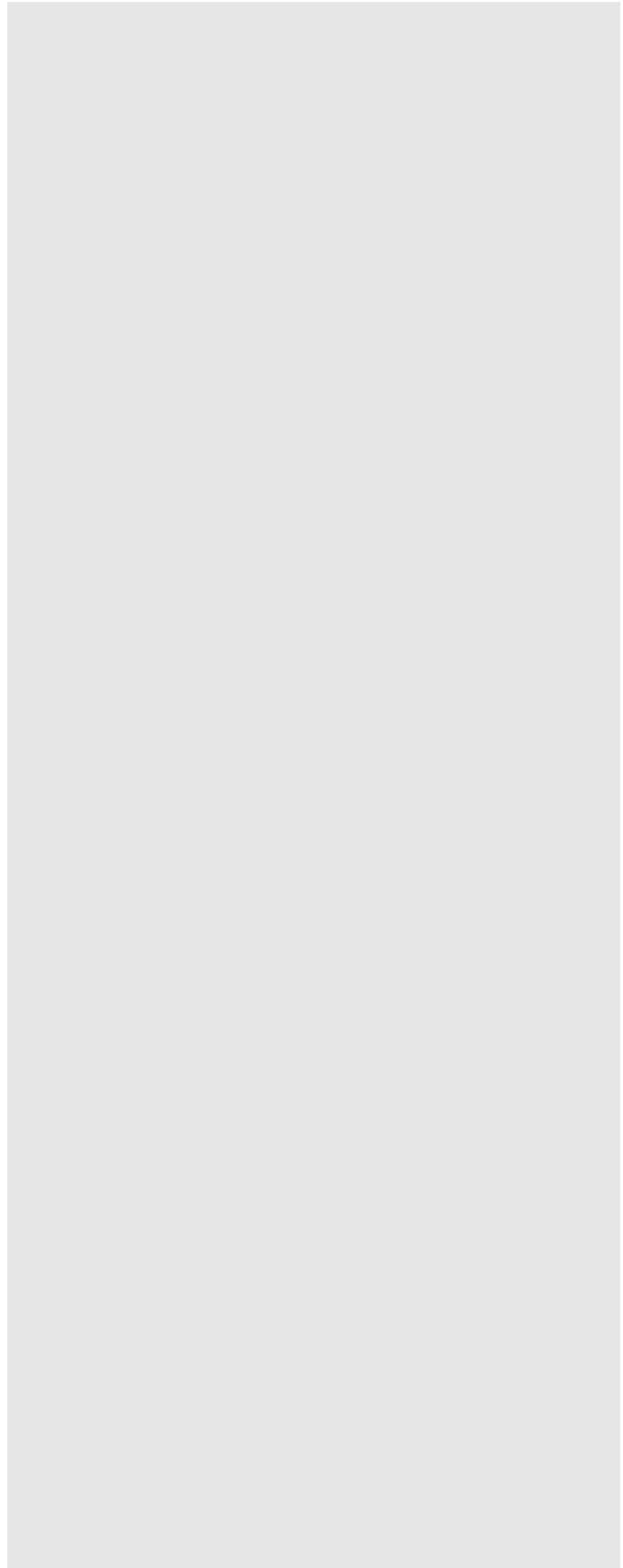
4.5 Process Menu

Azimuth determination options

1. **Off, no azimuth determination** - Process using this option first to see the quality of the solution. If the quality is good, then the option 2 or 3 will work.

2. **On, use distance constraint in ARTK and engage ARTK if out of tolerance** - Single frequency users who know the fixed distance between the L1 phase centres of their moving antenna should use this option because it speeds up ARTK resolution time. Otherwise, use option 3.

3. **On, but compute only** - Use this option if you need straightforward azimuth, if the quality of the data is not suitable for ARTK usage or if the distance is not known or unstable.

4. **On, but only use distance constraint to engage ARTK if out of tolerance** - Dual frequency users should use this option if they know the fixed distance between the L1 phase centres of their two moving antennae. If not, use the option 3.

See *Section 2.3,* on *Page 25* or information regarding all of the options available via this menu.

4.6 Setting Menu

See *Section 2.6,* on *Page 64* for information regarding all of the options available via this menu. Only the *Moving Baseline Options* feature will be discussed here, as it is exclusive to GrafMov.

4.6.1 Moving Baseline Options

This feature is the only way for GrafMov to distinguish a moving baseline project from a typical project with a static base station.

Moving Baseline Processing
Determines whether or not to process data as a moving baseline project. If this option is disabled, the processor will behave as it does in GrafNav, and assume the base station is static.

Azimuth Determination
These options are listed in the shaded box.

Standard deviation/tolerance
This value is used to engage ARTK if the distance between the two antennas becomes too large or too small. Using a strict tolerance might cause GrafMov to engage ARTK continuously, resulting in a possible infinite loop or very long processing time. By default, 2 cm is used, but you can change this after processing without azimuth determination.

4.7 Output Menu

See *Section 2.7,* on *Page 73* for information regarding all of the options available in this menu. This section only has a brief point relevant to GrafMov.

4.7.1 Plot GPS Data

Table 16, in the shaded box, contains a description of those plots available only through GrafMov. See *Table 4* on *Page 76* for a list of other plots available.

4.8 Tools Menu

See *Section 2.8,* on *Page 96* for information regarding all of the options available via this menu.

4.9 Interactive Windows

See *Section 2.9,* on *Page 112* for information regarding all of the options available via this menu.

4.10 Help Menu

See *Section 4.10,* on *Page 151* for information regarding the features available via this menu.

Table 15: List of Attitude Plots Available with GrafMov

Plot	Description
Azimuth/ Heading Data	Plots the azimuth, in degrees. Only available if azimuth determination has been enabled. See on *Page 150* for more information.
Estimated Azimuth/ Heading Accuracy	Shows the standard deviation of the azimuth computation. Only available if azimuth determination has been enabled. See on *Page 150* for more information. You should also examine the fixed/float ambiguity status flag.
Antenna Distance Error	Shows the difference between the computed antenna distance and that you entered. This is a good quality control check.

5.1 Overview of the File Formats

5.2 CFG File

The configuration (CFG) file stores all the options in a project. It is rare to need to edit a CFG manually. When editing a CFG file, be careful to follow the exact syntax. To learn the commands of CFG files, you should look at those created by GrafNav and refer to Appendix A for a list of all the commands and their meanings.

5.3 GPS Data Files

This section concerns the format of those files (GPB/EPP/STA) created upon the conversion from a raw data format to Waypoint's proprietary format.

5.3.1 GPB File

Binary measurement data is stored in Waypoint's custom GPB format. This format is receiver-independent and only stores necessary information to minimize disk space requirements. This format contains one position record and a measurement record for each satellite being tracked, for every epoch.

⊠ There exists a new and old version of the GPB format. The new version has L1 and L1/L2 records sizes, additional header information that is, receiver information, software name, and version number. The new version also has C/NO, L2C indicators, and P1 + P2 codes. *GPBView* is a useful utility for inspecting and modifying GPB files.

You can export this file to ASCII from the *GPBViewer*, or convert to RINEX via the *GPB to RINEX* utility.

5.3.2   STA File

Every station file must have the following string at the top or else it will not load.

$STAINFO

The station file may have a header record. The header is optional and will not be present in most cases. The following is a description of the header format.

```
Hdr {
    Proj:      "Name of Project"            Field project name
    User:      "User Name"                  Name of field operator
    Time:      hh:mm:ss LOCAL/GMT           Start time
    Date:      mm/dd/yyyy                   Start date
    RxName:    Receiver                     Receiver type
    RxSub:     Model                        Receiver sub type
    Hi:        Hi_m VERT/SLANT              Antenna height, measured vertically or slanted
    Ant:       V_Offset H_Offset "Name"     Antenna info (vertical offset to phase centre,
                                            horizontal distance to measurement mark,
                                            antenna model name)
    Pos:       phi lamda ht ELL/ORTHO       Computed position of antenna
    Mode:      SP/DGPS/RTFL/RTFX/RTK/FIX    Mode of solution (RTFL=float, RTFX=fixed,
                                            RTK=float/fixed not known, SP=single point,
                                            GPS=DGPS, FIX=known)
}
```

The following is the format for the stationary station marks:

```
Sta {
    *ID:       "Station ID"
    *GTim:     SecOfWeek [WeekNo]           GPS Time
    UTim:      SecOfWeek [WeekNo]           UTC Time could be used instead of GTim but this
                                            is not recommended and often not supported.
    Pos:       phi lamda ht ELL/ORTHO       Computed position of antenna
    Mode:      SP/DGPS/RTFL/RTFX/RTK/FIX    Mode of solution (RTFL=float, RTFX=fixed,
                                            RTK=float/fixed not known, SP=single point,
                                            DGPS=DGPS, FIX=known)
    Std:       SdE SdN SdH                  Standard deviation, in meters
    Hi:        Hi_m VERT/SLANT              Antenna height, measured vertically or slanted
    Ant:       V_Offset H_Offset "Name"     Antenna info (vertical offset to phase centre,
                                            horizontal distance to measurement mark,
                                            antenna model name)
    OffR:      Range TrueAzimuth DH         Offset to actual point (2D range in meters, azimuth
                                            in degrees, height difference in meters)
    OffL:      DE DN DH                     Offset in local level frame, in meters
    OffB:      DX DY DZ                     Body frame offset, where X-RightWingPos,
                                            Y-ForwardPos, Z-UpPos
    Att:       roll pitch heading           Attitude, in degrees
    Desc:      "description"
    Rem:       "remarks"
    Nsv:       NumSats NumGPS NumGlonass
    Dop:       PDOP HDOP VDOP
    Rms:       L1Phase CACode
```

Age:	*Sec*	Age of last correction or RTK receipt
Enable:	1/0	Used in GrafNav
}		

✉ * indicates a required field.

The new station file format also handles event marks. Saving a project with event marks loaded will bring the event marks into the station file. The following is the event mark format.

Mrk {

*Event:	*Number*	Event number or name (no spaces)
Desc:	*"Name"*	Roll name
*GTim:	*SecOfWeek [WeekNo]*	GPS Time
*UTim:	*SecOfWeek [WeekNo]*	UTC Time could be used instead of GTim but this is not recommended and often not supported
Pos:	*phi lamda ht* ELL/ORTHO	Computed position
Mode:	SP/DGPS/RTFL/RTFX/RTK/FIX	Mode of solution (RTFL=float, RTFX=fixed, RTK=float/fixed not known, SP=single point, DGPS=DGPS, FIX=known)
Std:	*SdE SdN SdH*	Standard deviation, in meters
Vel:	*VE VN VH*	Velocity, in m/s
Att:	*roll pitch heading*	Attitude, in degrees
Rem:	*"remarks"*	
Nsv:	*NumSats NumGPS NumGlonass*	
Dop:	*PDOP HDOP VDOP*	
Rms:	*L1Phase CACode*	
Age:	*Sec*	Age of last correction or RTK receipt
Enable:	1/0	Used in GrafNav
}		

✉ * indicates a required field.

GIS marks are also available in the new station file format. Note that GIS marks can only be created using Waypoint's logging software, WLOG.

Gis {

Count:	*counter*	
Feat:	*"name"*	
Attrib1:	*"name"*	
Value1:	*"name"*	
Attrib2:	"*name"*	
Value2:	*"name"*	
Attrib3:	*"name"*	
Value3:	*"name"*	
Rem:	*"remarks"*	
Type:	POINT/LINE/POLYGON NONE/START/END/NODE NONE/CW/CCW	
		Feature type, position, direction
GTim:	*SecOfWeek [WeekNo]*	GPS Time
UTim:	*SecOfWeek [WeekNo]*	UTC Time
Pos:	*phi lamda ht* [ELL/ORTHO]	Computed position
Mode:	SP/DGPS/RTFL/RTFX/RTK/FIX	Mode of solution (RTFL=float, RTFX=fixed,

<table>
<tr><td></td><td></td><td>RTK=float/fixed not known, SP=single point,
DGPS=DGPS, FIX=known)</td></tr>
<tr><td>Std:</td><td>*SdE SdN SdH*</td><td>Standard deviation in meters</td></tr>
<tr><td>OffR:</td><td>*Range TrueAzimuth DH*</td><td>Offset to actual point (2D range in meters, azimuth
in degrees, height difference in meters)</td></tr>
<tr><td>OffL:</td><td>*DE DN DH*</td><td>Offset in local level frame, in meters</td></tr>
<tr><td>OffB:</td><td>*DX DY DZ*</td><td>Body frame offset, where X-RightWingPos,</td></tr>
<tr><td>Hi:</td><td>*Hi_m* VERT/SLANT</td><td>Antenna height, measured vertically or slanted</td></tr>
<tr><td>Ant:</td><td>*V_Offset H_Offset "Name"*</td><td>Antenna info (vertical offset to phase centre,
horizontal distance to measurement mark,
antenna model name)</td></tr>
<tr><td>Nsv:</td><td>*NumSats NumGPS NumGlonass*</td><td></td></tr>
<tr><td>Dop:</td><td>*PDOP HDOP VDOP*</td><td></td></tr>
<tr><td>Rms:</td><td>*L1Phase CACode*</td><td></td></tr>
<tr><td>Age:</td><td>*Sec*</td><td>Age of last correction or RTK receipt</td></tr>
<tr><td>Enable:</td><td>1/0</td><td>Used in GrafNav</td></tr>
<tr><td>}</td><td></td><td></td></tr>
</table>

Another new data type handled in the station format is an RTK epoch, where every epoch can be recorded.

RTK {

<table>
<tr><td>*GTim:</td><td>*SecOfWeek [WeekNo]*</td><td>GPS Time</td></tr>
<tr><td>*UTim:</td><td>*SecOfWeek [WeekNo]*</td><td>UTC Time</td></tr>
<tr><td>*Pos:</td><td>*phi lamda ht* [ELL/ORTHO]</td><td>Computed position</td></tr>
<tr><td>Mode:</td><td>SP/DGPS/RTFL/RTFX/RTK/FIX</td><td>Mode of solution (RTFL=float, RTFX=fixed,
RTK=float/fixed not known, SP=single point,
DGPS=DGPS, FIX=known)</td></tr>
<tr><td>Std:</td><td>*SdE SdN SdH*</td><td>Standard deviation in meters</td></tr>
<tr><td>Vel:</td><td>*VE VN VH*</td><td>Velocity, in m/s</td></tr>
<tr><td>Att:</td><td>*roll pitch heading*</td><td>Attitude in degrees</td></tr>
<tr><td>Nsv:</td><td>*NumSats NumGPS NumGlonass*</td><td></td></tr>
<tr><td>Dop:</td><td>*PDOP HDOP VDOP*</td><td></td></tr>
<tr><td>Rms:</td><td>*L1Phase CACode*</td><td></td></tr>
<tr><td>Age:</td><td>*Sec*</td><td>Age of last correction or RTK receipt</td></tr>
<tr><td>Enable:</td><td>1/0</td><td>Used in GrafNav</td></tr>
</table>

}

✉ * indicates a required field.

5.3.3   Old Station File Format

Feature points can be loaded into GrafNav via a station file. This station file is an ASCII file from which station names, GPS times, antenna heights and related information is read. GrafNav will select the nearest epoch time to extract the position, and will not interpolate in this situation. For interpolation, the user should select *File | Camera Event Marks*. The station file can contain a named station feature, or a GIS feature mark.

A named station has the following format:

STA: * *GPSTime* * *StaName* * *AntHeight* * *Description* * *Remarks* [CR][LF]

Where:

GPSTime   Time of feature mark, defined in GPS seconds of the week

StaName	Alpha-numeric station identifier [16 chars max]	
AntHeight	Height of the range pole or tripod in meters	
Description	Description of station [32 chars max]	
Remarks	Remarks for the station [32 chars max]	
[CR][LF]	Carriage return + line feed to end line	
*	Field separator; should not appear in any of the above fields	

The second feature is called a GIS feature mark and has the following format:

GIS: *_GPSTime_ * _Counter_ * _AntHeight_ * _Attribute_ [CR][LF]
Where:

GPSTime	Time of feature mark, defined in GPS seconds of the week	
Counter	Numeric counter, which normally increments	
AntHeight	Height of the range pole or tripod, in meters	
Attribute	Feature name and attribute string	
*	Field separator; should not appear in any of the above fields	

5.3.4   EPP File

Waypoint's software uses a custom ASCII file format for the ephemeris records. These records are created in real-time with Waypoint's data loggers, or from the *Convert Raw GPS data to GPB* utility. Since this file format is ASCII, a simple text-editor can be used to combine ephemeris records from multiple concurrently collecting receivers. This is useful if some ephemeris records were missed from some stations. Duplicate records will be automatically ignored by the software.

5.4   Output Files

This section discusses some of the different output files that are created when processing with Waypoint's software.

5.4.1   FML & RML Files

The *Forward Message Log* and *Reverse Message Log* files simply echo all error and warning messages sent to the *Processing Window* during processing. The common messages are explained here:

Reading ephemeris files...
Processing ephemeris file 'C:\GPSData\rover_.epp'
Detected 40 GpsEph, 0 GlonassEph, 0 GpsIono and 0 GpsAlmanac records
This message is shown at the start of the file. It is a good message to check to see how many ephemerides were loaded.

Best base on BL1 is PRN 17 with 4 points and elevation of 62.1 degrees
Second best on BL1 is PRN 16 with 2 points and elevation of 51.7 degrees
This message indicates the base satellite (and its elevation) selected after a base change or at outset. The second best base is also shown. Base satellite selection is based on a point system that includes a number of factors such as elevation above the horizon, whether it is rising or falling, and ambiguity determination accuracy.

Prn 15 dropped out for 2.0 s on baseline BL1--ambiguity reset
Prn 23 dropped out for 2.0 s on baseline BL1--will try to save ambiguity
These message are displayed when an individual satellite drops out for a short period. Whether the first or second message is displayed depends on if the *Save ambiguities on satellite drop-outs* option is selected. See *Section 2.5.1,* on *Page 50* for help. For some data sets, this saving process may be followed by data errors ($$$). In such a case, try de-selecting this option.

Detected bad Phase measurement. Rms is 2.091 m (Worst Prn is 10 on B/L BL1 with residual of 2.325)

This is almost always caused by one or more undetected cycle slips. In most cases, the software will be able to correct for the problem by removing the affected cycle slip. If not, a cycle slip will be induced to all satellites.

Skipped 83 epochs or 76.1 % due to long distance (used 26 epochs or 23.9 %)
This message shows up if the *Maximize long baseline data usage* option is enabled. See *Section 2.5,* on *Page 50* for help. It indicates what percentage of the data is shorter than distance tolerance.

Performing KAR search at 525 seconds on baseline BL1
KAR used 525.0 s (PASS) with average of 7.1 sats over average distance of 21.9 km
RMS is 0.0809 cycles (FAIL), Reliability is 1.2 (FAIL), Float/fixed sep. is 0.47 m (PASS)
KAR failed 2 out of 4 tests, will try again in 15.0 seconds
Message printed for an unsuccessful KAR search. Indicates various statistics.

KAR failed on baseline BL1 after 30.1 minutes--too much time used and starting over
Printed if KAR went too long. The tolerance is generally 30 min., and can be set from the KAR option.

Note: KAR cannot be engaged at this distance (68.6 km) on baseline BL1
Printed if distance too long for KAR to engage. The software will wait until it gets closer.

Epoch rejected due to poor satellite geometry--DD_DOP of 918.0 too large
This message warns that an epoch has been rejected because of poor satellite geometry. The default DOP tolerance is 100.0. This can be changed in the user defined options with the command DOP_TOL.

Doppler L1 cycle slip on PRN 24 of 1575419.57 cycles on baseline BL1
Indicates that a large change in carrier phase has been encountered which is interpolated as a cycle slip. If this message appears continuously, the Doppler may need to be recomputed. See *Section 6.2.3.5,* on *Page 170* for help.

Locktime cycle slip on PRN 4 of -5.92 cycles on baseline BL1
Cycle slip has been reported by base or remote receiver. Size of cycle slip is on approximate.

Inserted L1 cycle slip due to locktime reset for PRN 4 on baseline BL1
Receiver cycle slip counter reset at some time in the past but was not caught. Therefore, slip inserted now.

Less that four satellites at startup--Will try next epoch(s)
Software needs at least 4 satellites and good measurement quality at startup.

Warning: Epoch with less than 4 good satellites (Cycle slips)
This message warns about an epoch with less than 4 satellites. Usually the result of cycle slips.

Locktime cycle slip on PRN 26 of -41.31 cycles on baseline BL1
Small L2 cycle slip on PRN 26 of 0.65 cycles on baseline BL1
Both messages warn of cycle slips on L2. The DPH is an indicator of the size of the cycle slip. It shows the difference in phase. If the data contains alot of L2 cycle slips, it will make for a bad ionospheric-free solution. If there are a lot of L2 cycle slips, try using the relative ionospheric solution.

Prn 15 is below mask angle of 10.0 degrees
This message indicates that a satellite has gone below the elevation mask.

Satellite 7 is rising or re-appearing
This message is usually caused from a satellite on the horizon.

*** KAR engaged due to total loss of lock
*** KAR now engaged because distance became lower than tolerance
*** followed by a message indicates if and why KAR was engaged.

Prn 27 disappeared for 33.0 seconds on baseline BL1
Indicates that as satellite dropped out and is reappearing, a new ambiguity will be solved.

Calculating fixed solution
Calculating RMS values
Continuous fixed solution reliability: 7.43 (PASSED), RMS: 0.0372 m (PASSED), STD:
0.0014 m

Continuous fixed solution position is: 39 01 23.54716, -84 36 21.25817, 259.7909 m
Computing New Fixed solution
This message shows the results from the multi satellite fixed solution. The reliability is the ratio between the second best RMS and the best RMS. The minimum reliability for a pass is 1.35. The RMS is the RMS fit of the fixed solution. This number is in meters and the maximum value to pass is 0.025 m + 1PPM for dual frequency and 0.015 + 1PPM for single frequency.

Warning: No precise available for prn 21
Message warns that a precise ephemeris is missing for a satellite. The user may want to try another SP3 file to better the results.

$$$ GPS data errors detected--will try and reject measurements, baselines or satellites
Error messages starting with *$$$* indicate bad carrier or code measurements encountered. The above message should be following another message indicating what residuals are out-of-range and which satellite has the largest value. This indicated satellite may not be the actual problem one because the Kalman filter distributes the errors around. A number of tests will be performed to isolate the problem data and satellite. Therefore, this message is followed by the messages shown below.

C/A code tested OK (CaRms is 2.1 m)--The problem must be due to the carrier phase
Indicates that the C/A-only tested OK and a problem is very unlikely to be a problem. If the C/A was invalid, then another message will be printed.

On code, worst PRN is 20, RMS is 1.46 m (PASS), reliability is 1.84 (FAIL)
A further test on the combined code-carrier solution to ensure that the code is OK.

On phase, worst PRN is 28, RMS is 0.0949 m (PASS), reliability is 1.19 (FAIL)
This test will generally indicate if a missed cycle slip to other carrier phase problem was fixed by removing a particular satellite. The above message indicates that the problem could not be fixed, and will generally be followed by a filter reset message. See below. The reliability must be greater than 4.0 to be signaled as a pass. The user should investigate the clock offset information at this epoch via *GPBView* to see if the problematic epoch is due to an incorrectly computed clock shift.

Could not fix Kalman filter by rejecting a satellite--Failed 2 out of 4 tests
Unable to correct bad GPS data--issuing filter reset
This message indicates that a data problem could not be repaired.

$$$ Engaging filter reset--Accuracy is severely reduced
This is printed when the filter reset is being engaged. It should be preceded by a message indicating why the filter reset was issued. A filter reset is when a cycle slip is issued to all satellites and the position is reset to startup values.

*** KAR engaged due to occurrence of filter reset
Printed when a manual KAR record is being implemented and the **Engage Filter Reset** flag has been enabled. See *Section 2.5,* on *Page 50* for help.

Locktime and doppler cycle slip on PRN 30 of -307.64 cycles on baseline BL1
Indicates that a cycle slip has occurred and it has been detected by both the locktime and a large changed in the carrier phase.

%%% PRN 18 was omitted for time range 488400.0-488500.0 s on ALL baselines
%%% ALL satellites were omitted for time range 8000.0-8100.0 s on baseline mast
'%%%' followed by a message indicates when and how long a baseline and/or prn was omitted from processing.

@@@ followed by a message indicates if a position fix was processed. Position fixes can originate from fixed static or from user-entered remote initialization. See *Section 2.6,* on *Page 64* for help.

5.4.2   *FSS & RSS Files*

The *Static Session Summary* files present a summary of the float, fixed static and ARTK processing. The FSS file is created during processing in the forward direction, while the RSS file is created in the reverse direction. The project configuration and processing settings are at the beginning of the file and return status at the end of the file. The following is an example of the project configuration and processing settings.

```
--------------------------------------------------------------------
 Configuration and processing settings
--------------------------------------------------------------------
Project settings:
 Master 1              : Name    GRN04-0107a  ENABLED
                       : Antenna SIMPLE_VERT 0.000 m
                       : File       \\waypoint01\c\GPSData\Manual_Data\GRN04.gpb
                       : Position 43 45 49.97515 -87 50 51.75271 198.262
 Remote                : Name    Remote         ENABLED
                       : Antenna SIMPLE_VERT 0.000 m
                       : File       \\\waypoint01\c\GPSData\Manual_Data\air_rover.gpb
                       : 0 static sessions
 Direction             : FORWARD
 Process Mode          : Dual frequency carrier phase
 Static Initial.       : Float
 Use KAR               : Yes
 Use Glonass           : Yes

General Options:
 Elevation Mask        : 10.0 degrees
 Data Interval         : 1.00 s
 Fixed Interval        : 15.00 s
 Time Range            : From 494298.0 to 604800.0 s
 Datum                 : WGS84 using conversion 'WGS84 to WGS84 (Same)'

Advanced 1 Options:
 Base Satellite        : (auto)
 Locktime Cutoff       : 4.0 s
 Model Tropo.          : Yes, using Saastamoinen model
 Use Doppler           : Yes
 Dynamics Model        : No
 Write Bad             : No, (Yes if epochs containing bad data to be written)
                          Skip Bad: No, (Yes if epochs with bad statistics to be skipped)
                         Output Format: Normal
 Write settings        :Yes, (to static summary file)
 Write .fbv/rbv        :No, (includes satelite residual and multi-base binary values)
 Write Slip Warn       :No
Advanced 2 Options:
 Split Static          : No
 Use fixed stat.       : Never
 Cycle slip checking   :
                         Doppler: Yes, (using 10.0 cycle tolerance)
                         Locktime : Yes
```

Static tol. : 0.40 cycles
Save ambig.: Yes, (on satellite drop-out)

Measurement Weighting Options:
  Weighting Mode   : Elevation Based
  Main SD Values   :
                    Code SD : 2.00 m
                    Phase SD: 0.0350 m, (adjusting for iono. correction)
                    Doppler SD   : 1.000 m/s
  Baseline Values   :
                    GRN04-0107a   : Using Main SD Values
  Reject. Level   : NORMAL
  Max Rej Sec   : 15.0 (s)
  Skip Code Rej   : 5 nEpochs
  Skip Phase Rej   : 1 nEpochs
  Reliability Tol   : 4.00 , (for rejecting bad satellites)
  Dist. Effects   : Low, (HzPPM: 0.3, VertPPM: 3.5)

Ionosphere/L2 Options:
  Iono Correction   : Yes, using Iono-free model
  Corr. Code Iono   : No
  Use IONEX model   : Off
  Use L2/P2 SF   : No
  Use P1-Code   : No, (instead of C/A code)
  Use P2-Code   : No
  Use L2 for Amb   : Yes
  Small L2 Slip   : 0.40 (tolerance)
  Use L2 Locktime   : No

KAR 1 Options:
  Minimum Time   : 2.00 minutes
  Additive Time   : 1.50 minutes/10-km
  Search Region   : Adaptive, using StdDev scale factor of 3.00
  Max. distance   : 30.00 km
  Start in Static   : No
  Engage on Dist   : No
  Engage on Time   : No
  Engage Bad DOP   : No

KAR 2 Options:
  Strict Rel. Tol   : Yes
  Strict RMS Tol   : No
  Fast KAR   : No
  Fast KAR (5SV)   : No
  Refine L1/L2   : Yes
  Search Closest   : Yes, (Use closest baseline for MB processing)
  Use More Data   : Yes, (if Yes, use all data < max. distance)
  Distance Weight   : Yes
  Maximum DOP   : 9.00

```
    Maximum Time      : 30.00 minutes
    Data Filter       : 5.0 s
    Exact Interval    : No
    Search Interval   : 15.0 s
    L2 Noise Model    : AUTO, (iono. distance tolerance is 5.0 km)

    GLONASS Options:
    Solve for Time    : Yes
    Initial Value     : 0.0 m
    Initial StdDev    : 1000.000 m
    Initial Density   : 0.000 m^2/s
```

The following is an example of the return status:

```
    ------------------------------------------------------------------------
     Program finished, return status
    ------------------------------------------------------------------------
    Finish {
          Status:        "SUCCESS"
          RetValue:      -100 "Successful program completion--end of file reached"
          ErrMsg:        "End-of-file Reached"
          NumEpochs: 7704
          UsageTime:   12.48 s
          ProcInfo:      "Run (8)" by "MB"
          ProcTime:      16:45:02 08/10/2005
    }
```

The file may look slightly different depending on whether static or kinematic processing was performed. When static processing, output includes the final coordinates and various statistics associated with those coordinates. In kinematic processing, the ARTK summary record is the only output. When doing kinematic processing without the use of ARTK, the user will not see these output in the FSS or RSS file.

The following is the output satellite tracking list. This output is only displayed on fixed static solutions. It shows which satellites are tracked when, how long, and the status of the satellite. The status is important because it will show if any satellites are rejected. This output can also be seen for all data types in the plot 'Satellite Lock'.

```
    --------------------------------------------------------------------------------
     Session: 511, Base: BL1, Satellite status in fixed solution
    --------------------------------------------------------------------------------
```

PRN	START	END	DT (SEC)	BASE	BEST RMS	INDEX	RMS@0	NUM RMS	NEPOCH	STATUS
21	149910	151050	1140.0	2	0.044	0	0.044	39	39	Rejected
10	142530	151260	8730.0	2	0.022	0	0.022	292	292	OK
26	148740	151260	2520.0	2	0.028	0	0.028	85	85	OK
29	146820	151260	4440.0	2	0.033	0	0.033	149	149	OK
21	151740	151950	210.0	6	0.038	0	0.038	8	8	Rejected
18	151710	152130	420.0	6	0.024	0	0.024	15	15	OK
10	151350	154770	3420.0	6	0.013	0	0.013	115	115	OK
10	155070	155280	210.0	6	0.018	0	0.018	8	8	OK

Following are the final coordinates that are output in a static solution. This is not seen for kinematic data. The difference between the fixed and float output is the fixed will have an RMS and reliability output. The RMS is the RMS fit of the fixed solution. This number is in meters and the maximum value to pass is 0.025 m + 1PPM for dual frequency and 0.015 + 1PPM for single frequency. The reliability is the ratio between the second best RMS and the best RMS. The minimum reliability for a pass is 1.35.

```
-----------------------------------------------------------------------------------------
 Final FIXED static position for Station STATIC, Base BL1
-----------------------------------------------------------------------------------------
Static {
        ToSta:          "STATIC"
        FromSta:        "BL1"
        IsBest:         Yes
        AntHgt:         0.486 m

        StartTime:      6240.00 1318 01:44:00.0 04/10/2005
        EndTime:        6375.00 1318 01:46:15.0 04/10/2005
        TimeLen:        2 minutes, 15 seconds

        Latitude:       -39 00 33.18453
        Longitude:      174 10 46.74393
        EllHeight:      63.8096
        SolType:        L1L2-Fixed
        IsFixed:        Yes
        RMS:            0.0040 PASS ; m
        Reliability:    10.3 PASS ; RMS ratio

        StdDev:         0.0063 0.0068 0.0147 ; m (e,n,h)
        EcefVec:        45.4059 -48.5693 -63.9423 ; m
        EcefCov1:       2.02423923e-004
        EcefCov2:       -5.94309046e-005 4.99990537e-005
        EcefCov3:       6.87795183e-005 -1.87233603e-005 5.03819486e-005
        AvgDDDop:       3.35
        AvgPDop:        2.12
        AvgNumSats:     7.0
        Quality         1

        SlopeDist:      92.246 ; m
        HorizDist:      92.235 ; m
        SurfaceDist:    92.235 ; m
        Azimuth12:      151 42 36.21749
        Azimuth21:      331 42 35.07388
}
```

The only output from kinematic processing is the ARTK summary record as shown below. Note that if kinematic processing is used without ARTK, no output will be shown in the FSS/RSS files.

```
-------------------------------------------------------------------------
 KAR summary records for succeeded solutions
-------------------------------------------------------------------------
Kar {
        EngageTime:   343269.00 1272 23:21:09.0 05/26/2004
        RestoreTime:  343270.00 1272 23:21:10.0 05/26/2004
        SearchTime:   343329.00 1272 23:22:09.0 05/26/2004
        TimeSkipped:  0.0        s
        TimeUsed:     60.0       s        PASS
        RMS:          0.010      cyc      PASS
        Reliability:  6.2                 PASS
        FloatFixSep:  .42        m        PASS
        SearchDist:   0.02       km       "HIGH L2 noise model"
        AvgDist:      0.02       km
        AvgSats:      7.0
        SearchSats:   7          "13 3 19 1 28 27 31"
        RestoreSats:  7          "13 3 19 1 28 27 31"
        RestoreDop:   2.6
        RestorePos:   -21 10 09.12638 149 11 00.32129 58.989
        Message:      "KAR success!"
    }
```

ARTK does a good job of determining which fixes are acceptable. For each fix, the following parameters are available:

Baseline	This is the base station that ARTK fixed from
EngageTime	If GrafNav engaged ARTK, then this is the time of engagement. Otherwise, it is the search time.
RestoreTime	This the time ARTK rewound to.
SearchTime	ARTK used the data from this epoch to perform its search
TimeSkipped	Generally, this will show how many seconds of time were skipped in restoring. IT really only has meaning if ARTK was engaged by GrafNav.
TimeUsed	This indicates show many seconds of data were used to fix. Again, if not engaged, then this number can just be the time since the last fix
RMS	This is the goodness of fit test value
Reliability	This is the ratio value. Larger values indicate a more reliable fix
FloatFixSep	This is the difference between the float and fixed solution at the search time. If the previous solution was already fixed, then this is the amount that the trajectory "jumped" by after the fix.
SearchDist	This is the base-rover distance at time of search
RestoreSats	This is the number of fixed satellites
SolutionInfo	Can be either 'GPS Fixed' or 'GPS Fixed/Verified' Verified solution are deemed more reliable.
RestoreDOP	This is the DD_DOP using the satellites restored.

5.4.3   FWD & REV Files

This section explains the trajectory output, which has entries for each epoch. The first line of the output file always begins with *$OUTREC*, and is followed by the version number, the processing engine, and the type of output. An example of the first line is given below:

$OUTREC Ver7.50.2426 NGPS32 Forward Normal

The output format is shown below. Note that certain entries may not always appear, depending on which processing options were used. See *Section 2.5,* on *Page 50* for help selecting the output level.

Out { Tim: *even_sec_time corrected_time WkNum*	GPS seconds of the week, week number
Geo: *latitude longitude height anthgt*	Degrees minutes seconds, metres
Loc: *d-east d-north d-height v-east v-north v-heigh*t	Local level pos+vel, metres, m/s
Sta: *quality amb_drift dd_dop pdop hdop vdop*	1-6, cycles/sec, DOPs
Rms: *L1Rms CARms P1Rms D1Rms L1Std CAStd D1Std*	
	m, m/s; RMS of resid, Std. dev. of meas.
Var: *cee cnn czz cve cvn cvz cpos*	Position + velocity variance + trace with ppm, m^2, m^2/s^2
Flg: S/K L/F *NumGps NumGlonass SolType*	(S)tatic, (K)inematic, f(L)oat amb., (F)ixed amb.; SolType: (S)-SF carrier, (D)-DF carrier, (I)-IonoFree, (R)-RelIono, (C)-C/A Only
Cov: *cne cze czn cvne cvze cvzn*	Position and velocity covariance
Ecf: *dx dy dz*	ECEF base◊remote vector
Acc: *ae an au*	Local level accelerations (m/s^2)
Gln: *TimeOffset ToffSd NGps NGln*	m
}	

A numerical example is also given:

```
Out { Tim: 343277.000 343276.999962535 1272
      Geo: -21 10 09.16196 149 11 00.34808 58.9045 0.000
      Loc: -2.454 18.834 0.804 -0.002 0.022 0.045
      Sta: 4 0.118066 2.59 1.55 1.19 1.00
      Rms: 0.0060 0.545 0.000 0.028 0.0379 4.200 1.050
      Var: 5.89495e-001 7.70540e-001 4.04788e+000 2.80134e-001 3.47242e-001
      9.18255e-001 5.40791e+000
      Flg: K L 7 0 I
      Cov: 3.91145e-002 3.03102e-001 5.10459e-002 1.38708e-002 5.8769e-002 6.98362e-004
      Ecf: -5.228 5.976 17.272
      Acc: -0.020 0.037 0.038
      Gln: 0.000 1000000.0000 0 0
   }
```

5.4.4   FBV & RBV Files

Binary value file provide additional baseline and satellite output statistics, which are mostly used for plotting. An FBV/RBV file will be created when the multi-base processing is being performed, or when the *Write MB binary values/satellite residuals* option is enabled. See *Section 2.5,* on *Page 50* for help.

FBV/RBV files contain the following:
For each baseline:

i. Code, carrier and Doppler RMS values

ii. Code, carrier and Doppler SD values

iii. Code and carrier phase separation values

iv. DOP values

v. Ambiguity drift

vi. Effective weighting

For each satellite:

i. PRN

ii. Baseline

iii. Rejection + base satellite flags

iv. Code, carrier and Doppler residual values

v. Code, carrier and Doppler SD values

Export these files to ASCII in GrafNav via the *Export Binary Values* feature. See *Section 2.7.4,* on *Page 80* for additional information.

6.1   Utilities Overview

This chapter describes the following utilities that are included with Waypoint's software:

- • GPB Viewer

- • Concatenate, Splice and Resample

- • GPS Data Converter

- • GPS Data Logger

This chapter goes through each menu of their interfaces. Step-by-step instructions for first time users are also included.

6.2   GPB Viewer Overview

GPB files are in a binary format and cannot be viewed with a normal text editor. *GPBView*er allows you to both view and edit your data in the GPB View window.

6.2.1   File

6.2.1.1   Open

Any GPB file can be opened with this feature.

⊠   If the GPB file is corrupt, *GPBViewer* prompts for permission to fix the file.

6.2.1.2   Close

This feature will close the GPB file without exiting from *GPBViewer*.

6.2.1.3   Saving a GPB File

To make permanent modifications to a GPB file, save a copy the original file. *File | Save As…* gives saves a copy of the current GPB file, and its associated EPP file, under a new name. This lets you edit the new file without losing the original file.

Use this feature to save a file from a newer format into an older format, making it compatible with older versions of the software.
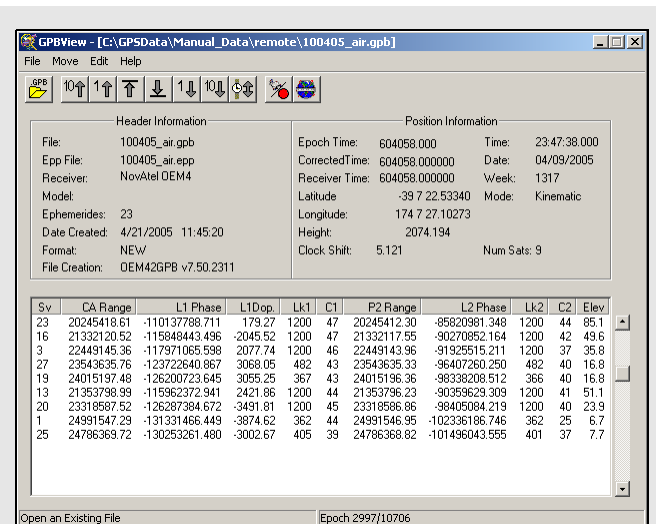
⊠   L2C tracking is indicated as a C2 after the satellite.
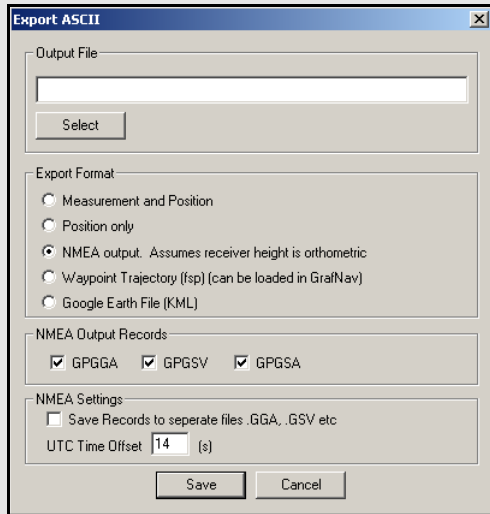
ASCII formats for saving files

Measurement and Position
Exports time, date, raw measurement data and position information for each epoch.

Position only
Exports time, date and position information for each epoch.

NMEA output
Exports data from every epoch in the well-documented NMEA format.

Waypoint Trajectory
Exports the data in Waypoint's single point trajectory (FSP) format. This trajectory file can then be loaded into GrafNav as a solution. See *Chapter 3* on *Page 153* for a definition of the format.

Google Earth
Exports position information into a KML file, which can then be plotted into Google Earth. If you are hoping to download nearby base station data, this feature is very helpful when used in conjunction with the KML files produced for each available download service.

6.2.1.4   Export ASCII

This feature saves data from the binary GPB file into various ASCII formats.

Output File
This option allows you to name the output file. Provide a filename extension because the software will not automatically assign one.

Export Format
The five choices of ASCII formats to save your file in are listed in the shaded box.

NMEA Output Records
This is available for exporting into the NMEA format and allows you to choose which NMEA strings to write to the output file.

NMEA Settings
This is available for exporting into the NMEA format. Enabling the *Save Records to separate files* option writes individual files for each NMEA output record selected under *NMEA Output Records*. You can also enter the appropriate *UTC Time Offset* with respect to GPS time.

6.2.1.5   Load Alternate Ephemeris File

If you lack ephemerides to cover the entire observation period, *GPBViewer* displays a warning message when opening the GPB file. Without a valid EPP file, many features are disabled, including the display of elevation angles and the re-computing of positions. This feature allows you to specify an alternate EPP file for use in the *GPB Viewer*. You can see how many ephemerides have been loaded with the *Ephemerides* field of the *Header Information* box in the top half of the *GPBView* window.

6.2.1.6   Exit

Exits the program.

6.2.2 Move

Forward n and Backward n
Scrolls through *n* epochs in the direction indicated.

Start of file and End of file
Moves to the first and last epoch in the file.

> ⊠ It is easier to scroll through the GPB file using the shortcut keys, specified under the *Move* menu beside each option.

Search
Moves to a specific location in the file. You can specify an epoch number or a time, in either GPS seconds of the week or GMT format.

6.2.3 Edit

Several options under this menu make permanent changes to the GPB file. You are warned when one of these options has been selected so that you can save a copy of the original GPB file before using it. See *Section 5.3.1,* on *Page 153* for additional information.

6.2.3.1 Switch Static/Kinematic...

If you are unable to switch your data between kinematic and static mode during logging, do it post-conversion with the *GPB Viewer*. This is important for processing kinematic data.

> ⊠ The status is indicated in the top half of the *GPBView* window, under the *Mode* field of the *Position Information* box.

Process Mode
Specifies whether the mode is to be set to *Static* or *Kinematic*.

Epochs to Convert
Determines which observations will be switched. Convert using the options listed in the shaded box.

Start Location
Use in conjunction with *All epochs* and *Specified Epochs*, under *Epochs to Convert*. Determines the starting point of the conversion.
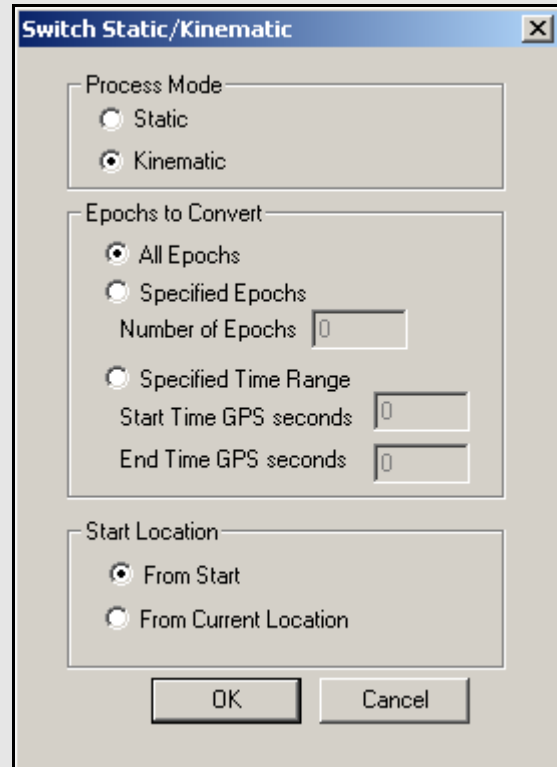
Epochs to Convert options

All Epochs
Switches all epochs from the start of the file onwards or from the current location onwards, depending which starting point is specified under *Start Location* options.

Specified Epochs
Converts the specified number of epochs, subject to the chosen starting point. You can also convert a specific time range that is based on GPS seconds of the week.

When to recalculate position and time

- To compute position records when they are not being logged because both GrafNet and GrafMov require the GPB file to contain positions.

- To correct erroneous clock shifts.

- To specify a time range to recalculate specific data. You are given the choice as to whether to recalculate only the positions or clock shifts, or both.

6.2.3.2 Recalculate Position and Time

Useful applications for this feature are listed in the shaded box. It removes or induces a cycle slip on any or all satellites at a given epoch. If you add a cycle slip, the locktime for the specified satellite(s) is set to zero. Do this at any epoch where a locktime is greater than zero.

6.2.3.3 Add/ Remove Cycle Slips...

Only remove cycle slips at epochs with a zero locktime and a valid locktime for the satellite of interest at the previous epoch. This feature increments the locktime for the current epoch until the next loss of lock.

⊠   Use this feature carefully because the changes can cause problems during processing.

6.2.3.4 Disable Satellite (s)

If a data record is corrupt, eliminated it with this feature. When this option is engaged, the program sets the pseudorange to zero and removes the satellite from any processing that takes place using this file.

6.2.3.5 Recalculate Doppler Measurements

Use this feature if the velocity output from processing appears to be erroneous, indicating possible corruption in the Doppler measurements. The methods available for this recalculation are dependent on the mode in which the data was collected.

6.2.3.6 Align Epoch Time

This feature specifies the data interval and is for data sets where the epoch times are not falling on the proper interval. When this option is activated, *GPBViewer* shifts the epoch time to the nearest epoch, based on the specified interval. Use this feature if the software cannot find any overlapping data between rover and base station files that were logged concurrently.

6.2.3.7 Edit Meteorological Values

This feature edits the GPB file pertaining to the environmental conditions for better troposphere modeling. A TRP file is created, and the processor looks for it when processing. Information about the new troposphere parameters appear in the message logs (FML/RML) after processing. Enter meteorological values for both the master and remote stations. If you do not, the post-processor utilizes the values from one of the stations for both and only the effect of height difference will be accounted for.

6.2.3.8 Edit Satellite Tracking L2C

In order to properly handle carrier phase measurements tracked using L2C (instead of L2P/Y), a correction value must be applied to make the satellite compatible with L2P/Y. In order to apply this correction, it must be known which satellites are tracking L2C. For some formats such as OEMV, Leica 1200 and RINEX 2.11 can insert these flags automatically. However, L2C decoding for Trimble and possibly some other formats is not supported, and this feature permits the user to set the L2C satellites to be marked. It assumes that there are no changes between L2C and L2P tracking during the data. The software will automatically fill the list of PRNs to change by selecting those that are block IIR-M and later.

6.2.3.9 Edit L2C Phase Correction

In addition to proper satellite registration, L2C processing also needs a correction value. The magnitude of the correction tends to be -0.25, 0.50, 0.25 or 0.00 cycles, and it can be stored in the GPB header. The feature permits the changing of the correction or inserting a correction for those files which do not have one already defined.

Some manufacturers may choose to align L2C with L2P resulting in a correction of 0.00. For the NovAtel OEMV, firmware versions 3.0 and 3.1 use 0.5 cycles while future versions (3.2 and greater) will either use -0.25 or 0.00. For Trimble, early versions used 0.5, while later versions will require -0.25.

6.3 Concatenate, Splice and Resample Overview
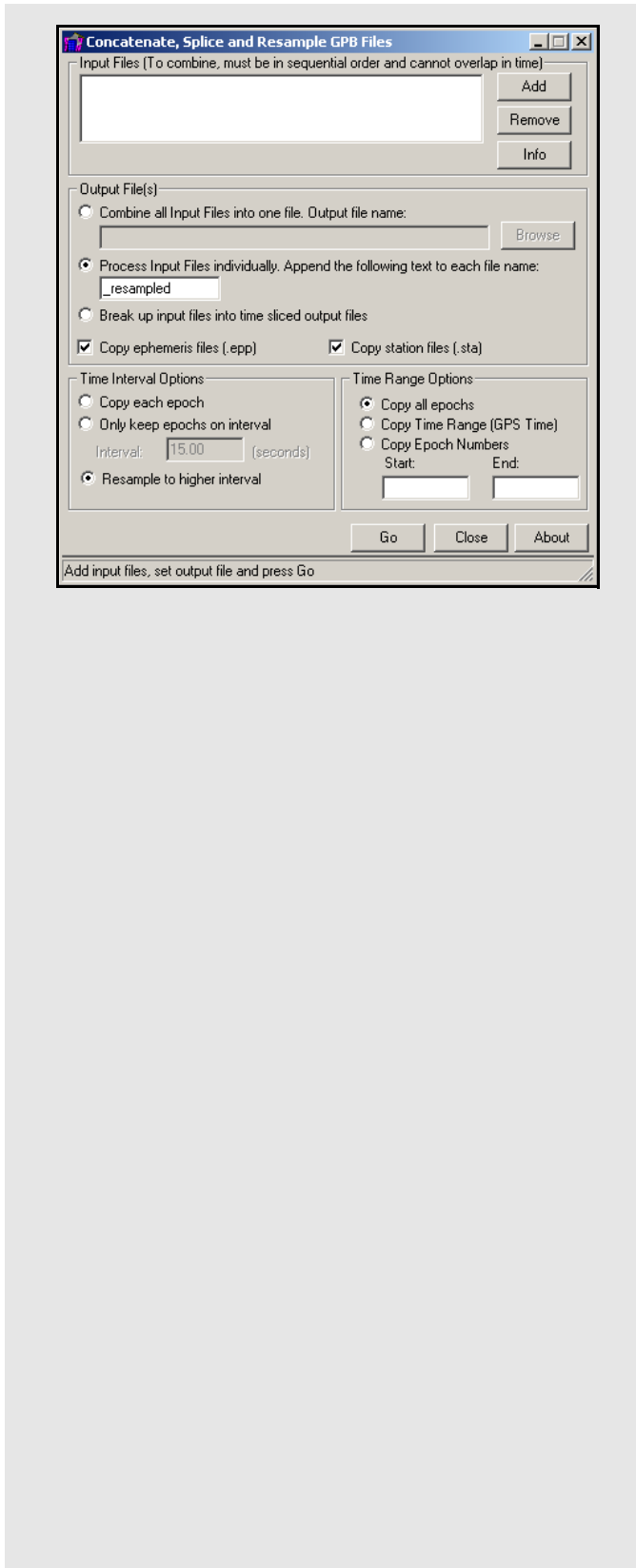
This utility is available via *File | Utilities* in all of Waypoint's programs. This utility joins multiple files together, cuts out a small portion of a file or resamples a file.

6.3.1 Concatenate, Splice and Resample GPB Files

Input Files
Use the *Add* button to locate the GPB files that are to be used. To concatenate several files, add them all at once. The program will sort them chronologically.

Output File(s)
Determines how the creation and naming of new files is handled. For concatenating files, use the *Combine all Input Files into one file* option and provide a name for the output GPB file. For resampling or splicing multiple files, use the *Process Input Files individually* option. The name of the created output files depend on the name of their respective input file and the suffix that is specified. To break up a file into multiple files of *n* minutes, enable the *Break up input files into time sliced output files* option.

Time Interval Options
The three options are the following:

> ***Copy each epoch***
> Select this if the data rate of the output file is to match that of the input file.

> ***Only keep epochs on interval***
> Use this when a file is resampled to a lower data rate. The interval specified determines which epochs are copied into the output file.

> ***Resample to higher interval***
> Use this when a file is resampled to a higher data rate.

⊠   Resampling can only be performed on static data. Vehicle motion is not well characterized by the polynomials used so its interpolation is unreliable.

Time Range Options
Determines the range of time that is to be used for the
creation of the new file. *Copy all epochs* is generally for
resampling purposes. Splicing a file requires the
selection of either *Copy Time Range* or *Copy Epoch
Numbers*.
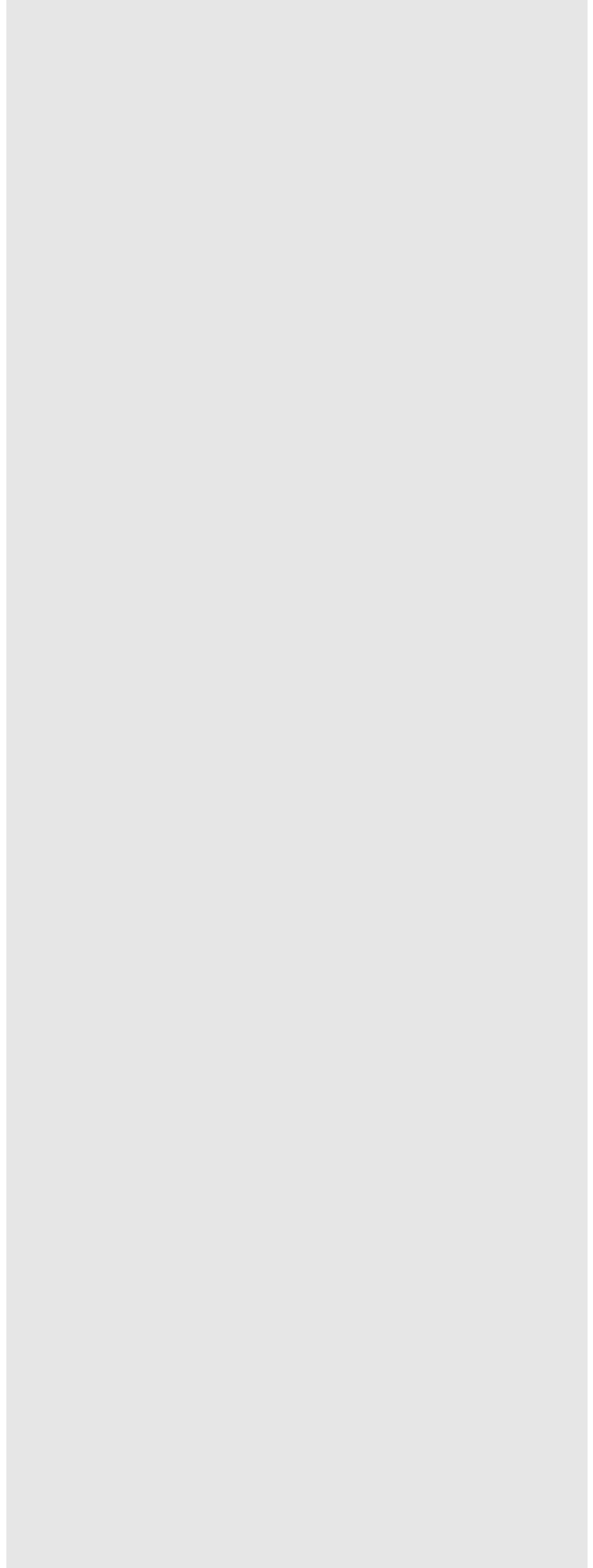
6.4 GNSS Data Converter Overview
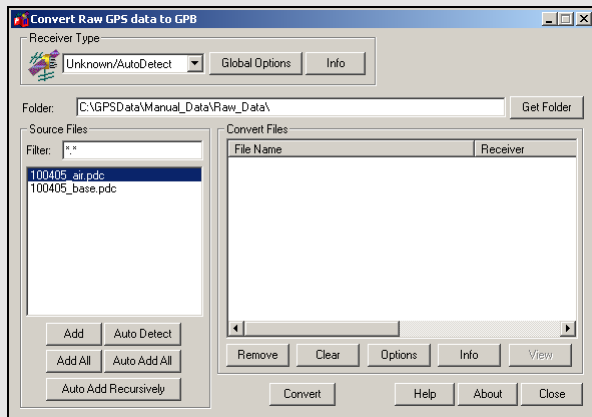
Source file options

Add

Adds the selected file in the *Source Files* window to the *Convert Files* list.

> ⊠ If a receiver type has not been specified, the utility will attempt to perform auto-detection.

Add All

If a receiver is selected, it adds all files in the *Source Files* list to the *Convert Files* list as data files. Otherwise, it performs auto-detection on every file in the *Source Files* list.

Auto Detect

Auto-detects the selected file in the *Source Files* window for conversion.

> ⊠ Not all receivers are automatically detected.

Auto Add All

Auto-detects all the files showing in the *Source Files* list for conversion.

> ⊠ Not all receiver types are automatically detected

Auto Add Recursively

Auto-detects all files in the immediate folder and its subfolders. 128 files can be added.

If you logged data with any logging utility other than Waypoint's, this utility converts data into GPB format. If you logged data with Waypoint's logging software and saved it to a binary LOG file, also convert this data. This tool decodes raw GNSS data from numerous receivers and is available in all of Waypoint's programs. The supported receivers are listed in *Section 6.4.3,* on *Page 177* .

6.4.1 Convert Raw GNSS data to GPB

Receiver Type
Choose the receiver used to collect the data. Otherwise, leave the selection at *Unknown/ AutoDetect.*

> #### *Global Options*
> These options depend on the type of receiver and are applied the raw data files in the *Convert Files* window that were logged using that receiver type and are retained as future values.
>
> #### *Info*
> Provides information on the version and status of the DLL file used for the conversion, including whether it is loaded and allows for auto-detection.

Folder
Specifies the folder to look for data in. Type the directory in manually, or browse for it with the *Get Folder* button.

Source Files
Lists the files in the folder with filtered extensions matching those specified in the *Filter* field. The options available here are listed in the shaded box.

Convert Files

This lists all the files waiting to be converted and has icons corresponding to their associated receiver type. Once the *Convert* button is pressed, these icons indicate whether or not conversion was successful. Options available here including the following:

> **Remove**
> Removes the selected file from the *Convert Files* window.
>
> **Clear**
> Remove all files from the *Convert Files* window.
>
> **Options**
> Displays the options associated with the receiver type of the selected file. Any change are only applied to the selected file and will not be retained.
>
> **Info**
> Displays file path, receiver type, and conversion status of the selected file.
>
> **View**
> Available after conversion to open the selected file in *GPBView.*

6.4.2   Pre-processing Checks

All supported receivers in GrafNav's raw GNSS converter now feature pre-processing checks. The checks attempt to automatically solve unusual decoding problems and help ensure that files are ready to be post-processed. Each function performed in pre-processing has been developed to automatically solve common problems that would require user intervention to resolve.

Specifically, the pre-processing checks compute a single point position for as many epochs as possible if no position records are logged. The unprocessed position is used for several purposes in GrafNav, such as plotting the unprocessed position to the map window when loading a file. Position records determine if ionospheric processing should be automatically engaged.

Automated ionospheric processing activates ionospheric processing when it can produce better results on surveys with a large master-remote separation (> 7 km) and disables processing on short baselines.

Pre-processing checks also perform functions such as disabling impossibly large or small pseudoranges and removing any duplicate satellite measurements. These can be caused by receiver tracking errors or known firmware bugs. To avoid rejecting a satellite due to missing Doppler information (used in cycle slip detection), any missing Doppler values are calculated by the pre-processing checks from the C/A code (if available). Any unusual time reversals or duplicate epochs are removed, both of which can cause degraded processing results or processing to halt prematurely.

In addition, pre-processing checks attempt to determine the survey's processing environment. In other words, the position records are analyzed to determine if the survey is conducted in an airborne, marine, or ground vehicle environment. GrafNav uses this flag to automatically load the recommended processing profile when you initially access the processing dialogue after creating a project. This function helps to ensure quality post-processing results for new users and to speed the workflow of existing GrafNav users. The processing environment determination may not be perfectly accurate. For example, a slow moving ground vehicle survey may be detected as a marine survey.

The pre-processing checks also include automatic static/kinematic detection. GrafNav's processing mode (static or kinematic) is controlled by a flag decoded to the remote GPB file. Previous versions of GrafNav converted all epochs to static by default, which meant that attempts to process a kinematic survey without modifying the conversion defaults resulted in gross processing errors. To avoid this problem, GrafNav uses a kinematic default conversion option for all non-RINEX data types. To avoid inconveniences, automatic static/kinematic pre-processing minimizes user intervention when converting data that is known to be static or kinematic.

Unprocessed position records also automatically detect the presence of static and kinematic data. This is limited by the quality of the position records decoded (or calculated) from the raw data and is subject to failure in cases such as where the survey vehicle moves very slowly or in fast, very short bursts. The minimum static session length is three minutes and applies a buffer of 30 seconds where the start of kinematic data is detected. If the automatic static/kinematic detection produces undesirable results, manually change the conversion type to static or kinematic in the Global Options for your receiver type.

6.4.3   Supported Receivers

This section discusses the receivers that are currently supported by the *Raw GNSS Data to GPB* converter. This information includes the conversion options, as well as the supported formats and records for each receiver.
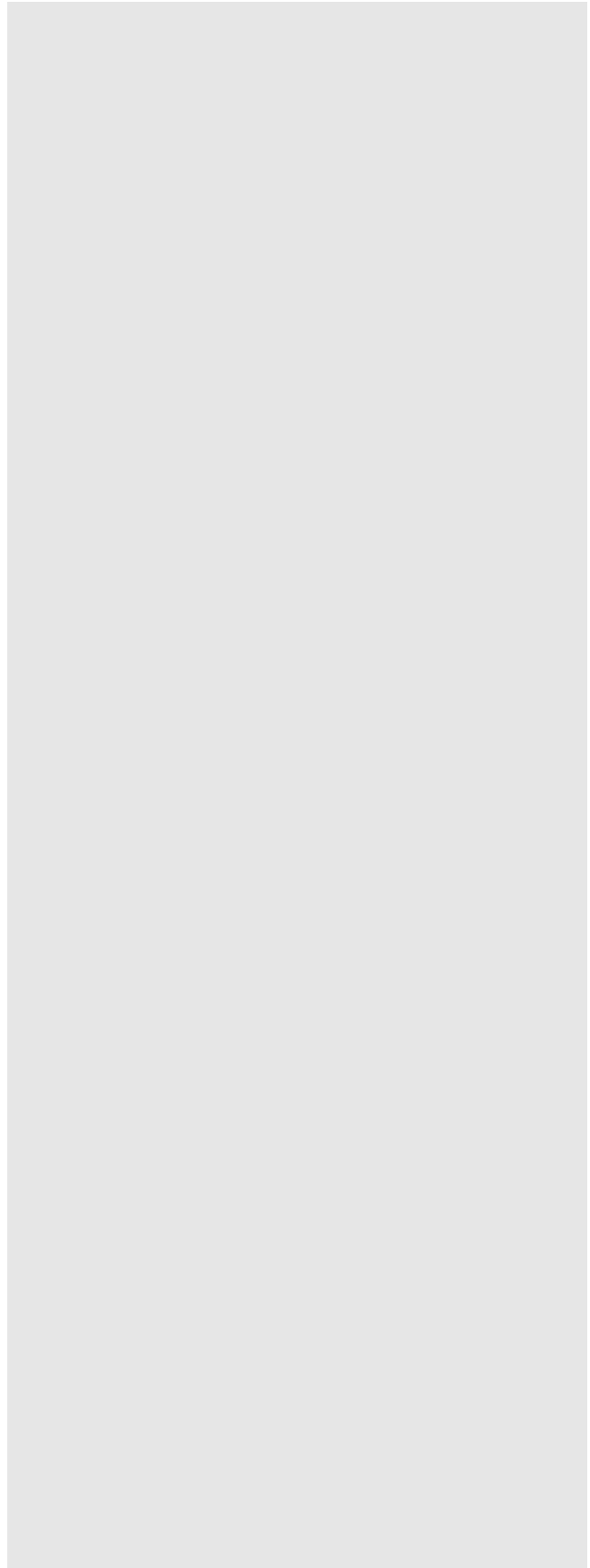
Table 16: Records Supported for Javad & Topcon

Record	Type	Comment
RC, rc	C/A Code Measurement Block	RC suggested.
1R	L1 P-Code Measurement Block	
3R	L2 C/A Code Measurement Block	
R2, r2, 2R, 2r	L2 P-Code Measurement Block	2R suggested.
PC, pc, CP, cp	L1 Phase Measurement Block	CP suggested.
P2, p2, 2P. 2p	L2 Phase Measurement Block	2P suggested.
3P, 3p	L2C Phase Measurement Block	
DC	L1 Doppler Measurements	Strongly recommended.
GE	GPS Ephemeris	Required.
NE	GLONASS Ephemeris	Required.
TO	Clock Offset	
TC	Locktime	
PO	Position	Recommended for GrafNet Users.
SI	PRN List	
RD	Receiver Date	

Javad Options

- ☑ Perform pre-processing checks
- ☐ Use carrier phase from P1 instead of C/A
- ☑ Use locktime records for cycle slip detection
- ☐ Decode epochs with bad checksums
- ☑ Use SAVE marker to store sites to .sta file (otherwise each site saved)
- ☐ Verbose messaging mode

L2C phase correction: -0.25 (cycles)   ☐ Ignore L2C data

Static/Kinematic Mode
- ⦿ Auto   ○ Kinematic   ○ Static

Factory Defaults   OK   Cancel

Javad and Topcon

✉ This converter supports GLONASS-enabled receivers.

Table 16 describes the supported records.

The following describes the options available for this converter:

Perform pre-processing checks
If enabled, data is scanned after conversion to correct potential issues. See *Section 6.4.2,* on *Page 175* for more information.

Use carrier phase from P1 instead of C/A
Measurements from P1 can be used instead, but this is not recommended.

Use locktime records for cycle slip detection
Locktimes from the Javad receiver are used instead of those computed by the decoder. Enabled this if Javad locktimes are problematic.

Static/Kinematic Mode
This option controls how the static/kinematic flags are set in the final GPB file. *Auto* is only used in conjunction with the pre-processing checks. It attempts to automatically set the flag based on the computed dynamics. This could result in a mixture of static/kinematic flags within the GPB file. If you wish to force the entire GPB file to be a certain mode, you can use the *Static* or *Kinematic* option.

Decode epochs with bad checksums
If disabled, epochs containing records with failed checksums will not be decoded. Otherwise, only the affected data is ignored.

Use SAVE marker to store sites to.sta file
Markers are saved to an STA file.

Verbose messaging mode
Alerts of warnings and errors that have occurred.

L2C phase correction
If your receiver logs L2C measurements, then the phase offset must be entered. If you are unsure, you can disable its usage.

Table 17: Records Supported for Leica 500

Record	Type	Comment
19	Measurements (compressed)	One of these records is required; record #20 needed if Doppler data is of interest.
20	Measurements (expanded)	
15	Ephemeris	Required.
10	Position	Recommended for GrafNet users.
13	Station/Event Mark	Written to STA file.
9	Antenna Height	Written to STA file.
108	Antenna Type	Written to STA file

Table 18: Records Supported for Leica 1200

Record	Type	Comment
119	Measurements	One of these records is required, but #120 is recommended
120	Measurements	
115	Ephemeris	Required.
110	Position	Recommended for GrafNet users.
109	Antenna Height	Written to STA file.
113	Event Mark	Written to STA file.
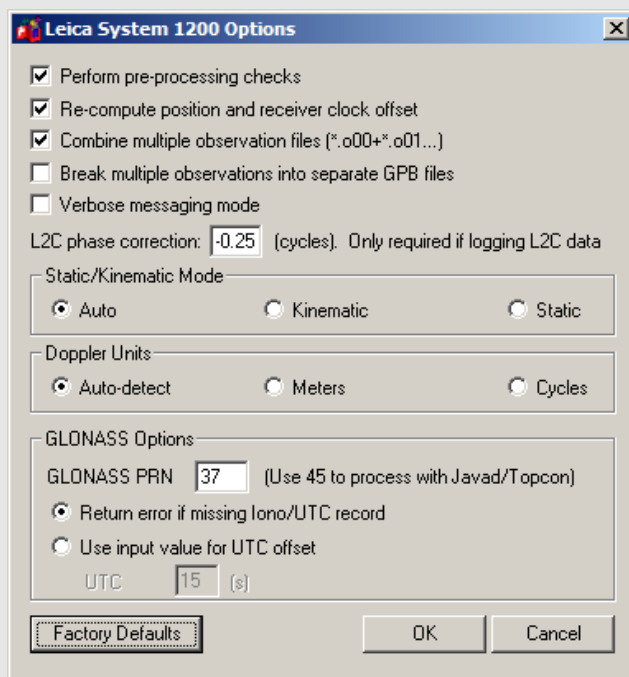
Leica System 500

This decoder handles data from the System 500 or SR530 receivers.

Table 17 describes the supported records.

Perform pre-processing checks
If enabled, data is scanned after conversion to correct potential issues. See *Section 6.4.2,* on *Page 175* for more information.

Re-compute position and receiver clock
Enable this option if the clock shift data is corrupt, or if positions records are not present.

Combine multiple (.o00,.o01…) files into single GPB file
Leica SR530 receivers write all data into separate files from one session with different extensions. Enabling this option will combine files from one session into one GPB file

Use P1 carrier instead of CA carrier for L1 phase
Measurements from P1 can be used instead, but this is not recommended. Only available if Record #20 was logged.

Verbose message information output
Alerts you of additional warnings and errors that have occurred.

Scale L1 Doppler to L1 cycles
Recalculates Doppler to correct early Leica firmware bug.

Insert kinematic markers after gaps and stations
Ensures that static sessions are properly created.

Use new station format for output
Utilizes a more-detailed format.

Use new GPB format
Converts data into the new GPB format.

Leica System 1200

Table 18 describes the supported records.

Perform pre-processing checks
If enabled, data is scanned after conversion to correct potential issues. See *Section 6.4.2,* on *Page 175* for more information.

Re-compute position and receiver clock offset
Enable this option if the clock shift data is corrupt, or if positions records are not present.

Combine multiple observation files
Leica receivers write data into separate files from one session with different extensions. This option combines files from one session into one GPB file

Verbose message mode
Alerts you of additional warnings and errors that have occurred.

Static/Kinematic Mode
This option controls how the static/kinematic flags are set in the final GPB file. *Auto* is used in conjunction with the pre-processing checks. It attempts to automatically set the flag based on the computed dynamics. This could result in a mixture of static/kinematic flags in the GPB file. If you want to force the entire GPB file to a specific mode, use the *Static* or *Kinematic* option.
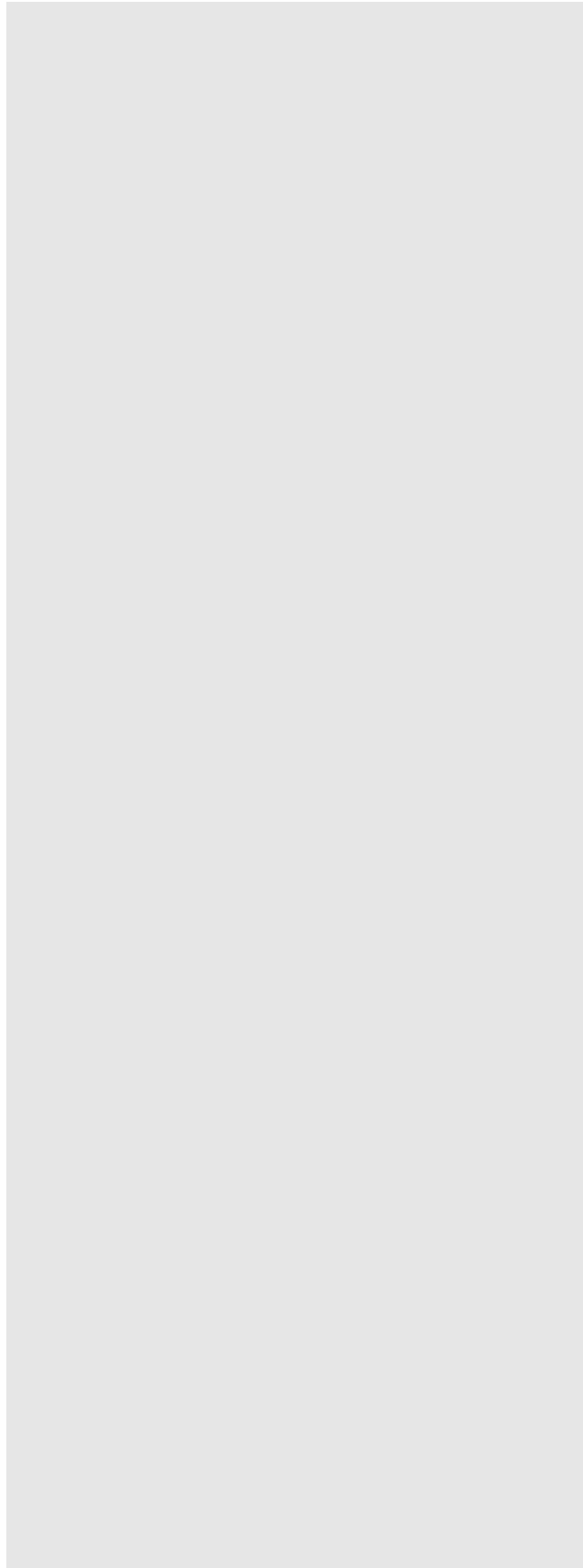
Break multiple observations into separate GPB files
If you have logged data from multiple sessions and/or days, enable this option to create a separate GPB file for each.

Doppler Units
Some Leica firmware versions use different Doppler units. You can specify a unit, but we recommend that you rely on the decoder to automatically choose an appropriate unit.

GLONASS PRN
If you plan to process the data with a different brand of receiver, ensure that the GLONASS satellites are correctly numbered.

NavCom

Table 19 describes the supported records.

Perform pre-processing checks
If enabled, data is scanned after conversion to correct potential issues. See *Section 6.4.2,* on *Page 175* for more information.

Static/Kinematic Mode
This option controls how the static/kinematic flags are set in the final GPB file. Auto is used in conjunction with the pre-processing checks. It attempts to automatically set the flag based on the computed dynamics. This could result in a mixture of static/kinematic flags in the GPB file. If you want to force the entire GPB file to a specific mode, use the Static or Kinematic option.

Re-compute position and clock offset
Enable this option if the clock shift data is corrupt, or if positions records are not present.

Report L2 cycle slips
Print message if L2 cycle slip encountered.

Verbose messaging mode
Allows you to see additional warning messages**.**

Table 19: Records Supported for NavCom

Record	Type	Comment
0xB0	Measurements	Required.
0x81	Ephemeris	Required.
0xB1	Position	Recommended for GrafNet users.
0xB4	Event Marker	Written to STA file.

Table 20: Records Supported for NovAtel CMC

Record	Type	Comment
ID #23	Measurements	One of these records is required, but ID #23 is strongly recommended over the others.
ID #13	Measurements (old style)	
ID #14	Measurements (old style)	
ID #15	Measurements (old style)	
ID #16	Measurements (old style)	
ID #20	Position	Recommended for GrafNet users; should be requested last.
ID #22	Ephemeris	Required.

NovAtel CMC

This decoder handles data from the NovAtel CMC AllStar and SuperStar receivers. *Table 20* describes the supported records.

Perform pre-processing checks

If enabled, data is scanned after conversion to correct potential issues. See *Section 6.4.2,* on *Page 175* for more information.

Static/Kinematic Mode

This option controls how the static/kinematic flags are set in the final GPB file. Auto is used in conjunction with the pre-processing checks. It attempts to automatically set the flag based on the computed dynamics. This could result in a mixture of static/kinematic flags in the GPB file. If you want to force the entire GPB file to a specific mode, use the Static or Kinematic option.

Verbose messaging mode

Displays additional warning messages.

Reject satellites with low CNO

Satellites with C/N0 values below the specified threshold will not be decoded. This option is not recommended.

NovAtel OEM3

This decoder handles data from the NovAtel OEM3 receivers. *Table 21* describes the supported records and files.

Perform pre-processing checks
If enabled, data is scanned after conversion to correct potential issues. See *Section 6.4.2,* on *Page 175* for more information.

Static/Kinematic Mode
This option controls how the static/kinematic flags are set in the final GPB file. Auto is used in conjunction with the pre-processing checks. It attempts to automatically set the flag based on the computed dynamics. This could result in a mixture of static/kinematic flags in the GPB file. If you want to force the entire GPB file to a specific mode, use the Static or Kinematic option.

Re-calculate position and clock offset
If there is no POSB record, this option to re-calculates the position and time.

> ⊠ The REPB record must be present, any epochs collected before the first REPB are not re-calculated. *Section 6.2.3.2,* on *Page 170* for help correcting this.
>
> To ensure enough ephemerides, the REPB record should be requested *ONCE* on start-up and *ONCHANGED* afterwards.

POSB marks the end of record
If the POSB record is requested after the measurement record, this option ensures that their time records match. Otherwise, request the measurement record last. This is only used when RTK or DGPS positions are to be preserved.

Print L1 and L2 loss of lock warnings
Alerts you of the losses of lock on carrier phase.

Check NovAtel C/A code lock bit
If the receiver flags a C/A code measurement as being bad, the entire measurement record is ignored.

Reject bad C/A code meas.
Applies only to the RGED record, where a code is used to indicate the range of values that the standard deviation of the pseudorange measurement falls under. This option uses this code to reject bad C/A code measurements.
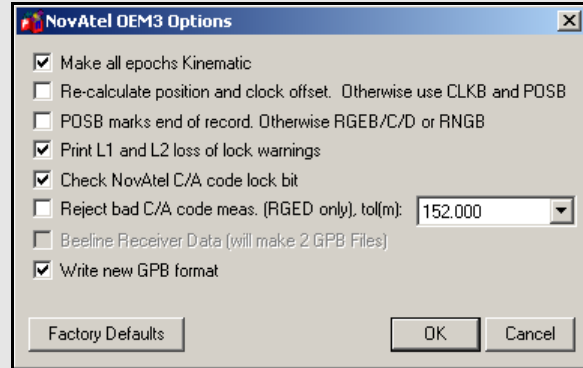
Table 21: Records and Files Supported for NovAtel OEM3

Record/File	Type	Comment
RGEB (ID #32)	Measurements (expanded)	One of these records is required, but RGED is recommended.
RGEC (ID #33)	Measurements (compressed)	
RGED (ID #65)	Measurements (compressed)	
REPB (ID #14)	Ephemeris	Required.
POSB (ID# 01)	Position	Recommended for GrafNet users.
MKTB (ID# 04)	Event Mark (time only)	Written to STA file.
MKPB (ID # 05)	Event Mark (time and position)	Written to STA file.
CLKB (ID# 02)	Clock Information	See **Notes.**

> ⊠ 1. If using receivers with standard correlators, you should either request the CLKB record, or else re-calculate the position and clock information. See the description of the decoder options on this page. The clock correction (offset) is needed for processing. This record is also suggested for users logging data right from power-up. Request the CLKB record before the measurement record.
>
> 2. Ensure that the baud rate is set high enough to properly handle 12 channels worth of measurement records, as well any additional records.
>
> 3. The GPS/GLONASS MiLLennium receiver has 24 channels.
>
> 4. Log MKTB or MKPB, but not both.

Table 22: Records Supported for Novatel OEM4

Record	Type	Comment
RANGEB (ID #43)	Measurements (expanded)	One of these records is required
RANGECMPB (ID #140)	Measurements (compressed)	
RAWEPHEMB (ID #41)	Ephemeris	Required
GLOEPHEMERISB (ID #723)	GLONASS Ephemeris	Required for OEMV-3
ALMANACB (ID# 73)	Decoded Almanac	
RAWALMB (ID #74)	Raw Almanac	Written to EPP file.
GLOALMANACB (ID #718)	GLONASS Almanac	
BESTPOSB (ID #42) RTKPOSB (ID #141) OMNIHPPOSB (ID #495) PSRPOSB (ID #47)	Position	Recommended for GrafNet users
MARKTIMEB (ID #231)	Event Mark Time	Written to STA file
TIMEB (ID #101)	Receiver Time Information	
IONUTCB (ID #8)	Ionospheric Parameters	Written to EPP file
GLOCLOCKB (ID #719)	GLONASS Clock Information	Optional for OEMV-3
RAWIMUSB (ID #325)	IMU Measurements	SPAN Technology users only
MARK*n*TIMEB (ID #1130, 616, 1075, 1076)	Event Mark Time	Written to -*n* STA file
BESTLEVERARMB (ID #674)	IMU to GPS Lever Arm	SPAN Technology users only
BESTGPSPOSB (ID #423) INSVAB (ID #507) INSPVASB (ID #508) INSPOSB (ID #265) INSPOSSB (ID #321)	Position	SPAN Technology users only
SETIMUTYPE (ID #569)	IMU Type	SPAN Technology users only
MARK*n*PVAB (ID #1067, 1068, 1118, 1119)	Event Mark Time	Written to -*n* STA file
DUALANTHEADINGB (ID #971)	Heading from dual antenna	Written to HMR file
SITEDEFB (ID #153)	Siter definitions	

NovAtel OEM4 / OEMV / OEM6

Table 22 describes supported files.

✉ Almanac data can be used in *Mission Planner*. See *Section 2.8.11,* on *Page 104* for help.

Perform pre-processing checks
If enabled, data is scanned after conversion to correct potential issues. See *Section 6.4.2,* on *Page 175* for more information.

Static/Kinematic Mode
This option controls how the static/kinematic flags are set in the final GPB file. Auto is used in conjunction with the pre-processing checks. It attempts to automatically set the flag based on the computed dynamics. This could result in a mixture of static/kinematic flags in the GPB file. If you want to force the entire GPB file to a specific mode, use the Static or Kinematic option.

Re-compute position and clock offset
GrafNav requires valid clock shift data, while GrafNet requires position records. Enable this option if the clock shift data is corrupt, or if positions records are not present.

Verbose messaging mode
Displays additional warning messages.

Create trajectory file (*.fsp) from following record
This option generates a separate FSP file for each supported position record that is logged. The files can be used to compare against the post-processed solution.

Create separate file for each MARKNTIME record
Enabling this option decodes the event marks from multiple inputs into separate station files.

GLONASS PRN Offset
Shifts PRN number for GLONASS satellites. Offset must be greater than 32 to avoid conflict with GPS constellation.

L2C phase correction
This correction value is inserted into the GPB header and can be used by the post-processing engine. OEMV firmware versions 3.0 and 3.1 use a correction of 0.50, while firmware versions 3.2 and later will use either -0.25 or 0.00. Generally, this value should occur on the ¼ cycle. See *Fixed Static* on *Page 61*.

Inertial Decoding Options
> ***Extract inertial SPAN data***
> This option is only for users of NovAtel's SPAN™ Technology, and is only available in Inertial Explorer. Refer to *Inertial Explorer Version 8.30 Manual* for details.

RINEX
Receiver Independent Exchange (RINEX) data consists of ASCII files. The most important is the observation file and contains the measurement data. The others are the navigation files and contain ephemeris data for GPS and/or GLONASS satellites..

RINEX is a very flexible format. It is interpreted differently by receiver manufacturers, software developers and government agencies. For this reason, RINEX data occasionally causes problems, and the use of options is necessary to convert the data properly to GPB.

> ⊠   This decoder also supports Hatanaka (compressed) RINEX data. It also supports GLONASS measurements and ephemerides.

Table 23 describes the supported files.

The following describes the options available for this converter:

General Options
> ***Perform pre-processing checks***
> If enabled, data is scanned after conversion to correct potential issues. See *Section 6.4.2,* on *Page 175* for more information.

> ***Static/Kinematic Mode***
> This option controls how the static/kinematic flags are set in the final GPB file. Auto is used in conjunction with the pre-processing checks. It attempts to automatically set the flag based on the computed dynamics. This could result in a mixture of static/kinematic flags in the GPB file. If you want to force the entire GPB file to a specific mode, use the Static or Kinematic option.
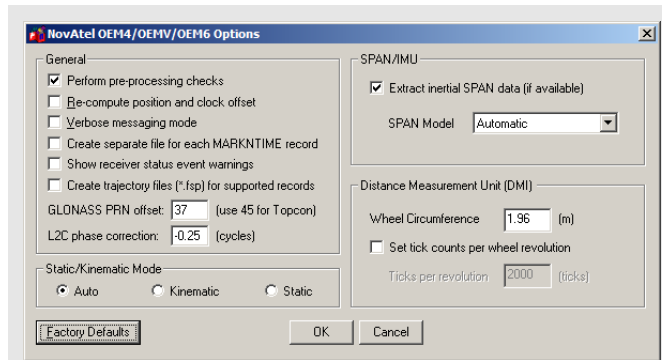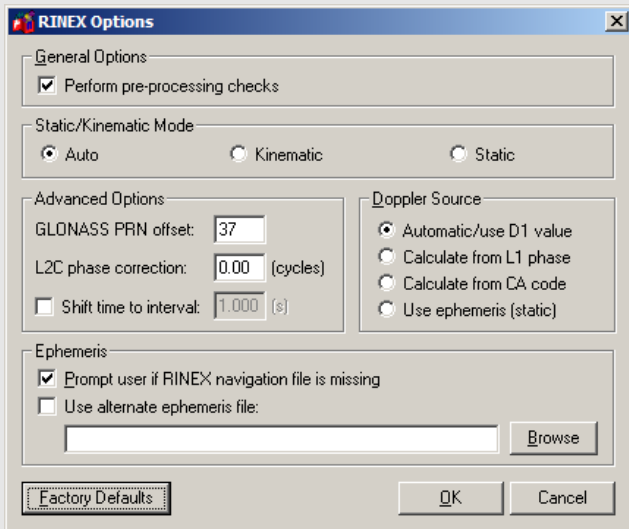
Table 23: Files Supported for RINEX

File	Type	Comment
*.*yy*o, *.obs, *.rxo	Measurements	One of these files is required.
*.*yy*d	Measurements (compressed)	
*.*yy*n, *.nav, *.rxn	GPS Ephemeris	Required.
.*yy*g	GLONASS Ephemeris	

✉ The *yy* in the file extensions found in the table above designate the last two digits of the year that the observations were collected in.

Advanced Options
The following options are available:

> **GLONASS PRN offset**
> Shifts PRN number for GLONASS satellites. Offset must be greater than 32 to avoid conflict with GPS constellation.

> **L2C phase correction**
> If the RINEX file contains L2C measurements, then the phase offset must be set.

> **Shift time to user interval**
> The decoder will attempt to determine the data interval by reading the header or scanning the observation file. If this fails, enable this option to force an interval.

Doppler Source
This options allows you to choose a method of obtaining Doppler measurements. The following choices are available:

> **Automatic/use D1 value**
> Uses D1 value, if present, from RINEX file for Doppler. Otherwise, it uses *Calculate from CA code* for data intervals of 10 seconds or less, and *Use ephemeris (static)* for anything else.

> **Calculate from L1 phase**
> Should be selected if the Doppler signal is missing or unstable.

> **Calculate from CA code**
> If the Doppler signal is missing or unstable, using the CA code will create fewer problems than using L1 phase, but velocity accuracies may be worse.

> **Use ephemeris (static)**
> Assumes static data and computes Doppler from satellite velocities.

Ephemeris
The following settings are available:

> ***Prompt user if RINEX Nav file is missing***
> If a navigation file is either missing or has a different name than the observation file, you will be prompted to select a navigation file.

> ***Use alternative ephemeris file***
> User may define path to navigation file manually. This will override the previous option.

RTCM Version 3.0

Perform pre-processing checks
If enabled, data is scanned after conversion to correct potential issues. See *Section 6.4.2,* on *Page 175* for more information.

Static/Kinematic Mode
This option controls how the static/kinematic flags are set in the final GPB file. Auto is used in conjunction with the pre-processing checks. It attempts to automatically set the flag based on the computed dynamics. This could result in a mixture of static/kinematic flags in the GPB file. If you want to force the entire GPB file to a specific mode, use the Static or Kinematic option.

Re-compute position and clock offset
GrafNav requires valid clock shift data, while GrafNet requires position records. Enable this option if the clock shift data is corrupt, or if position records are not present.

Verbose messaging mode
Displays additional warning messages.

GLONASS PRN offset
Shifts the PRN numbers for GLONASS satellites. Offset must be greater than 32 to avoid conflict with GPS constellation.
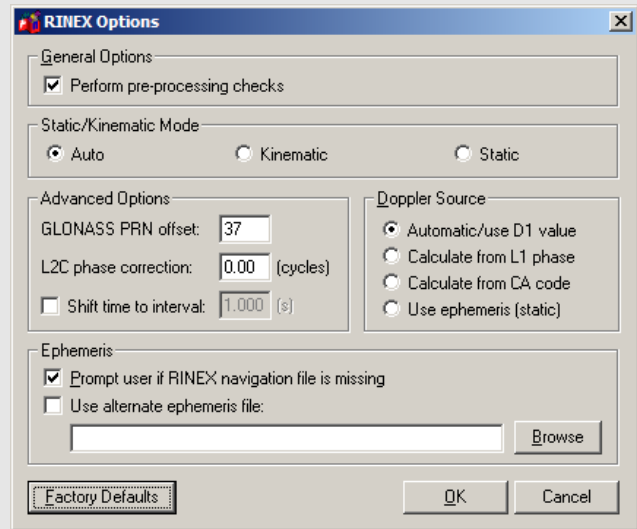
Table 24: Records Supported for RTCM Version 3

Record	Type	Comment
1002	L1 only measurement	One of these records is required, depending on the receiver's capabilities
1004	L1/L2 measurements	
1010	GLONASS L1 only measurements	If working with GLONASS, then one of these records is required, depending on the receiver's capabilities
1012	GLONASS L1/L2 measurements	
1019	GPS Ephemeris	Required
1020	GLONASS Ephemeris	Required for GLONASS users

Table 25: Records Supported for Septentrio SBF

Record	Type	Comment
5889	Measurements	One of these records is required.
5890	Measurements (compressed)	
5891	Ephemeris	Required.
5904	Position	Recommended for GrafNet users.
5924	Event	Written to STA file
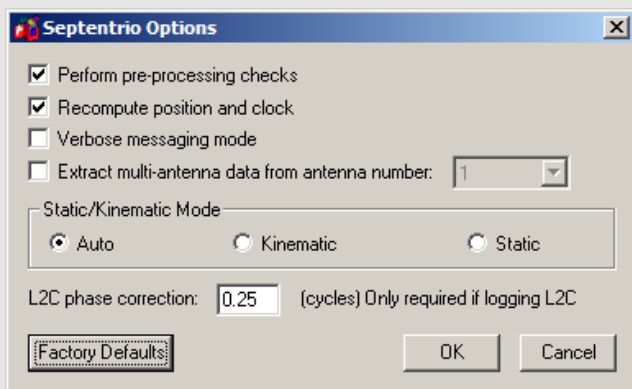
Septentrio SBF

Table 25 describes the records supported.

Perform pre-processing checks
If enabled, data is scanned after conversion to correct potential issues. See *Section 6.4.2,* on *Page 175* for more information.

Static/Kinematic Mode
This option controls how the static/kinematic flags are set in the final GPB file. Auto is used in conjunction with the pre-processing checks. It attempts to automatically set the flag based on the computed dynamics. This could result in a mixture of static/kinematic flags in the GPB file. If you want to force the entire GPB file to a specific mode, use the Static or Kinematic option.

Re-compute position and clock
GrafNav requires valid clock shift data, while GrafNet requires position records. Enable this option if the clock shift data is corrupt, or if positions records are not present.

Verbose messaging mode
Allows you to see additional warning messages.

Extract multi-antenna data
For multi-antenna applications only.

SiRF Binary

Table 26 describes the records supported.

Perform pre-processing checks
If enabled, data is scanned after conversion to correct potential issues. See *Section 6.4.2,* on *Page 175* for more information.

General Options
Static/Kinematic Mode
This option controls how the static/kinematic flags are set in the final GPB file. Auto is used in conjunction with the pre-processing checks. It attempts to automatically set the flag based on the computed dynamics. This could result in a mixture of static/kinematic flags in the GPB file. If you want to force the entire GPB file to a specific mode, use the Static or Kinematic option.

Verbose messaging mode
Allows you to see additional warning messages.

Reject satellite measurements with low C/No
Satellites with C/N0 values below the threshold will not be decoded. This option is not recommended.

Re-compute receiver position and clock offset
GrafNav requires valid clock shift data, while GrafNet requires position records. Enable this option if the clock shift data is corrupt, or if positions records are not present.

Reject epoch if receiver clock offset is missing
Data is unusable if clock offset is missing. Clock offset can be re-computed using *GPBView.*

New firmware version with different representation of double precision

Time Alignment
Leave time raw
Enable for kinematic or single point processing. Master data can be interpolated on to remote using *Concatenate, Splice and Resample* utility. See *Section 6.3.1,* on *Page 172* for help.

Adjust time to nearest interval
Kinematic/code-only shift to interval equal to base data interval.

Interpolate to data interval
Enabled for static only. Interpolates data onto regular data interval.

Advanced Options
The following options are available:

Move Point/Attribute to start and end of static
Links Point only.
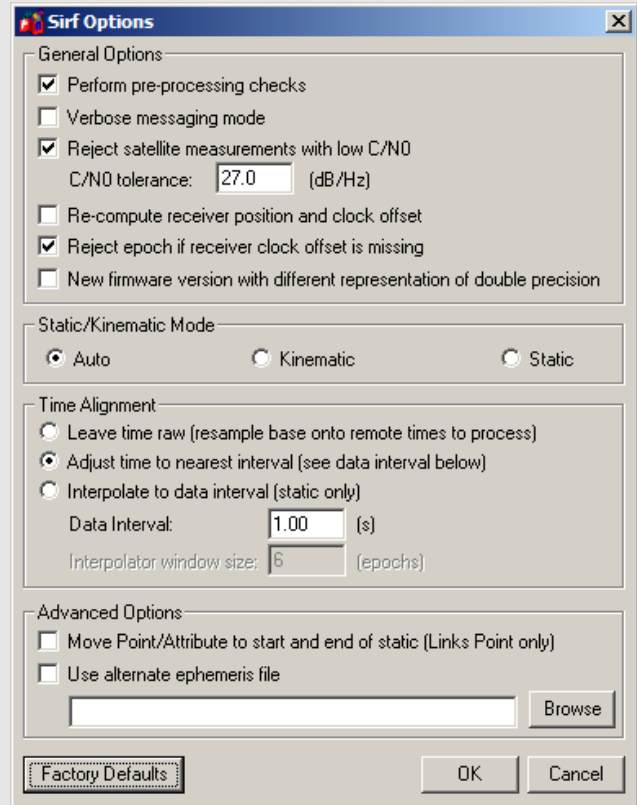
Table 26: Records Supported for SiRF Binary

Record	Type	Comment
28	Measurements	Required.
15	Ephemeris	Required.
7	Clock Offset	Recommended.
2	Position	Recommended for GrafNet users.

Use alternate ephemeris file
If ephemeris data is missing, select an alternate
EPP file.

⊠   SiRF receivers do not make
     measurements on the whole epoch.
     Either master or remote data must be
     interpolated onto the other in order to
     process. See *Section 6.3.1,* on *Page 172*
     for help.
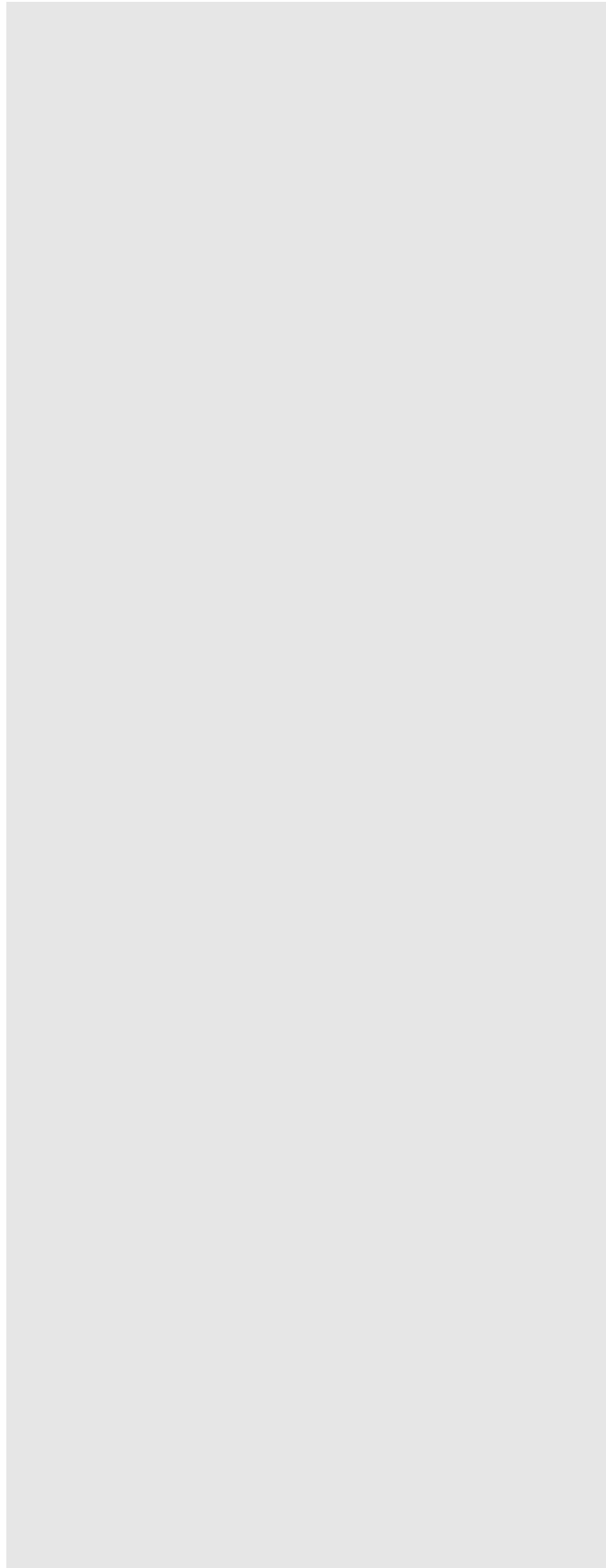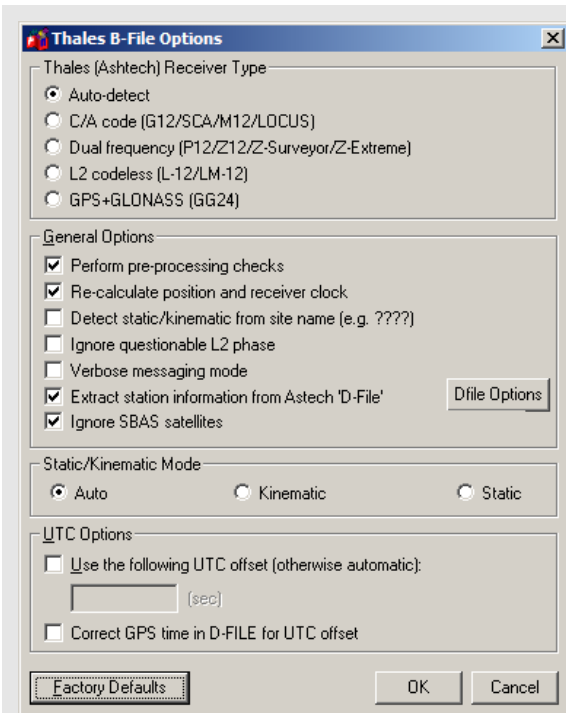
Thales B-File

This decoder handles Thales data that has been downloaded using the Thales utility. Log this data into internal receiver memory. *Table 29* describes the supported files.

Thales (Ashtech) Receiver Type
Selects the receiver used to collect the data. If auto-detect does not work, then select the receiver manually.

General Options

> ### *Perform pre-processing checks*
> If enabled, data is scanned after conversion to correct potential issues. See *Section 6.4.2,* on *Page 175* for more information.
>
> ### *Re-calculate position and clock offset*
> Thales receivers occasionally compute incompatible clock corrections. Enable this option if the clock shift data is corrupt, if positions records are not present or if many cycle slips exist.
>
> ### *Detect static/kinematic from site name*
> Looks in B-file for data tagged as static or kinematic, using *????* site ID.
>
> ### *Ignore questionable L2 phase*
> Allows for processing of highest quality L2 data only. Should be enabled if ARTK is having difficulties.
>
> ### *Verbose messaging mode*
> Allows you to see additional warning messages.
>
> ### *Extract stations information from Ashtech 'D-File'*
> Various Thales hand-held controllers output a D-file containing features and antenna height information. Enable this checkbox to utilize this information.
>
> ### *Ignore SBAS Satellites*
> Newer versions of Thales firmware have resulted in the logging of raw data from SBAS satellites, which are not supported by the software. As such, this option should be left enabled to ensure the data is not written to the GPB file.
>
> ### *Static/Kinematic Mode*
> This option controls how the static/kinematic flags are set in the final GPB file. Auto is used in conjunction with the pre-processing checks. It attempts to automatically set the flag based on the computed dynamics. This could result in a mixture of static/kinematic flags in the GPB file. If you want to force the entire GPB file to a specific mode, use the Static or Kinematic option.UTC Options
>
> ### *Use the following UTC time*
> Changes the GPS to UTC time offset from the current nominal value to user-defined value. Normally used for GLONASS processing if no UTC is contained in the data.
>
> ### **Correct GPS time in D-FILE for UTC offset**
> D-files can have GPS or UTC time. This option changes time from UTC to GPS.

Dfile Options

Chain Repeated Station Marks into 1 Static Session
Combines sessions that are repeated in the Seismark software into one session.

Do NOT Chain Marks that are more than n seconds apart
This value controls the time tolerance used in the previous setting. If two static periods are marked less than the amount apart, they will be combined.

Table 27: Files Supported for Thales B-File

File	Type	Comment
B*ssss*A*yy.jjj*	Measurements	Required.
E*ssss*A*yy.jjj*	Ephemeris	Required.
S*ssss*A*yy.jjj*	Static Station Information	Written to STA file.
D*ssss*A*yy.jjj*	Kinematic Station Information	Written to STA file.
PHOTO.DAT	Event Mark	Read in directly by software.

✉ Thales files follow a strict naming convention. In the table above, *ssss* is the site name, *yy* is the last two digits of the year, and *jjj* is the day of the year.

Antenna heights may need to be edited within the feature editor if not kept constant, as the Thales format only allows for one value.

You might need to select receiver type manually.

Table 28: Records Supported for Thales Real-Time

Record	Type	Comment
MBN	Measurements	One of these records is required; see **Note 1**
MCA	Measurements	
MPC	Measurements	
MCL	Measurements	
MACM	Measurements	
ITA	Measurements (C/A Code Only)	
CT1	Measurements (C/A Code Only)	
CT2	Measurements (C/A Code and L1 Phase)	
CT3	Measurements (C/A Code, L1 Phase and C/A Code)	
SNV	Ephemeris	Required.
SNG	Ephemeris (GLONASS)	Required for GLONASS users.
PBN	Position	See **Note 2.**

✉ 1. The MBN or MACM records are recommended for G12 receivers. The MACM record is designed for high-speed data output that is, 10Hz or 20Hz, under limited bandwidth conditions. The ITA record is for G8 receivers, while the MPC is for dual frequency receivers, such as those in the Z-series. The MCL record is an L2 codeless record.

2. Marks the end of the record. Recommended for GrafNet users.

Thales Real-Time

This decoder converts Thales Real-Time (DG16, G12, or Super C/A) data. The real-time data forms when data is logged externally from the receiver using a utility such as WLOG or another custom data logger. *Table 28* describes the supported records.

General Options

Perform pre-processing checks
If enabled, data is scanned after conversion to correct potential issues. See Section 6.4.2, on Page 175 for more information.

Recompute position and time
Enable this option if the clock shift data is corrupt, or if positions records are not present.

Decode MACM messages and ignore others
If both MBN/MCA and MACM records exist, only the MACM will be decoded.

Decode old-style MBN locktime
Some older units (for example, Sensor II) output locktimes with a different resolution. Enable this option to output the locktime value.

Static/Kinematic Mode
This option controls how the static/kinematic flags are set in the final GPB file. Auto is used in conjunction with the pre-processing checks. It attempts to automatically set the flag based on the computed dynamics. This could result in a mixture of static/kinematic flags in the GPB file. If you want to force the entire GPB file to a specific mode, use the Static or Kinematic option.

Parthus MACM Settings
These settings are for logging MACM records:

Decode Parthus style MACM record
Parthus units (NS100, GSU-1, and GSU-2) utilize the MACM record. However, due to timing differences, its implementation is not compatible. Therefore, enable this option.

Data interval adjustment
The GSU-1 benefits greatly by having the correct data interval entered, while the GSU-2 is best processed using the raw time and having the base interpolated onto these times. See *Section 6.3.1,* on *Page 172* for help.

UTC Offset for GLONASS decoding
The following option is available for those users logging GLONASS measurements:

Use the following UTC offset for decoding
Allows you to define your own UTC offset rather than using the nominal or detected value. Important for GLONASS processing.

Alternate Ephemeris
The following option is available:

Use alternate ephemeris
Enable this option if ephemeris data is missing (for example, Parthus, GSU-2) to specify an outside EPP file.

Thales DNSP

Table 29 describes the supported records.

⊠ The Measurement Q record includes the receiver time record, while the Measurement R record includes the satellite time record. As such, the former is recommended.

Perform pre-processing checks
If enabled, data is scanned after conversion to correct potential issues. See *Section 6.4.2,* on *Page 175* for more information.

Static/Kinematic Mode
This option controls how the static/kinematic flags are set in the final GPB file. Auto is used in conjunction with the pre-processing checks. It attempts to automatically set the flag based on the computed dynamics. This could result in a mixture of static/kinematic flags in the GPB file. If you want to force the entire GPB file to a specific mode, use the Static or Kinematic option.

Trimble DAT

This decoder converts data from Trimble 4000-5800 receivers. The Trimble data files (DAT) are formed when data is logged internally in the receiver.

The *Table 30* describes the supported files.

Perform pre-processing checks
If enabled, data is scanned after conversion to correct potential issues. See *Section 6.4.2,* on *Page 175* for more information.

Static/Kinematic Mode
This option controls how the static/kinematic flags are set in the final GPB file. Auto is used in conjunction with the pre-processing checks. It attempts to automatically set the flag based on the computed dynamics. This could result in a mixture of static/kinematic flags in the GPB file. If you want to force the entire GPB file to a specific mode, use the Static or Kinematic option.

Recompute position and clock offset
Enable this option if the clock shift data is corrupt, or if positions records are not present.

⊠ The antenna height extracted by the decoder may be the slant distance.

Trimble SSF files cannot be directly decoded using this utility. As such, they must be converted to DAT or RINEX format first.

Table 29: Records Supported for Thales DNSP

Record	Type	Comment
Measurement Q (hex 51)	Measurements	One of these records is required; see **Notes.**
Measurement R (hex 52)	Measurements	
Measurement E (hex 45)	Ephemeris	Required.

Table 30: Files Supported for Trimble DAT

File	Type	Comment
*.dat	Measurements, Ephemeris and Event Marks	Required.

Table 31: Records Supported for Trimble Real-Time

Record	Type	Comment
0x0	Measurement	Required.
0x1	Position	Recommended for GrafNet users.
0x2	Ephemeris	Required.

Trimble Real-Time

Data captured directly from a Trimble 4000-5800 receiver can also be converted to GPB using this decoder.

The *Table 31* describes the records supported.

Perform pre-processing checks
If enabled, data is scanned after conversion to correct potential issues. See *Section 6.4.2,* on *Page 175* for more information.

Static/Kinematic Mode
This option controls how the static/kinematic flags are set in the final GPB file. Auto is used in conjunction with the pre-processing checks. It attempts to automatically set the flag based on the computed dynamics. This could result in a mixture of static/kinematic flags in the GPB file. If you want to force the entire GPB file to a specific mode, use the Static or Kinematic option.

Verbose messaging mode
Displays additional warning messages.

Table 32: Records Supported for U-Blox

Record	Type	Comment
ID #10	Measurements	Required.
ID #31	Ephemeris	Required.
ID #02	Position	Recommended for GrafNet users.
ID #22	Clock Information	Recommended.

U-Blox

Table 32 describes the supported records.

Perform pre-processing checks
If enabled, data is scanned after conversion to correct potential issues. See *Section 6.4.2,* on *Page 175* for more information.

Static/Kinematic Mode
This option controls how the static/kinematic flags are set in the final GPB file. Auto is used in conjunction with the pre-processing checks. It attempts to automatically set the flag based on the computed dynamics. This could result in a mixture of static/kinematic flags in the GPB file. If you want to force the entire GPB file to a specific mode, use the Static or Kinematic option.

Recompute position and time
GrafNav requires valid clock shift data, while GrafNet requires position records. Enable this option if the clock shift data is corrupt, or if positions records are not present.

Verbose messaging mode
Displays additional warning messages.

6.5 GNSS Data Logger Overview

All of Waypoint's software packages include *WLOG*, a data logger that supports various receivers from NovAtel, Ashtech/Thales, Trimble, CMC, Rockwell Jupiter, Javad/Topcon, Parthus, CSI, Navcom, Garmin, and Ublox. See *Table 2* on *Page 21* for more information on supported receivers.

WLOG configures the GNSS receivers, logs the measurement data, and converts it into Waypoint's proprietary format. Adjunct features include waypoint navigation, as well as satellite and scatter plotting capabilities. In addition, stations and events can be marked and written to STA files, which are compatible for post-processing in Waypoint's software.

6.5.1 Getting Started with WLOG

This section examines all the steps required to begin logging data through *WLOG* by analyzing each screen encountered when creating a new project.
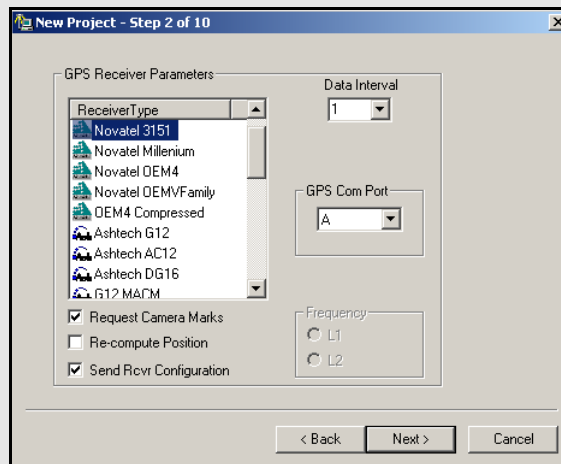
How to log data with WLOG

1. Select *File | New Project* and give the project a name. Click *Next*.

2. Select the appropriate receiver type.

3. Select an interval at which to record the data.

4. Specify the COM port that is being used on the receiver to send the data.

5. For camera marks, enable the *Request Camera Marks* option.

✉ This option is only available for use with NovAtel, Ashtech and Javad receivers

---

6. Enable the *Re-compute Position* option to force *WLOG* to output positions at the interval specified in *Step 3*. This alleviates the issue concerning receivers that only output position records on specific intervals.

✉ Users of NovAtel and Ashtech receivers have the option to send ASCII commands to the receiver. This feature can be used to either disable commands or over-ride various receiver commands. Refer to the receiver manual for information on such commands.

---

7. Click *Next*.

8. If the GPS receiver is sending the data directly to the COM port of the computer, select *Serial Port* under *Receive Data by* and proceed to *Step 9*. If the data is being received over a network, select *TCP/IP Network* and proceed to *Step 12*.
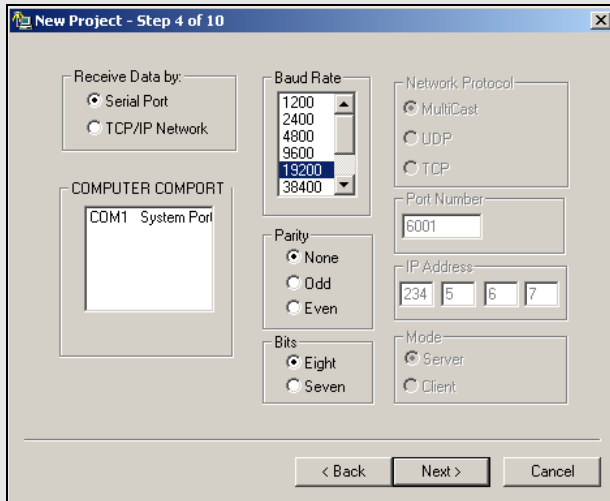
How to log data with WLOG cont.

9. If using serial communication to obtain data from the GPS receiver, specify the computer COM port to which the receiver is connected to.

⊠ Choose an appropriate baud rate from the list. The baud rate must be compatible with that of the receiver, and must take into account the amount of data being received that is, size of data records, data logging rate, and so on. Consult the receiver's manual.

10. Select the parity. For most receivers, *None* should be selected. Consult the receiver's manual.

11. Select the bits. For most receivers, *Eight* should be selected. Consult the receiver's manual. Click *Next*. Proceed to **Step 15**.

12. If receiving the data by TCP/IP, specify the network protocol and the port number to be used.

13. If using MultiCast protocol, type in the group IP address.

⊠ UDP and MultiCast protocols are ideal for communication over local networks that are within the same office, while TCP is recommended for wide-area communication. Be sure to select a port number that does not conflict with those reserved for standard network purposes. In general, numbers starting at 1024 are usually safe. For MultiCast groups, both the sender and the receiver must have the same IP address. For Win32, MultiCast IP addresses range from 224.00.00.00 to 240.00.00.00.

14. Click *Next*.
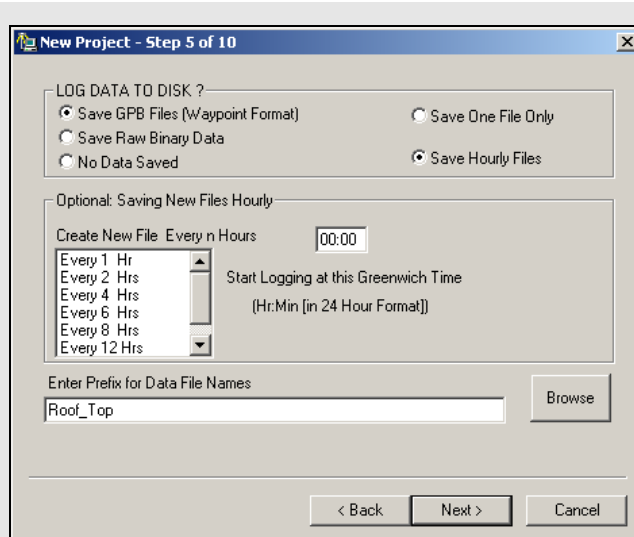
How to log data with WLOG cont.

15. Select how the data will be saved.

☒ Data can be saved byte-by-byte into a binary file. The entire session will be saved into one LOG file, which will have to be converted into GPB format before being post-processed.

Most users will find it preferable to log directly into Waypoint's proprietary format, because it saves the trouble of converting the data later on when it is time for post-processing. This option also allows for the flexibility of breaking up the data into separate files of *n* hours.

---

16. Any data being saved to disk will be given the filename specified under *Enter Prefix for Data File Names*. The file extension is dependent on the selection made in **Step 15**.

☒ Files being created every *n* hours will be given unique suffixes.

---

17. Click *Next*.
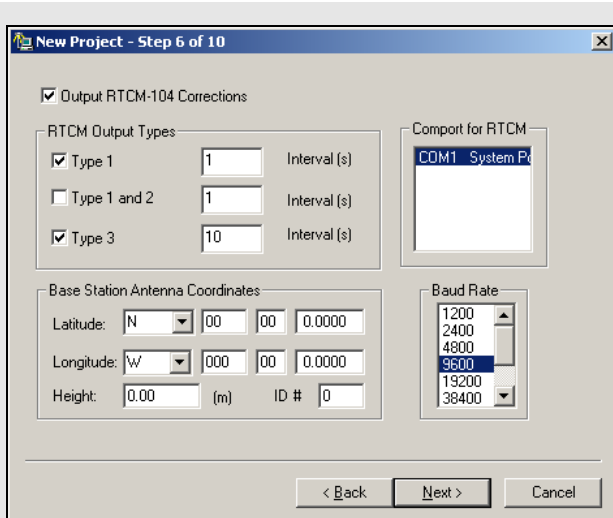
How to log data with WLOG cont.

18. You have the option to select *Output RTCM-104 Corrections*, which are the updated differential corrections. This option must be enabled for the corrections to be displayed.

19. Select the desired type of RTCM output and the interval for each of the following:

    Type 1: includes time, PRN, $\delta\rho$ and $\delta\rho$ rate.

    Type 2: has the last IODE (issue of data ephemeris).

    Type 3: gives position

    Select the COM port to use for the RTCM output, and enter the coordinates at the base station antenna. Finally, select the baud rate.

20. Click *Next*.
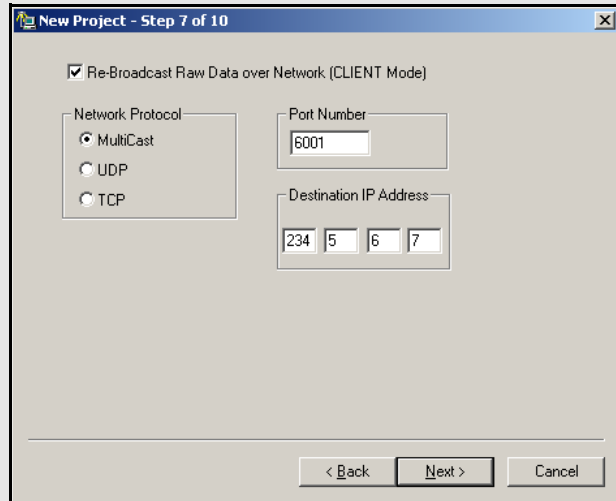
How to log data with WLOG cont.

21. Enable the *RE-Broadcast Data over Network* to re-broadcast GPS data collected by direct link to the GPS receiver over a local or wide-area network.

⊠ This allows two different computers in different locations can collect data from one GPS receiver and view that data in real-time, even though only one computer is directly linked to the receiver. This technique can be used to re-broadcast data using TCP protocol over existing internet connections.

22. Click *Next*.

23. Enter a port number to send out NMEA strings from a secondary serial port of the computer.

⊠ This would be useful in the case where some external device, such as an echo sounder, requires position input from GPS on its serial port.

24. Click *Next*.
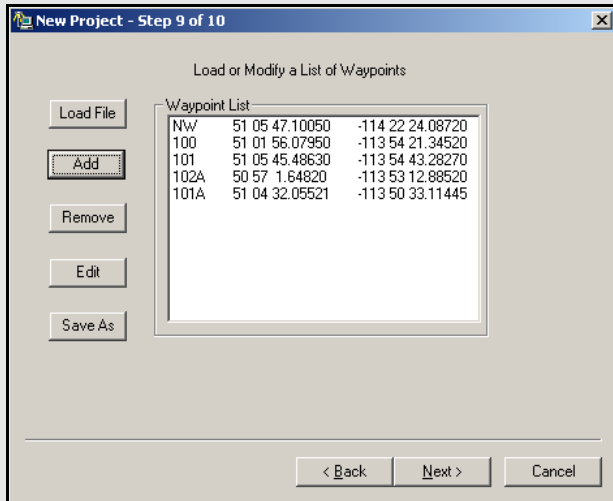
How to log data with WLOG cont.

25. If navigating with a roving receiver, input a list of waypoints for navigation is useful because *WLOG* will provide a text and graphical display of the distance and bearing from the current GPS location to the selected waypoint.

✉ *WLOG* also displays across and along-track information for navigation between any two selected waypoints.

Waypoints can be added in the following two ways:

1. An ASCII file can be loaded, as long as it is formatted correctly. The first element is a station name, followed by latitude and longitude, both in degrees minutes seconds. These fields must be space-delimited.

2. Waypoints can be added the *Add* button. These waypoints can be edited, removed, or saved to a file of their own for later use.

---

26. Click *Next*.

If these steps have been followed successfully, *WLOG* will start logging data. If the screen is blank, and the program appears to be inactive, initialization was not successful.

6.5.2 File

This menu allows you to create a new project, open an existing project, load waypoints, find out about the program and exit the program.

6.5.3 Display

This menu gives access to several text displays.

Position
This opens the *Position Information* window, which displays the GPS time, position, velocity, mode, number of epochs that have been logged, the number of ephemerides received, the station name, and the amount of disk space still available.

SatInfo
This opens the *Satellite Information* window, which displays information for each channel that is currently tracking a satellite. The PRN, azimuth, elevation, lock-time, and signal-to-noise ratio is displayed for each satellite being tracked.

Waypoint
This opens the *Waypoint Information* window, which displays information regarding the distance and azimuth between loaded waypoints.

RTCM
This opens the *Differential Corrections* window, which displays information pertaining to the choices made in **Step 19** in *Section 8.5.3* on *Page 221* during the configuration of the project.
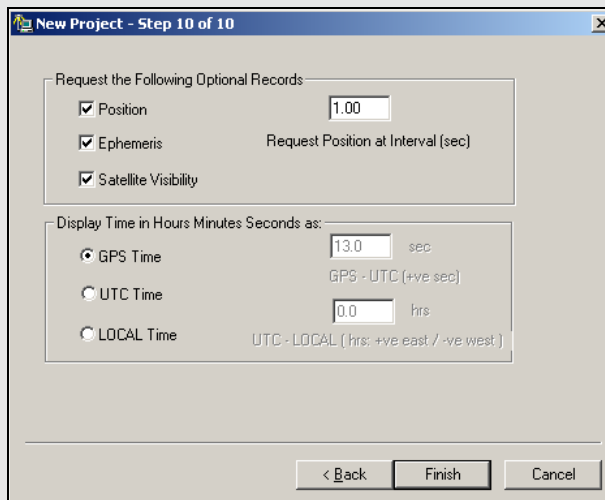
How to log data with WLOG cont.

27. Make requests for position, ephemeris, and satellite visibility records while logging. You can also display the time in HMS in GPS time, UTC time, or local time. UTC and Local time require the number of leap seconds to be entered as UTC time is a non-linear time system, unlike GPS time.

28. Click *Next*.

6.5.4 Plot

Satellites
This opens the *Satellite Az/Elev Plot* window, which is a graphical display of the satellites' elevation above the horizon, as well as their azimuths.

Scatter Plot
This opens the *Scatter Plot* window, which is a graphical display of the positions being computed by the receiver. When waypoints have been loaded, this plot is of more use for the remote station, especially waypoints that are represented on this plot by triangles.

6.5.5 Zoom Menu

This menu contains tools to zoom in or zoom out of the *Scatter Plot* window. These tools prove to be particularly useful when a waypoint file has been loaded.

> ⊠ The *Reset Zoom* option will scale the plot back to its default size.

6.5.6 Events Menu

Static/Kinematic *(Shortcut key = F3)*
This feature toggles the mode between static and kinematic. By default, the mode is static so change it for kinematic applications. Failure to do so results in errors during post-processing. Mark any static occupations that may occur during the kinematic survey.

Mark Station *(Shortcut key = F5)*

> ⊠ The toggling of the mode between static and kinematic is considered an event and is therefore automatically recorded in the STA file.

Mark stations that are occupied during the survey with this feature. Stations can be marked while the receiver is static or kinematic mode. Any station marks added are time-tagged according to the GPS time at which the feature was invoked and written to the STA file.

Next Waypoint *(Shortcut key = F6)*
This opens the *Choose Waypoints* window. Choose two waypoints from the list for the distance and azimuth between them and determines the distance from the receiver's current position to a waypoint, and the direction to reach it.

Appendices

0.1   A: Output Variables

Table 1: List of Output Variables

Variable	Description
Absolute ECEF-XYZ	XYZ coordinates in the Earth Centred Earth Fixed Frame which is a Cartesian frame centred at the ellipsoid origin
Ambiguity Drift	Drift on ambiguities over time; low ambiguities indicate stable solution
Antenna Height	Height of the pole or tripod above the station marker
Azimuth (1◊ 2)	Angle between true north and the baseline made from between FROM and TO stations
Azimuth (2 ◊ 1)	Angle between true north and the baseline made from between TO and FROM stations
Body Frame Acceleration - XYZ	Acceleration components in the vehicle body frame
Body Frame Velocity - XYZ	Velocity components in the vehicle body frame
Azimuth StdDev	Estimated error of the computed azimuth.
British-East, North	East and North coordinates in the British State Plane projection
C/A RMS	Root mean square of C/A code signal
Checksum (8-bit)	The absolute value calculated by using XOR, ADD, or NMEA methodology on the 8 data bits of each character in the sentence; decimal and hexadecimal formats may be selected (user will be prompted for these options after the profile is created)
Combined Scale Factor	Scale factor used by surveyors. It applies the map scale factor combined with the ellipsoidal height correction, which can be used to scale distances on the ellipsoid to the earth's surface.
Combined Standard Deviation	Combines east, north, up position standard deviations into one value. Same value is written by Write Coordinates.
Computed Azimuth	Azimuth from base antenna to remote antenna in GrafMov.
Convergence	Meridian convergence for the current location in the current map projection
Corrected GPS Time	GPS time corrected for receiver clock bias
Course Over Ground	Direction of travel indicated by velocity vector.
Date	Date of the epoch or feature
Description	Description of the station or feature from the STA file
Distance Error (Azimuth)	Error in the computed baseline length in GrafMov.
Double Difference DOP	Double Difference DOP which is approximately equivalent to PDOP[2]
East, North, Height Fwd/Rev Separations	Separations between the forward and reverse solution in the east, north, and height axes
East, North, Height Fwd/Rev RMS	Root mean square of the separations between the forward and reverse solution in the east, north, and height axes
East, North, Up Standard Deviations	Estimated east, north up position standard deviations in the local level frame
East, North, Up Velocities	East, North, Up velocity components in the local level frame
East, North, Up Velocity Standard Deviations	Estimated east, north up velocity standard deviations in the local level frame
East, North, Up Offset Applied	When a 3-D offset is applied to camera event marks, this field can be used to verify that the proper offset is applied. This offset is oriented to local level that is, true-north.

Table 1: List of Output Variables

ECEF Covariance Matrix	Estimated ECEF position covariance matrix; needs extended output in GrafNav
ECEF Vector XYZ	XYZ components of the vector between base and remote in the ECEF frame
ECEF Velocity Covariance Matrix	Estimated ECEF velocity covariance matrix; needs extended output in GrafNav
ECEF XYZ Standard Deviations	Estimated ECEF position standard deviations in the XYZ axes; needs extended output in GrafNav
ECEF XYZ Velocities	XYZ velocity components in the ECEF frame
ECEF XYZ Velocity Standard Deviations	Estimated ECEF velocity standard deviations in the XYZ axes; needs extended output in GrafNav
Ellipsoidal Height	Height above current ellipsoid; based on datum selected during processing
Ellipsoidal Height Scale Factor	Used to scale distances on the ellipsoid to the earth's surface.
End Time	End time of the static session
Error Ellipse Orientation	Orientation of the error ellipse (theta)
Error Ellipse Semi-Major	Estimated error along the semi-major axis of the error ellipse (a)
Error Ellipse Semi-Minor	Estimated error along the semi-minor axis of the error ellipse (b)
Extended Ambiguity Status	Indicates if KAR fixed the ambiguities.
Field Separator	User can select what character separates each variable in a record
Fixed Reliability	Reliability number for fixed static solutions
Float/Fixed Ambiguity Status	Indicates if KAR fixed the ambiguities. Also available in GrafNet.
Gauss Kruger-East, North	East and North coordinates in the Gauss Kruger projection
Geoidal Undulation	Height of the ellipsoid above or below the geoid (user will be prompted with options after profile creation)
GLONASS/GPS Time Offset	Time difference between GPS and GLONASS expressed in meters
GLONASS/GPS Time Offset Stdev.	Standard deviation of the time difference between GPS and GLONASS expressed in meters
GPS Corrected Time	Exact time of measurement in the GPS time frame.
GPS Course-over-ground (track)	Direction of travel computed from trajectory (velocity)
GPS Time/Date	Time of the epoch or feature; time format may be changed to user's preference
GPS Week Number	Week number for GPS data starting from January 4, 1980; Depending in the format, this week number may or may not reset after 1023
Heading Angle	Negative yaw (see IMU angle definition).
Height Difference	Vertical height difference between stations
Height Error Estimate	Estimated error along the vertical axis (dh)
Horizontal Distance	Horizontal distance on the ellipsoid between stations (geodesic)
Horizontal Standard Deviation	Estimated position standard deviation in the east and north axes of a local level frame
Irish-East, North	East and North coordinates in the Irish State Plane projection
L1 Doppler RMS	Root mean square of L1 Doppler signal; useful for INS integration
L1 RMS	L1, or Iono-free root mean square
Lambert-East, North	East and North coordinates in the Lambert Conformal projection

Table 1: List of Output Variables

Latitude	North/South geographic coordinate
Local Level Covariance Matrix	Estimated local level position covariance matrix; needs extended output in GrafNav
Local Level Velocity Covariance Matrix	Estimated local level velocity covariance matrix; needs extended output in GrafNav
Local Level XYZ	Local level left hand side frame where the x axis is pointing east, the y axis is pointing north and the z axis is pointing up; the frame is centred at the master station
Local Plane XYZ	XYZ axes of a coordinate frame defined by two or more points (see local plane options)
Local Time/Date	GPS time and date with time-zone offset applied
Longitude	East/West geographic coordinate
Map Scale Factor	Map projection scale computed for a location
Master File Name	Name of Master GPB file
Num Fwd+Rev or Comb Baselines	Number of baselines used in the combined solution.
Num GLONASS satellites	Number of GLONASS satellites
Num GPS satellites	Number of GPS satellites
Number of Satellites	Total number of GPS and GLONASS satellites
Orthometric Height	Height above the geoid (mean sea level height)
PDOP, HDOP, VDOP	Position dilution of precision, horizontal position dilution of precision and vertical DOP. May be slightly different than values from other sources due to the differential computation
Pitch Angle	IMU pitch angle (see IMU angle definition)
Project Name	Name of current project
P2 RMS	Root mean square of P2 code signal
Quality Number	Quality factor from GrafNav; 1 (best) to 6 (worst)
Relative Azimuth	Azimuth between current and previous feature or epoch.
Relative Height Difference	Relative height difference between current and previous epochs or features
Relative Horizontal Distance	Uncorrected horizontal distance on the ellipsoid between the current and previous epochs. Multiply by Combined Scale Factor to bring to mapping plane and surface
Relative Slope Distance	Free-air distance between neighboring epochs or features. Distance between current and previous.
Remarks	Remarks of the station or feature from the STA file
Remote File Name	Name of Remote GPB file
Roll Angle	IMU roll angle (see IMU angle definition)
Roll, Pitch, Heading Separation	The difference between the combined solutions in terms of Roll, Pitch, and Heading.
Roll, Pitch, Heading StdDev	Estimated attitude accuracy.
Scale Factor	Horizontal distance ratio between the globe and the map distance for the current point in the current map projection
Selectable Grid	Allows user to enter a north and east value for a user defined grid. Grids can be modified and added using the Grid Manager (see Tools Menu).
Sequence Number	Allows the user to number epochs in the data with a user defined start and end sequence number, as well as, an incremental value

Table 1: List of Output Variables

Slope Distance	Free air distance between stations
Solution Type	Type of solution used. In GrafNav, possible solution types include SF-Carrier, DF-Carrier, IonoFree, RelIono, CaOnly, SingPoint. In GrafNet, FixedSoln, FloatSoln.
Standard Dev. (NO PPM)	Trace of the covariance matrix expressed as a standard deviation; no distance dependent errors included
Start Time	Start time of the static session
State Plane-East, North	East and North coordinates in the US State Plane projection
Static/Kinematic Status	Indicates if an epoch is static or kinematic
Station Name	Name describing the station, feature or camera mark
Surface Distance	Horizontal distance between the two stations on the surface (corrected geodesic)
Sun Angle	Angle of the sun above the horizon.
Time Length	Time length of the static session
TM-East, North	East and North coordinates in the Transverse Mercator projection
Total Slope Distance	Spatial distance between two points
Total Horizontal Distance	The shortest path between two points on the surface of a sphere (for example, Great circle)
Transformed Grid	Allows for scaling, rotating and translating of a selectable grid.
User Text String	String of text defined by user
UTC Corrected Time	Same as UTC Time, but a correction for the receiver clock bias is applied. This is the most precise time. Only applicable for epochs.
UTC Date	Date in UTC time.
UTC Time	Time which is available in various format. This is the epochs or feature time offset from GPS seconds by the GPS-UTC time offset. This time is uncorrected for the receiver clock bias
UTM-East, North	East and North coordinates in the Universal Transverse Mercator projection
VSF Ellipsoidal Height	Ellipsoidal height corrected by the map scale factor
VSF Orthometric Height	Orthometric height corrected by the map scale factor. Used in photogrammetry applications to create an elevation that is more compatible with measured ground coordinates
XYZ Accelerometer Bias	This is the apparent output in acceleration when there is no input acceleration present. It is computed by the GPS/INS Kalman filter and the effects may be sinusoidal or random.
XYZ Gyro Drift	This is the apparent change in angular rate over a period of time. It is computed by the GPS/INS Kalman filter and the effects are usually random.

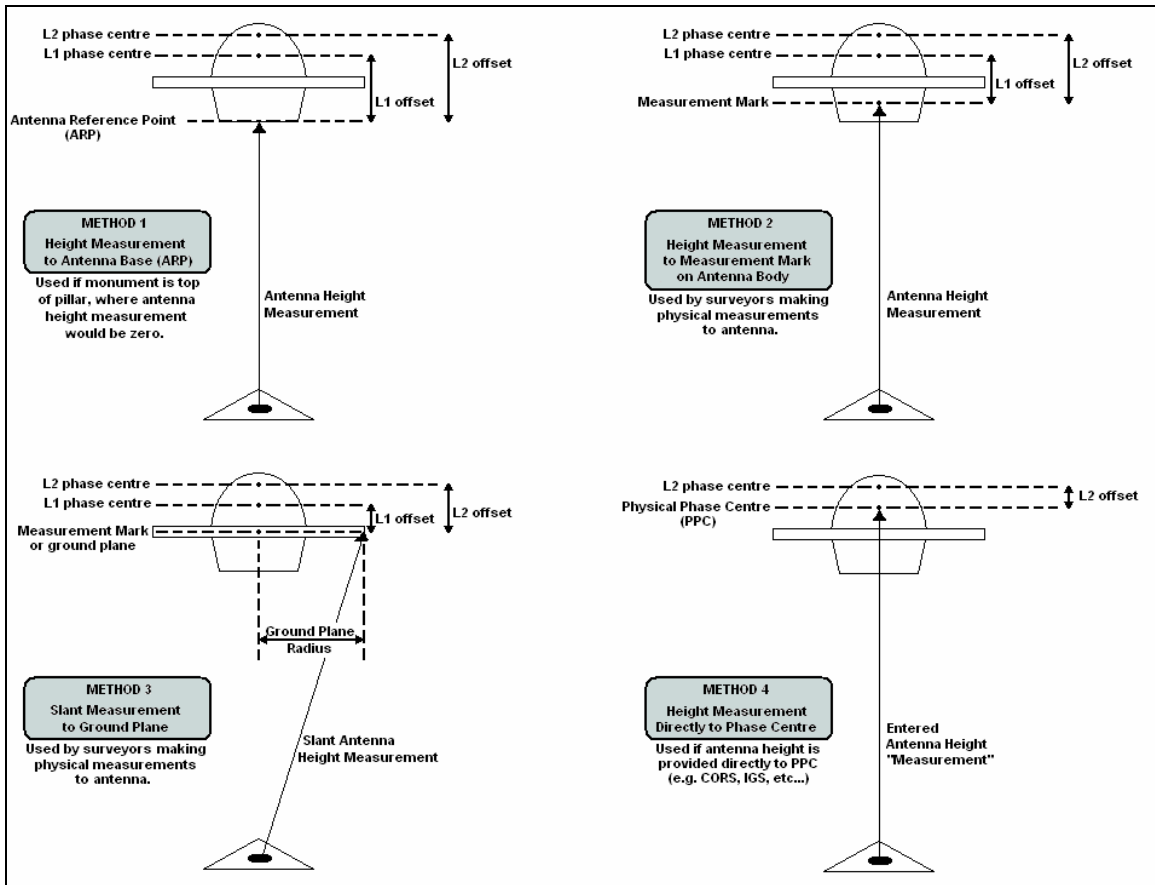## 0.2   B: Antenna Measurements Diagram

Figure 1: Antenna Measurements

0.3   C: Summary of Commands

The following lists the available commands and a short description of their usage. The required format, status, and a description of each command is given. Any subset of the following may be used for the user's particular input file. User commands can also be observed via *Settings | Individual | User Defined* in GrafNav. Note that any spaces in file names, datum names, and so on, are substituted in the configuration file with an asterisk (*).

ALT_FILE = fname EPP/SP3/CLK/IONEX ENABLE/DISABLE

This specifies the alternate ephemeris file (.epp file), or precise ephemeris (.sp3), or IONEX file (.yyI), or Satellite Clock file (.clk). They are set to ENABLE once added to the project. DISABLE will disable the processor from using the file.

APPLY_ANT = ON/OFF

Set to ON if elevation based antenna corrections are to be employed. Note that an antenna profile must also be specified for master and/or remote receivers. This is ON by default; use OFF to disable antenna correction.**AZ_DETERM = ON/OFF Dist DistSD**GrafMov only. Used to enable azimuth computation using an antenna distance constraint. Distance and standard deviation are in meters. Typical standard deviations are 2-3 cm.

BASE_SAT = sv_num

Satellite PRN number of base satellite used for differenced computations. Normally, this value should be left at 99, which will cause the program to automatically choose the best satellite using a number of criteria. The default value is 99.

CYCLE_TEST = mode

This can be LOCKTIME, DOPPLER, or BOTH, and determines the manner in which cycle slips are detected in kinematic mode. In general, either BOTH or DOPPLER should be used. Basically, using DOPPLER will disable LOCKTIME check.

CYCLE_TOL = tol

Tolerance used to detect cycle slips on the L1 phase in kinematic mode. These tolerances generally vary from 1 - 500 cycles, and depend on receiver type, vehicle dynamics and type of Doppler. Numerous cycle slips reported may indicate that CYCLE_TOL is too low. A value of 0.0 will cause cycle slip tolerance to be computed automatically from data interval. This value is also subsequently multiplied by 30 [default is 0.0].

DATUM = ProcDatum [Wgs84Conv]

This is the datum that processing is to be performed in, and the satellite coordinates are transformed into this datum. See Graf-Nav for a list of available datums. WGS84Conv is the conversion to be used. Use WGS84Conv=AUTO to allow NGPS32.DLL to select the best datum. Note that datums are read from manufact.dtm and user.dtm located in the same directory as the DLL.

DETAILED_SUM = ON/OFF

ON if detailed parameter info is to be printed at the start of the static/kar summary (.fss/rss) file.

DOP_TOL = dd_dop_tol	Epochs with DD_DOP above this value are not printed to .FWD/REV files as the geometry is deemed too poor. Default value is 100.0.
DOPPLER_TOL = tol	No longer supported.
DUAL_FREQUENCY = on/off on/off off/relative/free on/off/smoothed OFF/ON	Use P-code for long baseline processing. No longer used; see USE_PCODE command. OFF/ON - Use L2 phase for ambiguity resolution (should be ON). OFF/RELATIVE/FREE – Use relative ionospheric correction or long baseline L3 iono-free baseline processing ON/OFF/SMOOTHED – Apply ionospheric correction to C/A. SMOOTHED applies a low pass filter to the raw ionospheric corrections before implementing them.
DYNAMICS = EnableFlag DynFlag	This parameter controls the vehicle dynamics model that can be employed in the Kalman filter. EnableFlag=ON/OFF/AUTO, while DynFlag=LOW/MEDIUM/HIGH. Generally AUTO should be used, which means that dynamics constraint is off if Doppler is employed or ON if no Doppler is used. If ON, HIGH dynamics is used. If ON, use DynFlag to set vehicle dynamics.
ELEV_MASK = angle	Cut-of elevation for excluding satellites from the computations. This value is expressed in degrees. This elevation mask value may have to be increased to 15 degrees or more in high multipath environments or during ionospheric storms. Some data tracked under 10 degrees may exhibit noise characteristics. Default value is 10.0.
FF_DOP_TOL = dop_tol	DD_DOP Tolerance over which a fixed integer solution is deemed "float". Allows user to control how easily a fixed changes to a float solution. Does not affect processing. Default is 25.
FIX_AUTO = Min DtL2 MaxLenL2 MinDtL1 MaxDtL1 ON/OFF	Controls automatic fixed static solution usage on static sessions. Use 'ON' to enable, or "OFF" to always use. Note that fixed static must also enabled in processing settings. MinDt is minimum time length in seconds while MaxLen is maximum allowable distance in km.
FIX_CORRECT_SLIP = ON/OFF	ON if whole cycle slips are to be corrected forming a continuous phase in fixed solution. By default this option is ON.
FIX_CUBE = mode L1User L2User	Mode is AUTOREDUCE, NORMAL, or USER. Sets the search region size for fixed solution. L1User and L2User are the sizes of

	the search are to be used for USER mode. Default is NORMAL. AUTOREDUCE often works very well.
FIX_INTERVAL = DataInterval	Data interval in seconds to use for fixed static processing. Default is 15 seconds.
FIX_IONO_DIST = dist	Used in the AUTO fixed solution L2 model for deciding between IONO and NORMAL L2 noise models. dist is in kilometers. Default is 5 km.
FIX_L2_NOISE = IONO/NORMAL/AUTO	
	Selects L2 noise model for processing fixed solution. IONO performs iono correction, NORMAL does not, AUTO selects between the two based on the FIXED_IONO_DIST command.
HGT_MODEL = EstFlg KalFlg KarFlg ZOff/USEHI HgtSd [KarTol]	
	Controls DEM height constraint (Sportvision version only!) EstFlag = NAV / ALL / OFF Kar/KalFlag = ON / OFF
INITEX = type time snap dir windowsize stdev anthgt phi lamda ht [[staname or ss_index] anthgt ELL/ORTHO]	
	Used to set the remote position at a given location. See GrafNav user interface.
INTERVAL = DataInterval	This specifies the processing interval in seconds. It should be equal to or greater than the recording interval for proper time length computations. If this value is larger than the recording interval, then this new value will be used for processing. Use 0.0 to process all epochs. The default value is 0.0.
IONO_DIST = dist_in_km	Baseline distance in km at which relative iono-free processing will begin. Default is 5 km.
IONO_PPM_TOL = tol	Reject KAR or fixed static solutions if computed ionospheric error is greater than tol in PPM. Default value is 10 PPM. This setting is not in GrafNav's dialogue boxes.
ISSUE_KAR_DIST = ON/OFF DistKm1 DistKm2	
	This will engage KAR on first occurrence of dist < dist1 and reset the distance check when dist > dist2.
ISSUE_KAR_DOP = ON/OFF doptol	Engage KAR every time DD_DOP goes above doptol.
ISSUE_KAR_TIME = ON/OFF NumMin	Engage KAR every 'NumMin' minutes.
KAR_COV_L2 = ON/OFF sf offset	Determines KAR search area using ambiguity variances. Search area is computed to be SearchArea=+/- sf*AmbVar + offset. This

option only works for dual frequency processing.

KAR_CUBE = cube_size_l1 cube_size_l2

Size of kinematic ambiguity resolution (KAR) search cube in meters. A cube +/- cube_size/2 will be searched from the initial approximate position, which is obtained from the program following the loss of lock. The default value is 2.0 m. This value should be increased if it is suspected that the remote position is outside of the search cube. However, larger values increase the possibility of an incorrect intersection found.

KAR_DISTANCE = l1_dist l2_dist

Do not engage KAR if distance is greater than value. Distances are defined in km. After KAR is engaged, it will search farther. Use KAR_USE_DIST to prevent KAR from utilizing data past a certain distance.

KAR_ELEV_MODEL = ON/OFF

Default is ON. KAR uses the KAR_TWOSTAGE_SAT highest satellites for its ambiguity search.

KAR_EPOCH_FILTER = epoch_size

Interval between storing epochs for KAR. epoch_size specified in seconds. This controls how much data KAR will use.

KAR_EPOCH_SIZE = epochs_l1 epochs_l2

Number of epochs between KAR ambiguity searches if L1 only or L1/L2. This controls how often KAR will search.

KAR_EXACT_INTERVAL = ON/OFF

Only use epochs exactly on KAR_EPOCH_FILTER in KAR.

KAR_FAST = ON/OFF

ON to enable 'Fast KAR'

KAR_IONO_DIST = dist_in_km

Used in auto L2 noise model for choosing between HIGH and IONO.

KAR_L2_NOISE = AUTO/HIGH/IONO/MEDIUM/LOW

Model used for KAR L1/L2 ambiguity search. Default is AUTO.

KAR_MAX_DOP = 7.0

Tolerance for allowable DOP during a KAR solution. Default is 9.0.

KAR_MAX_TIME = 30

After this number of minutes, KAR will restart searching

KAR_MB_NEAREST = ON/OFF

If this option is turned ON, KAR will use the nearest base station to engage (Multi-baseline processing only).

KAR_MIN_ADD = NumMinutes

Minutes added to the minimum KAR time for every 10 km in baseline length. Default is 1.5 minutes.

KAR_MIN_TIME = L1time L2time	Minimum number of minutes for single and dual frequency processing before KAR is searching begins.
KAR_OUTPUT = ON/OFF	TRUE if KAR is to output additional information for FWD/REV files.
KAR_RELTOL = tol	Reliability is calculated by dividing the lowest intersection RMS by that of the second lowest. Reliable intersections should have values of 1.5 or higher and preferably greater than 2.0. Default is 1.5.
KAR_RMS_TOL = 0.075	Tolerance for KAR statistical test on the RMS phase. Default is 0.065 cycles.
KAR_RMSKEEPTOL = tol	If the RMS from a KAR solution is higher than this tolerance (cycles), then a warning will result. If there are still 4 good satellites (see KAR_MAXSV), this solution will not be used. Default value is 0.06 cycles.
KAR_RMSUSETOL = tol	This is the tolerance (cycles) with which intersections will be kept in the list. This value should be 0.20 or higher. The default is 0.20 cycles.
KAR_SEP_TOL = 2.0	Tolerance for allowable separation between the float and fixed KAR solutions. This option can be used to "kick out" solutions with large float/fixed separations.
KAR_STATIC = ON/OFF	Turn ON to engage KAR in static mode. By default this option is OFF.
KAR_STRICT_TOL = rmsflag relflag	rmsflag=ON/OFF and enables stricter RMS tolerance for rejecting bad KAR solutions. relflag=ON/OFF and it enables stricter reliability tolerance.
KAR_TWOSTAGE_SATS = 6	Use this maximum number of satellites in the KAR ambiguity search routines.
KAR_USE_DIST = ON/OFF MaxL1Dist MaxL2Dist	
	ON to prevent KAR from using long baseline data. Tolerances for single and dual frequency processing are in km. Normally computed automatically from KAR_DISTANCE.
KAR_USE_FAR = ON/OFF	ON if KAR to use all data less than distance tolerances. OFF will just use data until maximum distance exceeded. Default is off.
L2_LOCKTIME = ON/OFF	ON to use L2 locktime for cycle slip detection. For some receivers (for example, Ashtech), this can lead to more cycle slips

being detected than really do occur.

L2_MAIN = ON/OFF   If turned ON, GrafNav will only use P2/L2 for single frequency processing (special applications only).

L2_SLIP_TOL = 0.20   Tolerance in L2 cycles at which an L2 cycle slip will be assumed. Default is 0.4 cycles.

LOCKTIME_CUTOFF = 8   Phase data will be ignored for the first 8 seconds after locking onto the satellite. Change this value to 0 to process all phase data or a large value to ignore the first n seconds of lock. This gives the phase lock loop a chance to stabilize.

MB_MASTER_ANT = L1VertHgt [L2Corr MeasDist SlantFlag(1/0) ProfileName] MeasToPC

This is the extended version of the antenna height for a multi-base master station. Only first two parameters and ProfileName used by processing engine.

MB_MASTER_DISABLE = ON/OFF   ON if the master station is to be disabled from processing.

MB_MASTER_FILE = Filename   The name of the multi-base master file (.GPB file). Use * as spaces.

MB_MASTER_INDEX = iIndex   Index of the master file in the project. Note that this starts at 0. It must proceed MB_MASTER_??? commands which refer to this location.

MB_MASTER_NAME = StaName   This is the name of the master station used in multi-baseline processing for identification and baseline settings matching. This name is also displayed on the map and used to refer to station/baseline specific settings.

MB_MASTER_POS = LatDeg LatMin LatSec LonDeg LonMin LonSec Ht(m)

These are the coordinates of a master station. The latitude and longitude must be entered in degrees minutes seconds with spaces in between. Latitude is positive in the Northern Hemisphere and negative in the southern. Longitude is positive in the Eastern Hemisphere and negative in the western (Americas).

MOVING_BASE = ON/OFF   Moving Baseline Option Only. If ON, this indicates to the Graf-Mov module that the base station is in dynamic mode as well as the remote. If MOVING_BASE=OFF, conventional processing is performed.

MOVING_BASE_FILE = Filename   No longer supported.

NAV_TOL = dist_in_m   Distance before using DGPS based navigation approximation.

	Affect Kalman filter convergence for slowly moving objects.
NOWRITE_HIGH = ON/OFF	Does not export epochs to the .FWD/.REV if statistics are too poor (if ON used).

OMIT = KAR/PROC $name/ALL sv#/ALL RANGE/ALL [start end]

This controls omitted objects (such as baselines and satellites) from GrafNav processing. KAR = remove from KAR/fixed static; PROC = remove from all processing; $name is baseline name (or use ALL); use start end to define RANGE of times to omit.

OUTPUT_MODE = NORMAL/EXTENDED

Determines output format for the ASCII FWD and REV files. EXTENDED includes velocity and ambiguity values.

POS_DENSITY = 1.0	This is the spectral density of the position states. The user may want to increase this value to 10 or more under high dynamics. This value should be left at 1.0 (default).

PPP_SP3_DATUM = Datum Conversion

Datum used for SP3 precise ephemeris and associated conversion to local datum.

PPP_PROCDESC = Description	Description of processing run. Used by *Processing History* feature.
PPP_PROCTIME = Time Date	Time, in *HH:MM:SS* format, and date, in *MM/DD/YY* format.
PPP_PROCUSER = Name	Name or initials of user. Used by *Processing History* feature.

PPP_PROCESS_MODE = PPP/SFCA/DFCA/AUTP

Specifies the single point processing mode. Dual frequency carrier phase [PPP], single frequency C/A code (SFCA), dual frequency C/A code (DFCA), automatic (AUTO).

PPP_USEP1OVERCA = ON/OFF	Turn ON to use P1 measurements in place of C/A code measurements. Requires new GPB format.

PPP_USESOLVEDCLOCK = ON/OFF

ON to use solved clock bias, or OFF to use corrected receive time from GPB file.

PPP_PRECISEONLY = ON/OFF	ON if only satellites with precise ephemeris and clock values are to be used.

PPP_PROCESS_DIR = FORWARD/REVERSE SINGLE/BOTH

First value indicates processing direction, while second is used by the interface to implement both directions.

PPP_SLIP_TOL = dCoarse dFine   Coarse and fine cycle slip tolerances, in cycles.

PPP_LOCKTIME = ON/OFF ON/OFF

Determines whether or not to use L1 and/or L2 locktime counters.

PPP_USE_DOPPLER = ON/OFF   ON if Doppler observable is to be used during processing.

PPP_DYN_MODE = LOW/MEDIUM/HIGH

If Doppler not used, this command determines level of dynamics modeling.

PPP_OUTPUT = NORMAL/EXTENDED ON/OFF

Determines whether to use standard or extended (with covariance information) output, and whether or not to include bad data.

PPP_TROPO = ON/OFF dDensity   Turns on/off tropospheric error state. If ON, specify the spectral density.

PPP_STD_MODE = Mode   Automatic [AUTO], elevation-based [ELEV], C/N0-based [CN0], or STANDARD.

PPP_STD_REJECT = Type CedeRej PhaseRej DopRej CedeReset PhaseReset

TYPE=MANUAL/NORMAL/STRICTALL/STRICTPHASE/ STRICTCODE/LOOSEALL/LOOSECODE/LOOSEPHASE, values are nSD that is, number of standard deviations. If type is MANUAL, the user needs to enter the rejection and reset tolerances.

PPP_STD_SKIP = MaxRejSec nSkipCodeEpochs nSkipPhaseEpochs

These are the advanced reset settings.

PPP_STD_RELTOL = Value   This is the reliability tolerance for rejecting outliers.

PPP_ETCOFF = ON/OFF   Enables or disables Earth tide corrections.

PPP_PWOFF = ON/OFF   Turns on/off phase wind-up correction.

PPP_NOECLIPSE = ON/OFF   OFF to account for satellite eclipse.

PPP_EPHRELCORR = ON/OFF	ON to use the relativity correction derived from the SV ephemeris instead of from the SP3.
PPP_SEPARATECLKS = ON/OFF	Enables or disables the use of separate clock states for the phase and code. Should be ON for Trimble users.
PPP_CODEONLY = ON/OFF	ON to for code-only processing.
PPP_NODCB = ON/OFF	ON to apply DCB correction for C/A – P1 bias.
PROCESSDESC = Description	This is the processing description. By default it uses Run(1) and increments after each processing run. The information is stored in the processing history. Use * for spaces.
PROCTIME = Time Date	Time (hh:mm:ss) and date (mm/dd/yy) of processing.
PROCUSER = Name	User's name or initials stored before processing. It is stored in the processing history (by GrafNav) and is outputted in ASCII and binary files.
PROCESS_DIR = direction	Processing direction is either FORWARD or REVERSE. Reverse processing can be useful if there are a major series of (fatal) cycle slips during a kinematic run. All features supported under forward processing are supported under reverse processing.
REMOTE_ANT = L1AntHgt [L2Offset …	Vertical offset from ground location to L1 phase centre. Second value is offset from L1 to L2 phase centre. Additional values used by GrafNav for internal use (see MB_MASTER_ANT).
REMOTE_FILE = [path]file_prefix[.gpb]	This is the name and location of the remote station binary GPS data file. This data must be in the .GPB format. If the data is not in this format, use one of the conversion utilities supplied. If this value is not entered, the program will prompt for it. Make sure to replace all spaces with '*' characters.
REMOTE_POS = lat long ht	These are the coordinates of the remote station. The latitude and longitude must be entered in degrees minutes seconds with spaces between. The processing engine now computes a differential pseudo-range solution at the start of the program if REMOTE_SD is greater than 1.0 meters. This means that this position can be many kilometers out and still work. Entering the position is not necessary. Latitude is positive in the Northern Hemisphere and negative in the Southern. Longitude is positive in the Eastern Hemisphere and negative in the Western Hemi-

sphere (for example, Americas). See also INITEX command.

RMS_MODE = NEW/OLD	No longer supported.

SAVE_AMB = ON/OFF ON if ambiguities are to be saved if a satellite drops out in the file but it's locktime is not reset. Disable if too many filter resets are occurring because of missed cycle slips.

SF_IONO_MODE = OFF/ON/BROADCAST/IONEX
Turned ON for automatic selection between IONEX and ICD-200 broadcast ephemeris corrections to be applied when processing single frequency data, or select type of correction manually. Such corrections will only help on very long baselines.

SHOTGUN = ON/OFF No longer supported.

SKIP_NOREPAIR = CaVal L1Val Maximum number of seconds of skip if bad data observed and could not be corrected on either L1 or C/A. Defaults are 10 s for C/A and 0.0 s for L1. Values are in seconds.

SPLIT_SS = ON/OFF dt Set ON to break up static sessions if a time gap of greater than dt is observed. Dt is in seconds. By default, this setting is OFF.

SP_??? Single point processing settings. Ignored by NGPS32.dll.

STANAME = name Used by GrafNet to set the station name for display in output files.

STATIC_SLIP_TOL = val Static cycle slips are declared if greater than val, which is in cycles.

STATICSESS = ID AntHgt StartTime EndTime IsSec80 UseFix 0
Define information about a static session. For instance, ID gives it's name (use '*' for spaces); AntHgt allows the antenna height to be changed (value in m); Start/EndTime define time range in TOW or seconds since 1980 (see IsSec80 flag); IsSec80=on/off; UseFix indicates whether fixed static solution is to be used (0=off, 1=use, 2=check distance and time, see FIX_AUTO command)

STD_MODE = AUTO/ELEV/CN0/STANDARD
This is the type of weighting mode that the measurements will use in terms of statistical handling.

STD_REF = REFCN0 REFELEV CN0_V These are the reference values that the measurement standard deviation's refer to. V in SD = V+10-cno/10 (note: scaled by REF_CN0)

STD_DIST = LOW/MEDIUM/HIGH/OFF/MANUAL [ManHzPPM ManVPPM]

This is the magnitude of distance dependent errors. The distance effect can be low, medium, high, or off. The user can override these settings and enter their own horizontal and vertical PPM manually.

STD_PPM = RejectPPM   This is only used if the user command STD_DIST = OFF above.

STD_REJECT = Type CedeRej PhaseRej DopRej CedeReset PhaseReset

TYPE=MANUAL/NORMAL/STRICTALL/STRICTPHASE/ STRICTCODE/LOOSEALL/LOOSECODE/LOOSEPHASE, values are nSD that is, number of standard deviations. If type is MANUAL, the user needs to enter the rejection and reset tolerances.

STD_SKIP = MaxRejSec nSkipCodeEpochs nSkipPhaseEpochs

These are the advanced reset settings.

STD_PHASE = SD_m ON/OFF   This is the standard deviation for the carrier phase. ON/OFF refers to if the standard deviation will be adjusted for additional ionospheric noise.

STD_CODE = SD_m   This is the standard deviation for the C/A code and P code.

STD_DOPPLER = SD_m/s ON/OFF This is the standard deviation for the Doppler. ON/OFF refers to the auto-doppler flag (used in GrafNav only).

STD_BL = Name UseMain(ON/OFF) [CodeSD phaseSD dopplerSD]

These are baseline specific values. Name refers to master; values in m or m/s.

STD_RELTOL = Value   This is the reliability tolerance for rejecting outliers.

STD_PHASE = SD_m ON/OFF   This is the standard deviation for the carrier phase. ON/OFF refers to if the standard deviation will be adjusted for additional ionospheric noise.

STD_CODE = SD_m   This is the standard deviation for the C/A code and P code.

STD_DOPPLER = SD_m/s ON/OFF

This is the standard deviation for the Doppler. ON/OFF refers to the auto-Doppler flag (used in GrafNav only).

TIME_CORR = 0.0 0.0   seconds. Time correction to master and remote files. This may be useful if a receiver has logged data in UTC time rather than GPS time. It is not suggested that this command be used unless there are errors in the GPS data timing.

TIMERANGE = ALL/RANGE StartSec EndSec Flag ShowHmsMdy

Processing time range. Replaces START_TIME and END_TIME commands. ALL processes entire data set. StartSec is time at beginning (regardless of forward or reverse processing). EndSec is time at end of processing period. Times can either be seconds of the GPS week or seconds since 1980 (see Flag). Flag is 0 for time not valid, 1 for seconds of the week, and 2 for seconds since 1980. ShowHmsMdy is only used by GrafNav for display purposes (1=show H:M:S …).

TROPO_MODEL = OFF/SAAS

Default is SAAS, which is the Saastamoinen model. OFF can be used with GPS simulators that have tropospheric correction disabled.

USE_DOPPLER = ForCarrier ForCode ForCarrier uses Doppler for carrier phase (ON/OFF); ForCode uses Doppler for code only processing (ON/OFF).

USE_PCODE = P1forCA(ON/OFF) P2(ON/OFF)

This will enable P-code and requires dual frequency processing.

USERKAR = gpstime FORWARD/REVERSE/BOTH

Engage KAR at this time for the direction(s) specified, may be multiple entries. gpstime is in seconds of the GPS week.

VEL_DENSITY = density   Spectral density for velocity states (m2/s2).

VERBOSE = ON/OFF   ON prints additional information to FWD/REV/FML/RML files.

VERSION = #.#.#   Ignored by .dll. It is used by GrafNav to indicate version number producing CFG file.

WRITE_BAD_EPOCHS = OFF/ON   Default is OFF. Use ON to write bad data to the .FWD/.REV files. This option is useful if the user wishes to view data at epochs where the RMS_TOL values are exceeded. Normally, data which is greater than RMS_TOL is not written to file.

WRITE_RESIDUALS = ON/OFF   Default is OFF. If ON, then write out each L1 phase and CA-code residual for each satellite to a .RL1 and .RCA file.

WRITE_SLIP_MSG = ON/OFF   ON if cycle slip and other satellite rising/falling warning messages to be written to message log.

Glossary

Observation

A raw measurement file collected from a receiver set up over a stationary point. GrafNet only accepts GPB files and, thus, other formats must be converted first. See *Table 3* for supported formats. GrafNet also requires single frequency carrier phase data as a minimum, and accepts dual frequency if available. Users wishing to perform code-only processing should use GrafNav.

Station

A point where the GPS receiver was setup over and there might be multiple observation files for a single station. However, one set of position values will be produced for each station as a final product of GrafNet. There are several types of stations.

Ground Control Point (GCP)

A reference station with known latitude, longitude and height coordinates. The user may also assign horizontal and vertical standard deviations for these values. There can be horizontal, vertical or 3-D points, and there must <u>always</u> be at least one 3-D point or else one horizontal and one vertical point per project.

Check Point

A station with known coordinates, but these coordinates are only used as a check against GrafNet's computed coordinates.

Tie Point

Such a point may also be called a *loop tie closure* and is formed when two or more sessions "point" to it. Thus, there is a redundant determination at this point.

Traverse Station

This is a point with no tie or control information. It might have two stations connected to it, but one is pointing to it and the other is pointing from it.

Session

Concurrent period of time between two observation files at two different stations. One of the two stations will be the remote, and the other will be the master. The arrow on the screen will be pointing from the master to the remote. The direction is determined by GrafNet in order to form loop closures as well as to minimize the number of legs from a control point. Each session will be processed individually and combined in either a network adjustment or traverse solution. A session can have different statuses and colours depending on whether certain tests passed or failed.

Baseline

Connection between two stations with one or more sessions. Normally, a session and a baseline can be considered the same. However, in some cases there may be more than one session per baseline. This is called a duplicate session baseline, and it is plotted yellow on the screen.

Control Point

See **Station** or **GCP**.