WAYP✸INT
PRODUCTS GROUP

A NovAtel Precise Positioning Product

GrafNav / GrafNet

GrafNav Lite
GrafNav / GrafNet Static
GrafNav Batch
GrafMov

USER GUIDE

GrafNav / GrafNet User Manual

Publication Number: OM-200000105

Revision Level: 1

Revision Date: 2006/12/01

This manual reflects GrafNav / GrafNet software Version 7.60.

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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, 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 GrafBatch, GrafMov and AutoNav. It is beyond the scope of this manual to provide details on service or repair, please see *Conventions and Customer Service* on *Page 15* for customer support.

Prerequisites

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

Operating System
Windows 98, 2000 or XP.

Hard Drive Space
55 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.

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) 720-3800

Fax: (403) 720-3868

Email: wpsupport@waypnt.com

Web: http://www.novatel.com/

Write: NovAtel Inc.
Customer Service Department
112-68 Avenue NE
Calgary AB
Canada, T2E 8S5

What's New!

GrafNav/Shared User Interface

The new shared user interface now has the ability to process forward and reverse simultaneously; this results in a 45% speed improvement on dual CPU machines and 30% improvement on Xeon processors. In the new interface, plots can be copied to clipboard much faster, the hand tool can be used to pan map screen and two GrafNav project files can be compared.

GrafNav 7.60 has the Ability to use antenna definitions for station features and static sessions and you can now set tolerances that determine when a static float solution passes or fails. This is useful for seismic processing. There is much better support for non-metric units in the map window and RMS (root mean square), average, maximum and minimum statistics can be computed from plots. Separate horizontal and vertical tolerances are now available for flagging outliers during export for short static session processing.

In this version of GrafNav, you can now export the sun's elevation for photogrammetry applications and use a new method for building local coordinate definitions that is more flexible. You can also solve for 14-parameter transformations.

Other improvements to the GrafNav interface include the following:

- MJD (Modified Julian Date) time is now supported in the *Export Wizard*.

- Now includes support for New Zealand and Oblique Mercator grids.

- Datum transformations now support 14 parameter transformations; this is useful for datums that are shifting with respect to each other due to tectonic movement.

- Software includes much better support for NAD83 ITRF datum conversions.

- Baseline and satellite processing statistics are now stored in binary value files that can be exported to ASCII.

- Initialization settings are now stored in the program instead of the windows directory.

- Batch processor now prints a map window.

GrafNet User Interface

GrafNet 7.60 has a redesigned user interface that is much more powerful and includes a new data manager that allows more intuitive control of project information. With GrafNet 7.60, any loop tie can be computed by selecting stations or baselines forming a closed loop; this is useful for determining erroneous sessions.

In 7.60, *Measurement* and *Advanced* settings can be modified in GrafNet and there is no longer a need to use GrafNav because you can plot baseline statistics directly from GrafNet. GrafNet now supports separate horizontal and vertical control points so there is no longer a requirement to have at least one 3-D point.

GrafNet 7.60 has better traverse and session reports and improved traverse computation. The session dialog box has been replaced with a menu that is easier to use. GrafNav's improved processing window is now implemented in GrafNet and the Mission Planner is now accessible from GrafNet.

For processing, multiple precise ephemerides are now permitted for long static sessions and you can specify observation GMT date to correct for GPS week number problems caused by mixed up or missing ephemerides. You can also control when float solutions are considered a pass.

The exporting error ellipse 'a' and 'b' now use proper unit scaling and you can use the hand and tool to pan the map screen. There is improved computation of combined and other scale factors and output coordinates can be scaled by a factor during export (i.e. inverse combined scale factor).

The map in GrafNet 7.60 can now plot in grid coordinates and show grid lines and be easily printed.

AutoNav (Automatic Processing Utility)

AutoNav is a new program that performs the following tasks without user intervention:

- Converts raw data to Waypoint Products Group GPB file format.

- Downloads nearby reference stations.

- Converts and resamples reference station data to proper interval.

- Base files can be stored for later reuse to avoid repeat downloading.

- Processes data files.

- Combines directions.

With AutoNav, you can export using a user selected profile and setup an AutoNav project with the flexible dialog based application. AutoNav also you to create configuration and processing files for quality control and plotting within GrafNav.

Processing Engine

In the new processing engine, carrier phase data error detection is stricter and support for ultra-strict carrier rejection has been added. There is now a *Very Low* distance PPM (parts per million) setting for processing very long multi-base data. With the new processing engine, you can also write individual satellite residuals to binary value files for fixed static solutions. Other improvements include the following:

- Added support for precise ephemeris SP3C.

- Better bad data rejection for GLONASS processing.

- Improved base satellite changing.

- Better engine startup for moving baseline processing.

Utilities

The download utility now accepts command line parameters, shows azimuth to stations in addition to distance and supports passive FTP transfer. The *Download Service Data* option utilizes CORS hourly files for downloading within 24 hours for stations that produce them.

The *GpbView* exports autonomous trajectory in NMEA, ASCII and Waypoint's own format and *GPBCat* can now interpolate date rates up to 1000 Hz. The coordinate conversion utility now outputs map scale and convergence, while permitting you to enter the epoch number for datum conversions.

Favourites manager now stores Geodetic Reference Point (GRP) coordinates for IGS (International GPS Service) stations.

Decoders:

In GrafNav / GrafNet 7.60, all decoders now support extended week numbering (to week 1724) and the GPB->RINEX decoder now allows you to specify GLONASS PRN offset. Improvements to other decoders include the following:

- OEM4 supports additional records, including clock information.

- Javad now correctly determines PRN number for GLONASS satellites.

- Trimble DAT converter has re-compute flag set correctly.

- Antenna height and station name now read from Leica System 1200 and Trimble decoders.

- Thales (Ashtech) has improved cycle slip detection.

- Thales (Ashtech) now decodes static/kinematic markers more efficiently.

- Thales (Ashtech) download now automatically detects DG-16.

- Septentrio decoder now supports external event marks.

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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 27* for product capabilities).

1.2   Installation

1.2.1   What You Need To Start

Waypoint Protection Key
As a new user, you can choose between a Sentinel parallel port or USB key. This is a hardlock key that gives you access to the software. This hardlock key must be burned for the correct product with a version number of at least 7.60.

Plug the hardlock key into a COM or USB port and install it before accessing the product (see *Section 1.2.2,* on *Page 24*).

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. The installation CD is available upon request.

Please see the *Forward* on *Page 15* for hardware requirements.
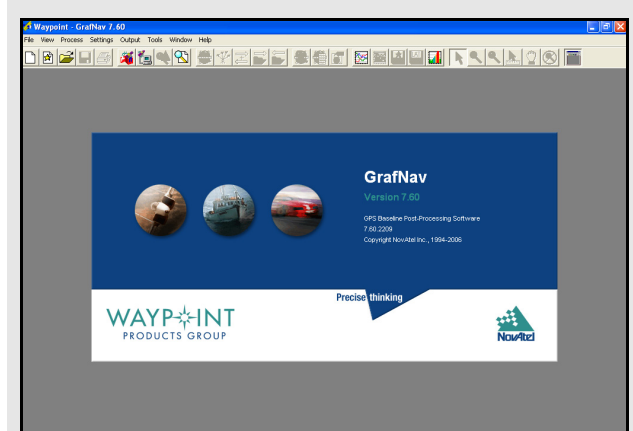
How to Install Waypoint Software

1. Plug your hardlock key into your COM or USB port.

2. Insert the CD into the CDROM drive.

3. Follow the instructions prompted by the program during installation.

How to Uninstall Waypoint Software

1. Select *Start | Waypoint 7.60 | Unistall Software*.

2. Follow the instructions prompted by the program.
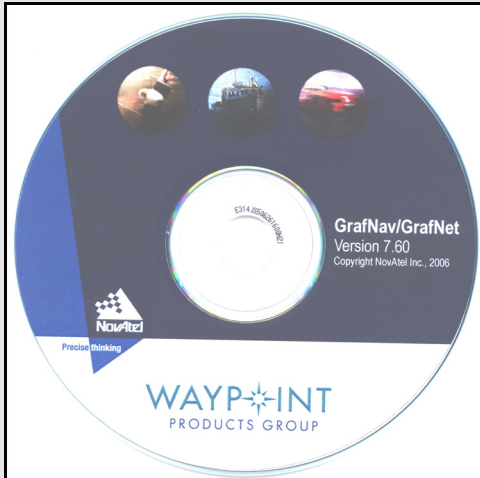
1.2.2   CD Contents and Installation

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 for various types of GNSS receivers. Browse through the subdirectories to see what data is available. To process, copy the contents of directories to the hard disk.

Hardlock
This directory contains the drivers necessary to install the hardlock key on Windows 2000 and XP. All hardlock drivers should be installed automatically during installation.

Geoid
This directory contains geoid files for U.S. (Alaska96, Geoid96, Geoid99, Geoid03), Mexico97, Australia (AusGeoid93 and AusGeoid98) and the world (EGM96). 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. Other regions of the world are also available.

DosUtils
This directory contains various DOS and Win32 console utilities that are not installed with the software. Generally, these utilities are replaced by capabilities within Windows.

Devkit
This directory contains a command-line program that can execute the Dynamic Link Library (DLL) that GrafNav, GrafNet and GrafNav Batch use for processing, which is useful for off-line batch processing. This directory also contains sample C source code for linking to this DLL. See the *Application Note.doc* file in the directory for further explanations.

ManualPdf
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 *Forward* on *Page 15*.
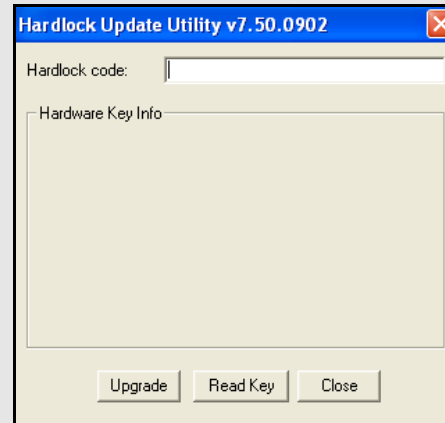
How to upgrade your software

1. Contact Waypoint to obtain a new key code for the hardware lock or expired demo codes. For contact information, see the *Forward* on *Page 15*.

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.

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 FTP site link provided by Waypoint.

⊠ Versions 7.50 and 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 7.50 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 (See *CD Contents and Installation* on *Page 24*).

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.

Kinematic Ambiguity Resolution (KAR) 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. KAR can be useful for single frequency receivers if there are enough satellites present for 20 to 30 minutes. KAR 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 KAR solutions, but it 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 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 Kinematic Ambiguity Resolution (KAR). 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 it has a fixed static solution for static initialization of short or medium length baselines that are 0 km and reliable to 25 km. A float static solution is available for long and/or noisy baselines. KAR allows you to start in kinematic mode and GrafNav's ionospheric processing improves accuracies for dual frequency users. See *Chapter 2* on *Page 31* 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, including fixed static, float and ionospheric free. See *Chapter 3* on *Page 145* 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 achieves accuracies of 5 to 20 cm even though it only includes float static initialization and does not support KAR.

> ⊠   Single frequency float solutions does not fix ambiguities.

See *Chapter 2* on *Page 31* 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. Please see *Chapter 2* on *Page 31*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	✓	✓	✓	✓
Moving Baseline				✓
Azimuth Determination				✓
IMU Processing*				
<1 sec Kinematic Data Rates	✓			✓

*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 KAR, 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, GrafMov's KAR, 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.

Main Uses of GrafNav Batch

One base station and many remote occupations

The remote occupation can be observed by one or more GNSS units. Up to 128 baselines can be processed in this manner.

One kinematic remote processed with respect to two or more bases

The batch processor can be used to automatically process forward/reverse and combine these solutions into one optimal solution. You can process multi-baselines in GrafNav Batch with two or more base stations.

1.4.5   GrafMov

GrafMov is a moving baseline module that allows for GPS post-processing between two moving platforms. It improves the accuracy of the relative trajectory over the stationary base by processing directly between two kinematic objects. 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   GrafNav Batch

GrafNav Batch is a program module that comes with GrafNav/GrafNet and GrafMov to facilitate batch processing of static and kinematic baselines. If you are using GrafNav Lite, use GrafNav Batch Lite because GravNet is not available. The two main uses of GrafNav Batch are explained in the shaded box.

GrafNav Batch has many of the features of GrafNav, including data plotting utilities. See *GrafNav Batch* on *Page 177* for more details.

> ✉ For static baseline processing in GrafNav / GrafNet, GrafNet is a more effective batch processing tool.

1.4.7   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 *Chapter 8* on *Page 219*.

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 AusLig.

1.5.3   GPS Data Logger

This utility facilitates GPS data logging directly from a variety of GPS receivers under a Windows 98, 2000, or XP environment. Features like station-tagging and satellite lock plots are also included. Please 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 *Chapter 8* on *Page 219* for more information.

There is also a Windows CE version of the data logger included. This version has many of the same capabilities as the Windows version. See *Chapter 8* on *Page 219* 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 *Chapter 3* on *Page 219* 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	WinCE
NovAtel	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	OEMV3 OEMV2 OEMV1 OEM4 OEM3 OEM2	✓ ✓ ✓ ✓ ✓ ✓
Allen Osborne	TurboBinary	⌘
CMC / NovAtel	Superstar II All Star	✓ ✓
Conexant	Juniper	✓
CSI	DGPS MAX	✓
Javad	All Models	✓
Leica	MX series SR series System 500 System 1200 MC 1000	✓ ✓ ✓ ✓ ⌘
Magellan	CAR MOB	✓ ✓
NAVCOM	OEM GPS	✓
NavSymm/ Parthus	XR5 XR6 XR7	☎ ☎ ☎
NavSys	AGR	☎
Rockwell	PLRG series NAVCOR	☎
Septentrio	SBF	✓
SIRF	Star II	✓
Thales	Real Time B-file DSNP	✓ ✓ ✓
Trimble	4000 series (DAT) 4000 series (RT) 5700 CMR TSIP Force5 (TIPY) SSx	✓ ✓ ✓ ☎ ✓ ✓ ✓
U-Blox	Antaris	✓
RINEX	2.0 2.1	✓ ✓
UKOOA		☎

1.5.6   *Data Converter*

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

✓ = Raw data conversion to Waypoint format supported

☎ = Supported, but converter must be obtained from Waypoint

⌘ = Supported, but converter must be obtained from manufacturer

2.1   GrafNav, GrafNav Lite and GrafNav / GrafNet Static Overview

GravNav

GrafNav is a full-featured kinematic and static GPS post-processing package that uses Waypoint's proprietary GPS processing engine. It supports both single and multi-baseline (MB) processing. GrafNav supports most single and dual frequency commercial and OEM receivers. See *Table 2* on *Page 29* for more information.

GrafNav automatically switches from static to kinematic processing and has a fixed static solution for static initialization of short or medium length baselines that are 0 to 30 km. A float static solution is available for long and/ or noisy baselines. Kinematic Ambiguity Resolution (KAR) 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 KAR.

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

See *Table 1* on *Page 27* for a capability comparison between GrafNav, GrafNav Lite and GrafNav Static.
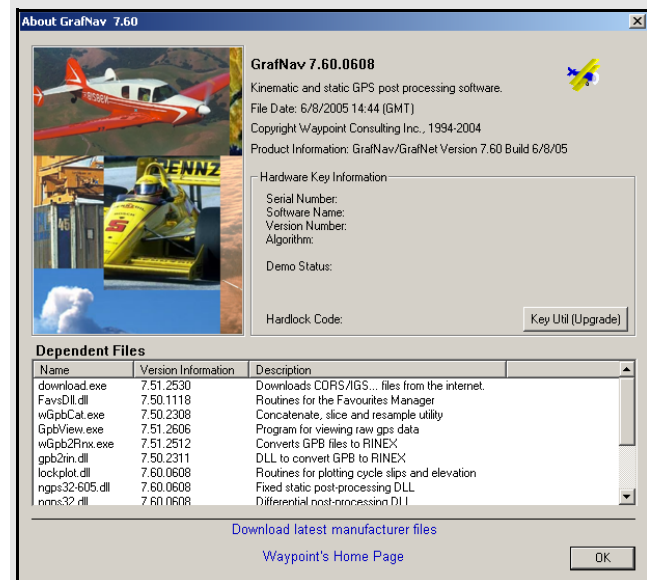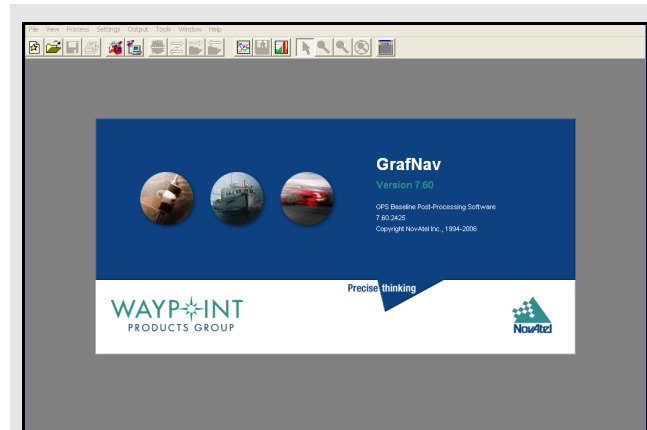
2.2   Start a Project with GrafNav

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

How to install

1. See *Section 1.2.2* on *Page 24* 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 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. If the position is not known, then compute the average position from the remote GPB file by selecting *Position from GPB* and choosing 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.

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 *Chapter 1* on *Page 23* 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 8* on *Page 219* 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 GPS 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 136* 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, you have to choose between *File Name* and *Auto Start*. This section discusses these options and gives step-by-step instructions to follow once you have decided on the method for starting your project.

File Name

File Name 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 7 on Page 205*.

The remaining steps must be performed manually. These steps are in the shaded box.
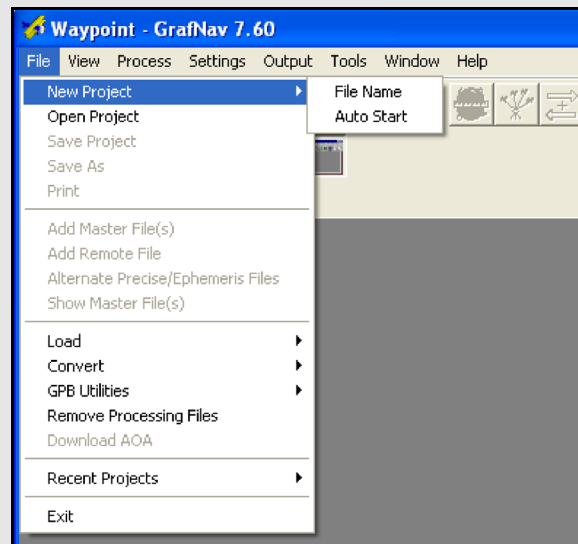
How to create a new project using *File Name*:

1. Select *GrafNav* or *GrafNav Lite* from the Waypoint GPS program group in your start menu.

2. Select *File | New Project | File Name*. A window appears asking for the name of the new project.

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

4. Click *Save*.

5. Select *File | Add Master(s)* to load master files.

6. Select from the list of GPB files, select those collected at the base station (s) and click *Open*.

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

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.

You can also choose to have *Auto Start* begin processing your data automatically by activating the *Start processing page right away* box. The *Auto Start* steps are in the shaded box.
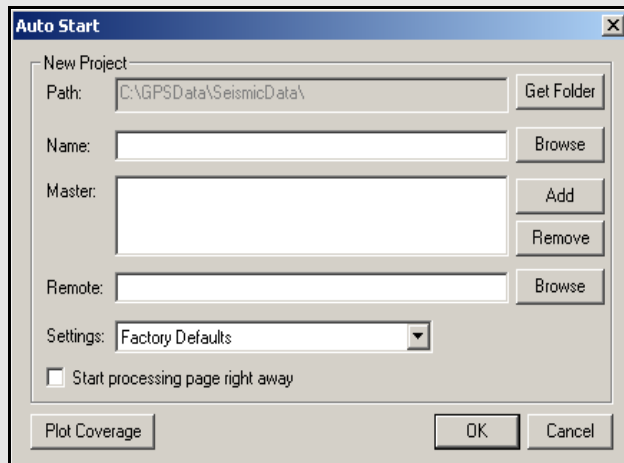
How to create a new project using *Auto Start*

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

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 *Static/Kinematic + Coverage* plot.

3. In settings, choose a processing profile.

4. Out of the five preset settings, choose the settings that best suits the application.

5. Enter the master station coordinates.

6. Enter the remote station antenna height.

7. Check the *Start processing page right away* box, and click *OK*. See *Section 2.5* on *Page 61* for more information on processing.

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

2.3.2   Open

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 2.4.3* on *Page 54* 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 Project As* from the menu.

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

3. Click *Save*

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

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, please see *Section 2.6.4* on *Page 95*.

5. Select the elevation type (orthometric or ellipsoidal) to tell the *Export Wizard* whether or not to apply a relative correction for orthometric height computations.

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

How to change the antenna height on static sessions:

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

2. Select *Edit* for each static session.

* This height is used for computation so if baselines are 300 km or more, you will get better results from entering an ellipsoidal height.

2.3.6 Add Master Files

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 *Enter Master Position* dialogue box appears with values averaged from the GPB file. These values might have errors of 10 meters or more. For IGS and CORS stations, ARP (antenna reference point) coordinates are pre-loaded in the *Favourites Manager*. See *Section 2.8.10* on *Page 131* for more information.

Datum Selection

Proper datum selection is very important. CORS sites 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. Be sure to set the ellipsoidal/orthometric height flag correctly. See *Section 2.6.4* on *Page 95* for more information.

Remote Station Coordinates

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.

Entering the proper remote station coordinates gets higher accuracies. 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 user-defined 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 57* for information about antenna heights for static sessions.

2.3.7 Add Remote Files

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 (Saved State) 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 36* for information regarding antenna height models.

Enter Remote Antenna Height

Remote

Remote file name:
  C:\GPSData\Manual_Data\remote\mac10990.gpb

Antenna Height

NOTE: This antenna height applies primarily to kinematic trajectories. It will be overriden by features (stations/events) and static sessions. For changing the antenna height on static sessions, select Output|View Objects|Static/KAR, then select 'Edit'.

(•) Use simple vertical antenna height (to L1 phase centre)

  Vertical antenna height: [0.028]   (m)

(○) Use advanced method (requires antenna profile)

  Antenna height measurement: [0.028]   (m)

  Antenna profile: [Generic ▼]   [Info]

  ☐ Slant distance measured to ground plane   [Define]

  ☐ Measurement directly to L1 phase centre

  [OK]   [Cancel]

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 static sessions

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

2. Click *Edit* for each static session.

How to specify alternate ephemeris files

1. Go to *File | Alternate Ephemeris 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.

How to load ephemerides from different stations

1. Select *Tools | Download Service Data*.

2. Download data from the nearest station for the day of interest.

3. For precise ephemeris, select the *Options* tab and enable precise ephemeris download.

2.3.8   Alternate Precise Ephemeris Files

Broadcast Ephemeris

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

Generally, the GNSS receiver includes 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 a specified alternate source. Please 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. Please 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 slightly more accurate than broadcast ephemerides but this accuracy difference is only effective when attaining the highest accuracies or using the longest baselines.

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 7 on Page 205* for details.

Waypoint software only supports precise orbits stored in the SP3 format, which was originally created by NGS. Fortunately, most agencies use this format. Orbits which have been optimized for the United States are available free of charge from NGS via their website (www.nga.mil).

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 downloading data from the nearest CORS or IGS station. See *Section 2.8.12* on *Page 136* 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.

How to load a precise ephemeris file in the SP3 format:

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

2. Select the appropriate SP3 file.

How to load IONEX files and satellite clock files:

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

2. Select the appropriate *yy*I and/or CLK file.

View/Edit GPS option settings

Show Station Info
Displays information about the station.

Show GPB Info
Displays information about the GPB file.

Show Time Gaps
Displays information about any time gaps in the data.

View Raw GPS 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 in the file.

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 be 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.

Remove
Removes the master file completely from the project.

Plot L1 Locktime
Launches the **L1 Satellite Lock/Elevation** plot.

Plot L2 Locktime
Launches the **L2 Satellite Lock/Elevation** plot.

2.3.9 Show Master Files

Object Menu Options

This command brings up the Object menu for the base stations, where the following features are available:

View
Brings up the Object Info message box for the selected base station.

Edit
Allows you to edit the name, coordinates, and antenna height of the selected base station.

View/Edit GPS
Displays a list of actions that are listed in the shaded box.

Disable
Disables the selected master station from being used for processing.

Remove
Removes the master file completely from the project.

Add to Favourites
This adds the object with solution to the list of Favourites. See *Section 2.8.10* on *Page 131* for more details.

2.3.10   Load

Existing Trajectory

Opening a project that has already been processed
does not automatically load 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. For
example, you can load a CMB file produced by the
baseline combination in GrafNav Batch this way.
To load a solution from another project, follow the
steps in the shaded box.

Single Point Solution (from .gpb file)

This option loads a GPB file that has a single point
solution. 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 2.6.6* on *Page 98* 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
appears when the remote is added to the project.
However, for a few receivers and user events, this
feature must be used.

How to load existing trajectories

1. Under *File | Load*, select *Existing Solution File*.

2. The program displays a list of forward trajectory files (FWD), reverse trajectory files (REV), combined trajectory files (CMB), forward single point trajectory files (FSP), etc. Select the appropriate solution file.

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 on *Page 36*.

4. 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.
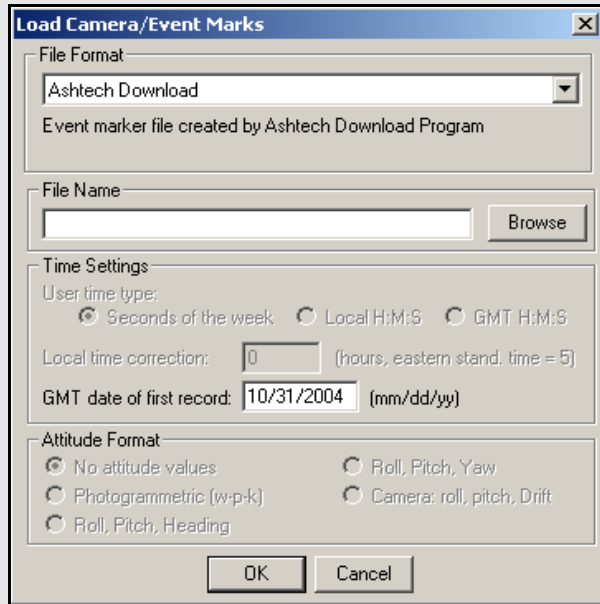
File Format

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 should load automatically 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 numbered starting 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. To load a station file, follow the steps in the shaded box.

RTK Dat File (.sta/nst)

This option loads converted RTK solution files and then uses the Export Wizard to re-format them for output. To load a RTK Dat file, follow the steps in the shaded box.

How to load a station file:

1. Under *File | Load*, select *Station File (.sta/nst)*.
2. The program displays a list of station files (STA). Select the appropriate STA file.

How to load RTK Dat File (.sta/nst):

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

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.

The *Lat/Long Format* option contains 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 Lat/Long

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

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

3. Under the *Lat/Long Format* choose the 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.

How to create a Leica IDEX file (idx.)

1. Unplug the Waypoint hardware lock.

2. Run *Ski 2.2* or higher.

3. Select *Project*, then *Manager*.

4. Click *New* to select an empty path, or *Open* to select an existing project.

5. Close the window by clicking on the *Close File* button.

6. Select *Import | Measurement | Back Up/ PCMCIA*.

7. Move to the rover directory containing DS and db files.

8. Select the jobs to include in IDEX file.

9. Press the *Insert button*, and then press *OK*.

10. Close the *Import* window by pressing the *Close* icon

11. Select *View/Edit | Utilities | Export to IDEX*.

12. Create a file name.

13. Clear *variance/covariance information* (optional).

14. Select *Measured*.

15. Click *Save* and *Close*.

How to load a Leica IDEX file (idx.):

1. Create or open a GrafNav project containing the Leica data.

2. Select *Load*, and *Leica IDEX file* from the *File* menu,

3. Move to the directory containing the IDEX file. You should see a message indicating how many IDEX points were matched to TTP points.

How to load a Aschtech OUT file (.out)

1. Create or open a GrafNav project containing an Achtech OUT file (.out).

2. Select *Load*, and *Aschtech OUT file* from the *File* menu.

3. Move to the directory containing the.out file.

4. Select the file and Click open.

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. The steps to so this are in the shaded box. 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. The steps to do this are in the shaded box.

Digital Elevation Mode (DEM)l

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

The DEM file has to be organized in one of the formats listed under the *Format* drop-down menu. The following options are also available to help read the input file:

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

> **Stop reading if incomplete line encountered**
> Aborts there 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.
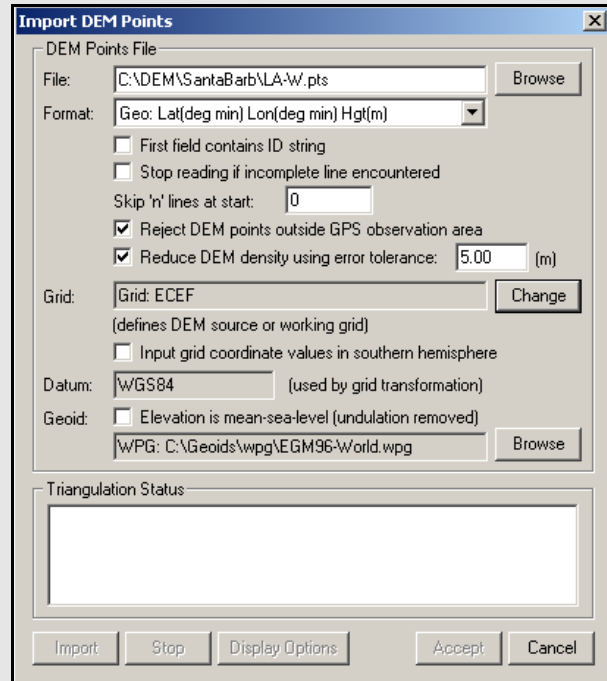
How to import a digital elevation model (DEM)

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

2. Select the DEM points (.pts) file under *File Name*.

3. Select one of the 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. In addition, the DEM is displayed in GrafNav. If no contour lines are visible, then the DEM is outside of the area.

How to load a digital elevation model (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*.

Import DEM Points

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 MLS (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)*.

2.3.11   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 8* on *Page 219* for more information regarding this utility.

GPB to RINEX

See *Chapter 8* on *Page 219*.

2.3.12   GPB Utilities

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

Concatenate, Slice and Resample

See *Chapter 8* on *Page 219*.

View Raw GPS Data

See *Chapter 2.4.1* on *Page 52*.

Convert GPB to RINEX

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

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

Data Types to Export
Specify which data to write to the RINEX observation file. If *Auto-Detect* is selected, the program writes all available measurements. Choose between the **Version 2.1** and **Version 2.0** format. The RINEX formats are well-documented. Consult with available sources to learn the differences between the two versions.

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.
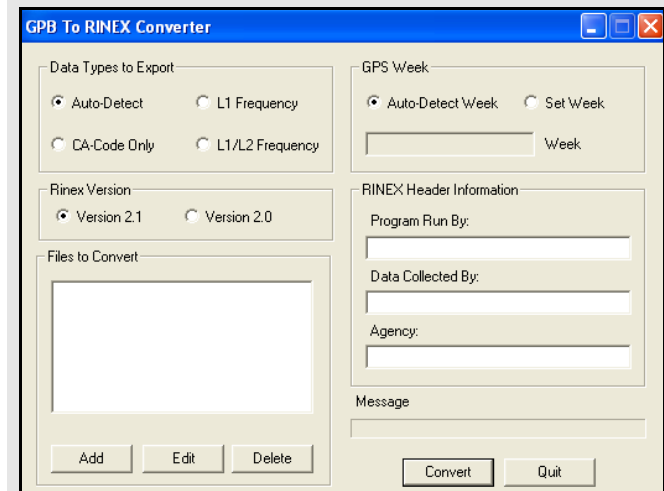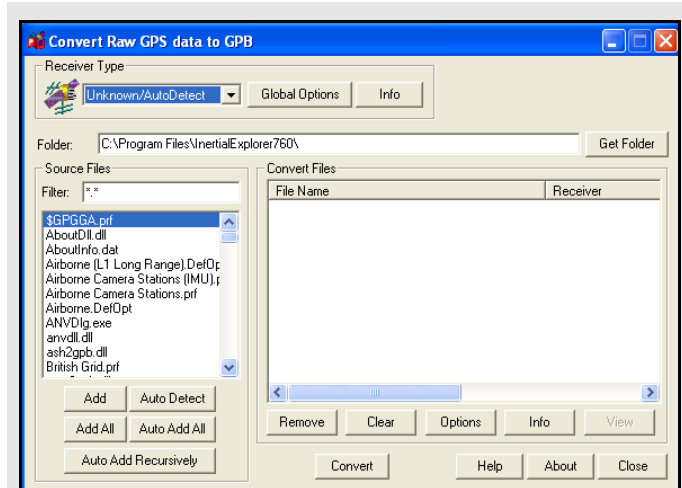
⊠   Regardless of the option selected, only data measurements that exist in the GPB file is exported so columns of zeroes are not created for missing data.

⊠   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.
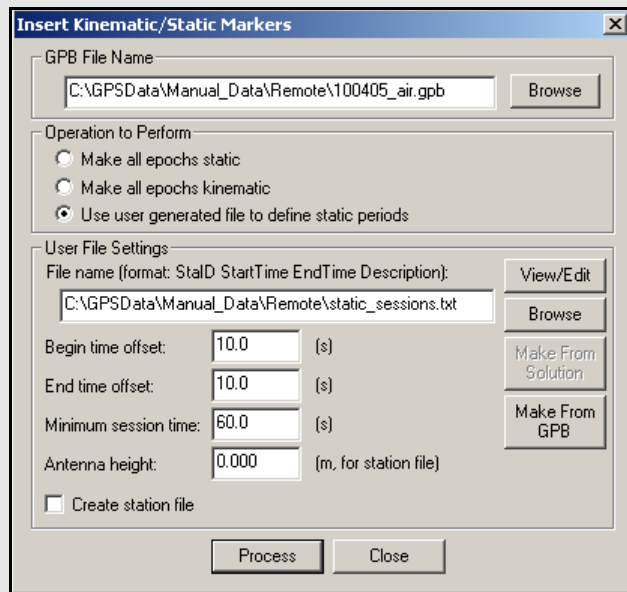
Space-delimited fields:

- StationID
- StartTime
- EndTime
- Description

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 8* on *Page 219* 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
This value is written to the station file for all user-defined static sessions, assuming the *Create station file* option has been enabled.

Create station file
Writes all static sessions to the station file (STA), regardless of whether an antenna height has been entered.

2.3.13   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.

2.3.14   Download AOA (Allen Osborne Associates)

This converter is only available in the AOA version of the software. See *Chapter 7 on Page 205* for details.

2.3.15   Recent projects

Provides a list of recent projects and allows you to left double click to load them.

2.3.16   Exit

Exits Waypoint software.

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 2.4.3* on *Page 54* for more details.

Project files

Contains project configurations and processing options.

2.4   View Menu
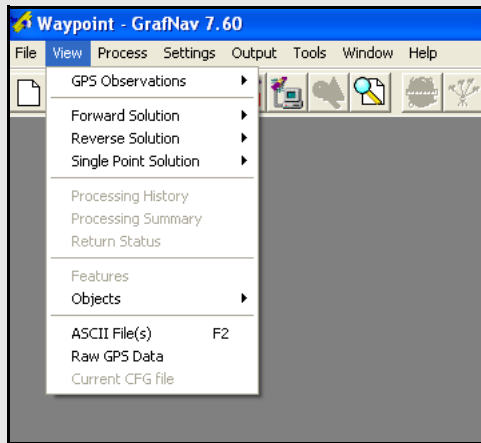
Messages reported from message log include the following:

- Times at which KAR 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.

2.4.1   GPS Observations

This option gives you access to all the features listed in *Object* menu found under *File | Show Master Files | View/Edit GPS* for all master and remote files in the project. Please see *Section 2.3.9* on *Page 40* for a list of the features.

2.4.2   Forward, Reverse and Single Point Solutions

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.

Static/KAR Summaries

This summary file displays the processing settings and the statistics for successful KAR fixes and static sessions. Other items reported in this summary are listed in the shaded box. See *Chapter 7 on Page 205* for an example of this summary file.

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 7.4.3* on *Page 216* for a complete description of both the old and new output formats.

Static/Kar summary report items:

- Final solutions for all static sessions, as well as type of solution obtained.

- Time and place at which KAR engaged successfully, as well as the corresponding statistics. Such information is useful for evaluating whether or not KAR resolved ambiguities correctly.

- Processing settings, including datum information, as well as master station coordinates.

- Satellite usage information pertaining to static sessions.

- Slope, horizontal, and corrected ellipsoidal distances for all static sessions.

- Program completion information.
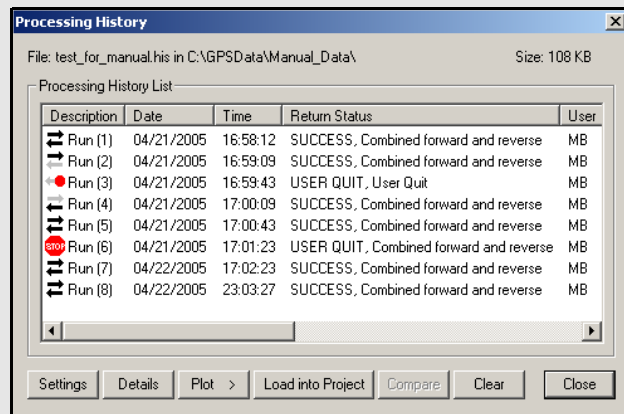
Processing history view options

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.

2.4.3   Processing History

This feature displays the processing history in a chronological list. 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 initials and the return status. View options in the *Process History* box are listed in the shaded box.

2.4.4   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 KAR 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 107* for information about the *Export Wizard*.

2.4.5   Return Status

This option displays the processing status of the most recent run. This feature allows you to see whether the processing was successful. It shows the contents of the Finish{} record in the FSS/RSS file.

2.4.6   Features

The *Feature Editor* 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*.

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 intege **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.

Name
Repeat of the feature name.

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.

Options in the *Features Editor* window

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.

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.

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.

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.

2.4.7   Objects

This command brings up the *Object Menu* for all of the epochs, static sessions, KAR 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 57 f*or details.

3. Use remote antenna height. See *Section 2.3.7* on *Page 37* 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.

Options available in the *Objects* 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 2.3.9* on *Page 40* 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 KAR
Forces the software to engage KAR at the selected object's time.

Add to Favourites
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 message log for a record closest to the time of the selected object.

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

⊠   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.

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.

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

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* on *Page 285* for a diagram of different methods for making antenna measurements.

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.

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.

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.

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)

- Output Files (LAT, UTM, ST, XYZ, LAM, LOC)

- Configuration Files (CFG).

2.4.9   Raw GPS

This option is also available under *File | GPB Utilities | View Raw GPS Data*, or through a separate utility called *GPB Viewer.* This option lets you view and edit binary GPS data in Waypoint's receiver-independent GPB format. See *Chapter 8* on *Page 219* 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.

2.5   Process Menu

2.5.1   Process Differential

The *Process GPS or GPS+GLONASS* window
provides access to most settings related to
differential processing and lets you choose the
options best suited to your application.

Process

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

Process Data Type
Defines the type of data used for processing
including the following:

> *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,
> and then dual frequency. If L2 tracking is very
> poor, then a dual frequency GPS receiver can
> be detected as single frequency.
>
> *Single frequency carrier phase*
> 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.
>
> *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 (KAR), this technique is more reliable,
> solves on longer distances and requires less
> observation time. For example, KAR resolves
> in few minutes what could take up to 20
> minutes in single frequency mode.
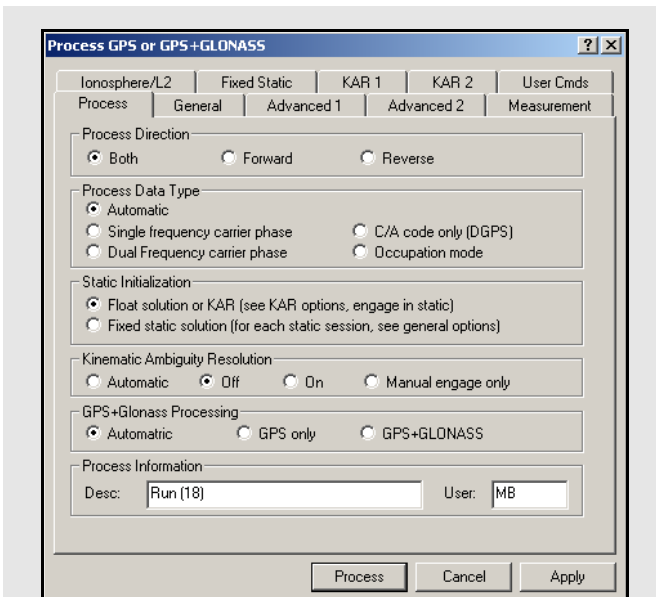
Process direction options

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.

Both: Processes in both directions. If this option is
activated, the two solutions are combined after processing.
See *Section 2.6.9* on *Page 100* for help doing so. This
method is most effective for kinematic processing. For
static processing, only use the forward or reverse options.

**Benefits of using the dual frequency carrier
phase**
The benefits of processing in dual frequency mode include
the following:

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

- Improves the reliability of integer ambiguity
  search techniques.

C/A code only (DGPS(Differential Global Positioning System))

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.

Occupation mode

This special mode of operation is designed for areas of heavy tree cover. In this mode, you should remain stationary over each point of interest for 2 to 5 minutes. In this mode, carrier phase lock does not have to be maintained during travel between points. Since the carrier phase is used only for static data, you can achieve sub-metre accuracies in this terrain. GLONASS processing is also suggested to include additional satellites.

Static Initialization

The two options are the following:

Float solution or KAR

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. For dual frequency data, enable the ionospheric free correction mode.

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 57* for important information regarding the processing of static sessions.

Kinematic Ambiguity Resolution (KAR)
This option solves for fixed integers on a moving antenna and is not applicable for C/A only processing. KAR regains fixed integer (high accuracy) positions at onset or after a loss of lock. KAR also engages in static mode. KAR processing options are listed in the shaded box. See *KAR 1* on *Page 77* and *KAR 2* on *Page 80* for more options.

GPS+GlonassProcessing
Applies only to data logged using Glonass-enabled receivers. The processing option settings are listed in the shaded box.

Process Information
Lets you enter processing information and then stores it in the processing history. The options of types of information are listed in the shaded box.

KAR processing option settings

Automatic
Enables KAR for dual frequency and disables it for single.

Off
Forces KAR to never engage.

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

Manual Only
KAR only engages at your selected times. Define these times under the *KAR 2* tab. See *Page 80* for help.

GPS + Glonass processing options settings

Automatic
Enables the use of available Glonass data.

GPS only
Disables Glonass processing. This option is useful if Glonass data causes problems.

GPS+GLONASS
Forces the use of available Glonass data. Use this option if automatic detection fails.

Types of Process Information:

Desc
Enter a description of the run here. The program numbers the runs numerically.

User
Enter your name or initials.

See *Section 2.5* on *Page 61* for more process options.
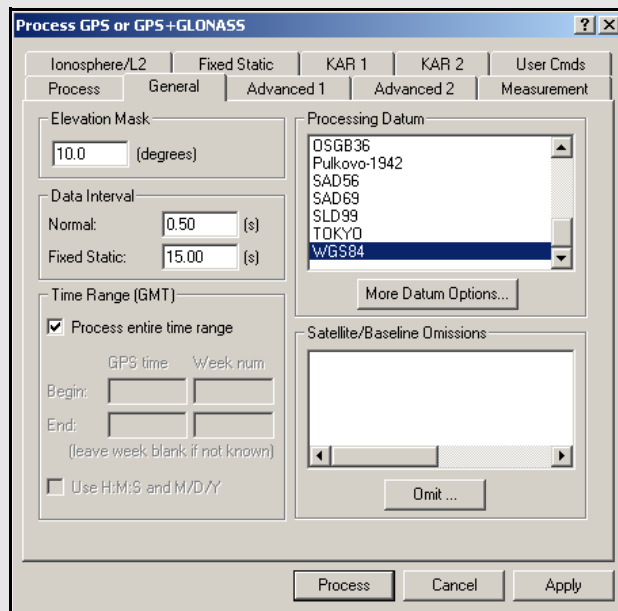
Data Interval option settings

Normal

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.

Fixed Static

Use this interval for the fixed static solution. 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.

General

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; 13 degrees has been found to work well for most airborne data sets.

You can raise the elevation to 15 degrees, but be aware that raising this value too high might cause satellites that are important to the geometry to be missed. Lowering this value is not suggested because it causes noisy satellites at low elevation to degrade the solution.

Data Interval

Defines the intervals to kinematic and static data at. The two setting options are described in the shaded box.

Time Range

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), but times can also be entered in hours, minutes and seconds if the *Use H:M:S and M/D/Y* option is selected.

⊠   Times are in GMT (Greenwhich mean time).

Processing Datum

By default, the processing datum is the same one that the base station coordinates are entered in. You have the option to process in a global datum and enter the coordinates in the local datum but this approach is more complex and should only be used if you thoroughly understand datums. Click on *More Datum Options* to do the following:

- to enable or disable datums.

- to enable coordinate input in a datum different than the processing datum. See *Section 2.6.4* on *Page 95* for more information.

Omit Satellite Info
This option brings up the *Omit Satellites, Baselines and/or Times* 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 KAR/Fixed-Static only
 Applies the omission only during ambiguity resolution.
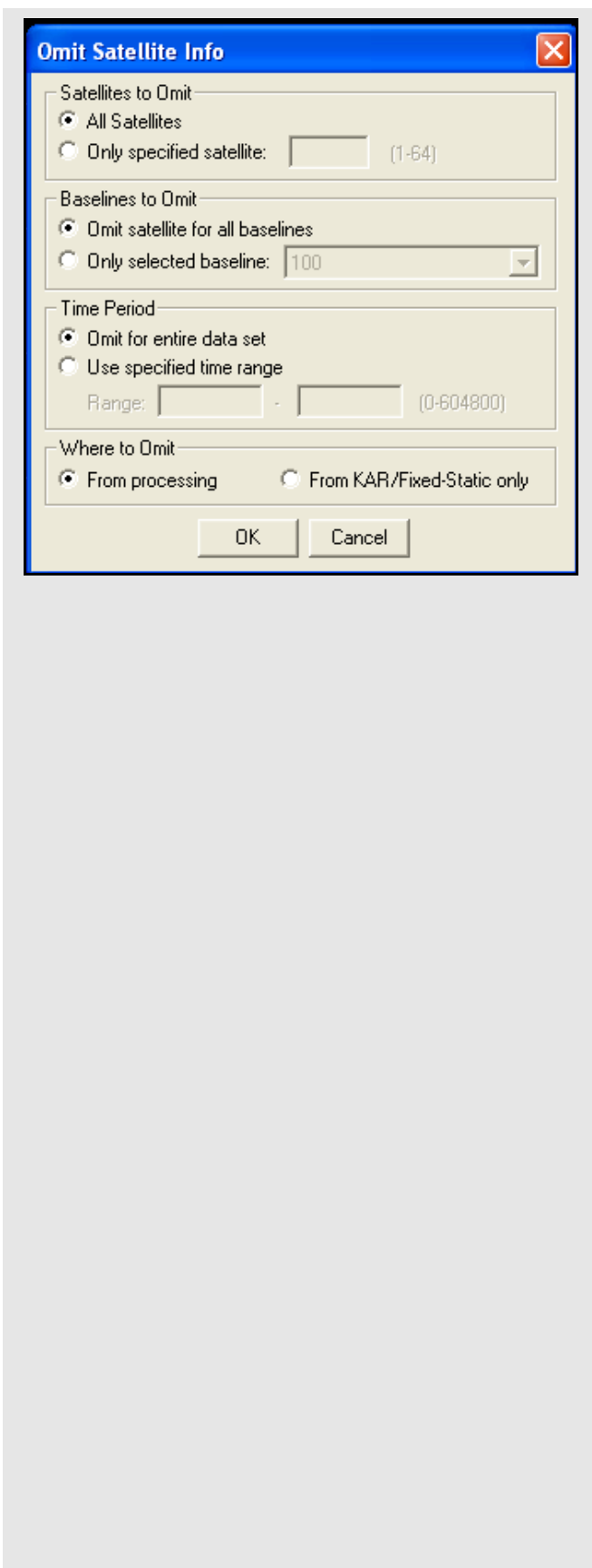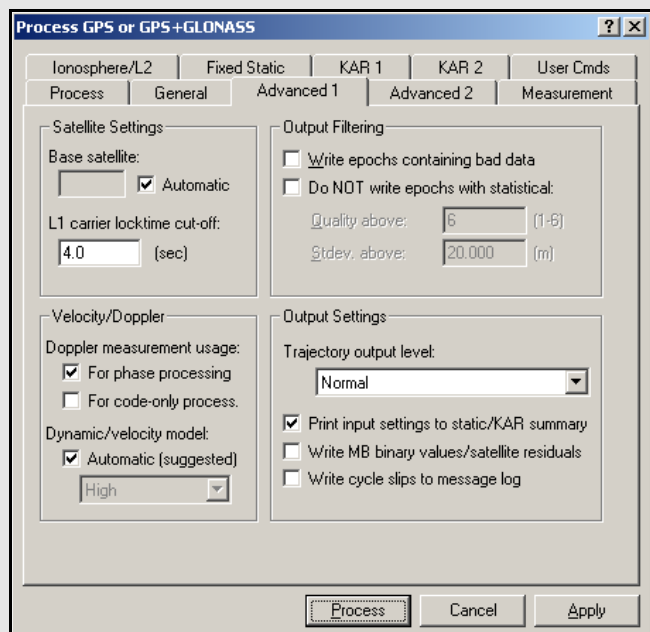
Dynamic/velocity model settings

Automatic
This setting is suggested because it turns off dynamic constraint if *Doppler measurement usage* is enabled, and turns on *High* dynamic constraint setting if it is disabled.

High
Vehicle dynamics (100 m position error due to velocity change).

Med
Vehicle dynamics (10 m position error due to velocity change).

Low
Vehicle dynamics (1 m position error due to velocity change).

Off
No constraint.

Advanced 1 Options

Satellite Settings
The two settings available here include the following:

Base satellite
Specifies the satellite to be initially used as the base for the differenced observations. Generally, *Automatic* selection is much preferred.

L1 carrier locktime cut-off:
The number of seconds of continuous carrier phase lock before data for that channel is deemed usable. This allow 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.

Velocity/Doppler
The following settings apply to the use of Doppler measurements.

Doppler measurement usage
The Doppler is mainly used for velocity determination. The default setting is *For phase processing* but you can disable it if several Doppler error warnings are present in the message log.

Dynamic/velocity model
This setting controls when to use the constant velocity vehicle dynamic constraint. The main purpose of this setting is to improve velocity determination accuracy if the *Doppler measurement usage* is disabled. The settings available for this option are in the shaded box.

Output Filtering
This option has the two following settings that affect GrafNav's handling of bad data:

> ***Write epochs containing bad data***
> Prints out all positions that GrafNav computes, good or bad. GrafNav does not print positions for epochs where the Kalman filter detects large measurement errors. This option should only be used if you need a position for as many epochs as possible and if you are not concerned about various low quality positions.

> ***Do not write epochs with poor statistics***
> This setting removes epochs from a solution 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.

> **Output Settings**

These options pertain to the amount of information written to disk.

> ***Trajectory output level***
> This option allows you to select the format of the epoch output files. The setting options in the drop-down menu are described in the shaded box.

> ***Print input settings to static/KAR summary***
> Prints processing settings at the start of the FSS and RSS files. This is useful for tracking the options that were used to create a solution file. After each run, a copy of the CFG file is also saved in the *Process History.*

> ***Write MB binary values/satellite residuals***
> Writes carrier code and residuals for each satellite and baseline to FBV and RBV files. This setting are always enabled for MB processing.

> ***Write cycle slips to message log***
> Prints satellite cycle slips and rising/falling messages to the FML and RML files. Disabling this option creates a more concise message log but these multiple messages might help locate a problem satellite.

Trajectory output level setting options

Normal
Default for GrafNav.

Extended (covariance)
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, as well as the ambiguity values.

GrafNet (minimal)
Suited specifically for GrafNet in order to minimize disk space usage.

Ultra-Extended (MB/SV info)
Identical to *Extended*, but with the addition of multi-base and satellite information.
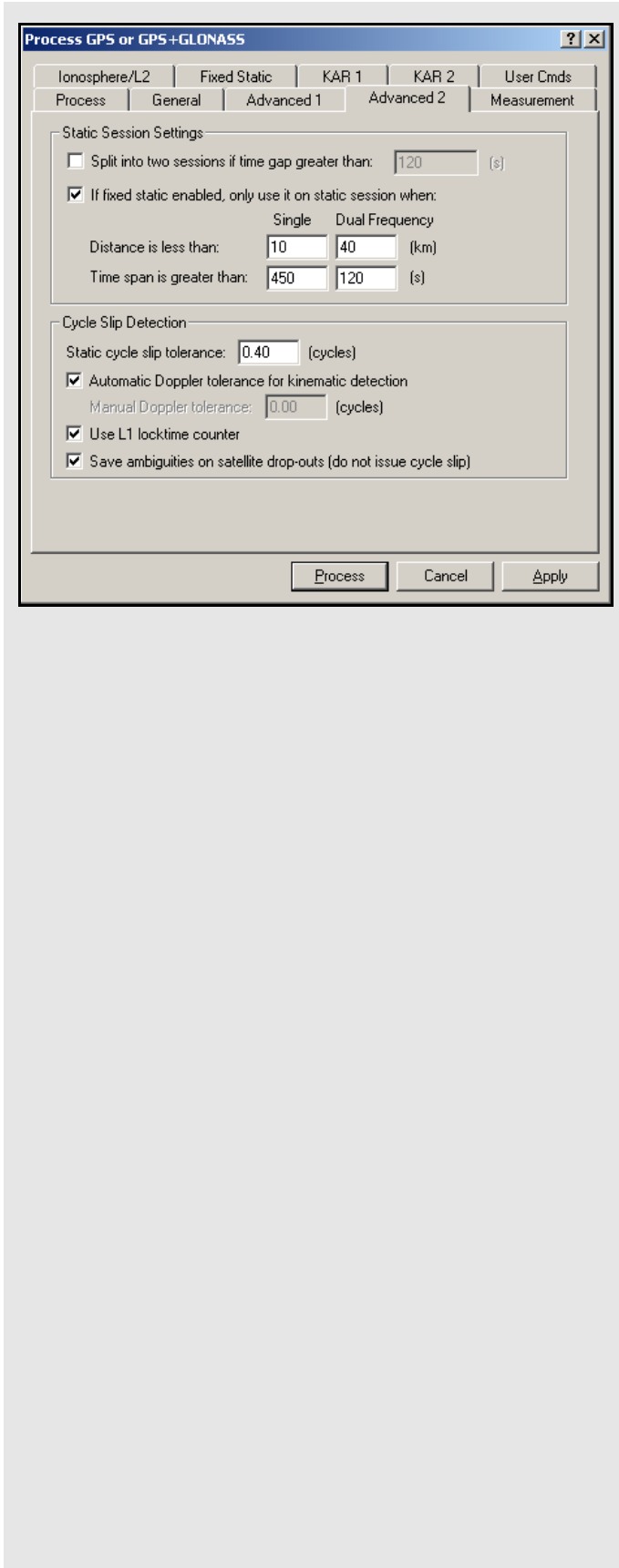
Advanced 2 Options

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.

> #### *If fixed static enabled, only use it on static session when*
> 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 the *Process* tab.

Cycle Slip Detection
GrafNav uses the locktime read or the computed locktime in the decoder combined with a Doppler check to detect L1 phase cycle slips.

Static cycle slip tolerance
Detects cycle slips in static mode. This value might have to be raised if you are processing extremely noisy carrier data. In static mode, the fine static check is turned on by default, allowing GrafNav to detect very small cycle slips. For fixed solution, this is automatically used and cycle slips are also corrected. Cycle slip corrections for the fixed solution can be disabled from the *Fixed Static* options tab.

Automatic Doppler tolerance for kinematic detection
This option computes a conservative tolerance based on the data and can be manually set if you are experiencing incorrect cycle slip detection. Use the *GPB Viewer* to re-compute the Doppler before you use this tool.

Use L1 locktime counter
In kinematic mode, the locktime cycle slip check uses flags generated by the GPS receiver to count the L1 locktime. Normally, this should be enabled.

Save ambiguities on satellite drop-outs
Due to serial data errors, some receivers drop satellites without a loss of lock occurring. Without this setting enabled, these drop-outs are treated as a cycle slip. Enabling this setting is especially beneficial for Ashtech receivers. In some cases, however, it is better to interpret this loss of lock as a cycle slip. A good indicator that this checkbox should be disabled is if a filter reset message follows the message "Prn # dropped out for *n* seconds on b/l *???* -- will try to save ambiguity" in the message log.

Measurement Options

Satellite Weighting Mode

This option includes the following preferences:

> ### *Elevation based (suggested)*
> Satellites are weighted inversely to their elevation angle using the following equation:
>
> $$w_f = 1 / \sin \varepsilon$$
>
> ### *C/N0 (carrier-to-noise ratio) based*
> Uses L1 C/N0 for weighting with the following equation:
>
> $$f = V + 10^{CN0/10}$$
>
> If L1 C/N0 is not available on all master/ remote raw data files, than weighting reverts to elevation based. If available, this mode uses L2 C/N0 for ionospheric processing. Before using this weighting mode, plot the C/N0 values for all files to verify that the data is available and that the values are in the proper 30-50 dB range. Some receivers output SNR or "signal counts" instead of C/N0; do not use this data.
>
> ### *Standard*
> Uses a constant weight value for all satellites. Be aware that this setting disables baseline distance effects.

⊠   GrafNav's weighting is relative, rather than absolute. The magnitude of the nominal elevation (45 degrees) or nominal C/N0 (50 dB) is controlled with the standard deviation measurement values. Advanced users can use *STD_REF* for more controls (See *Appendix A* on *Page 285*).

⊠   Using the C/N0 base weighting should theoretically produce the "best" weight. However, scientific testing has not shown this to always be the case. C/N0 values vary among receivers and may have a lag time associated with them. Many do not output C/N0 at all so using C/N0 based weighting is not always beneficial.

Measurement Standard Deviations
Sets the standard deviations of the measurements.
These values can be applied to all baselines or they
can be set individually for each baseline with the
Values are for drop-down menu. Baselines which
have been altered individually are denoted by an
asterisk in the drop-down list. See *Chapter 9* on
Page 257 for more information on setting these
values.

> **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.
>
>> *Adjust for iono* - Adjusts the carrier
>> phase standard deviation for additional
>> error resulting in L1/L2 combination.
>> This option should be enabled.
>
> **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.

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

Advanced Settings window showing:
Maximum continuous rejections before reset is engaged: 15.0 (s)
Epochs to skip before reset induced on code error: 5
Epochs to skip before reset induced on carrier phase error: 1
Reliability tolerance for rejecting satellites and baselines: 4.0
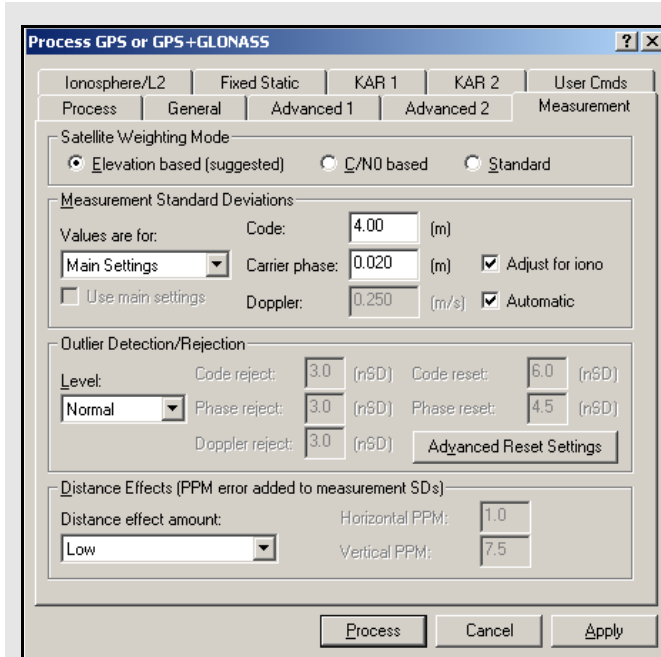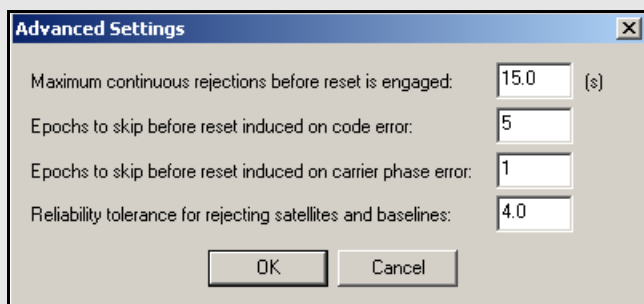
Maximum continuous rejections before reset is engaged
This is the number of seconds of continuous rejections before a reset is issued. Some high data rate kinematic applications may find it appropriate to lower this value.

Epochs to skip before reset induced on code error
On the occurrence of a code error, the processing engine attempts to skip and reject an epoch's data. This might prevent a reset, but at the expense of a position drop-out. Lower this value to allow fewer missed epochs.

Epochs to skip before reset induced on carrier phase error
This is similar to *Epochs to skip before reset induced on code error* but applies to the carrier phase. One or two epochs distinguish between one epoch carrier spike, which disappears, and a missed cycle slip, which acts as a step function on the carrier residuals. Only the former can be handled by skipping an epoch.

Reliability tolerance for rejecting satellites and baselines
This is the ratio between the second best residual and the best residual necessary to detect an successful satellite or baseline removal. Generally, this value is left at 4.0, but it can be lowered if a correction is missed or increased if incorrect corrections are occurring.

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 tries to reject satellites, measurements or baselines but if too many continuous rejections are encountered, then the software intentionally issues a cycle slip to all satellites. This is known as a filter reset.

The easiest way to control the amount of rejection is to select an option in the *Level* drop-down list. You can manually 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.

Advanced Settings (for advanced users)
A list of these settings are in the shaded box.

Distance Effects
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. The easiest way is to select the *Distance effect amount* from the drop-down list. *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 is dependent on the type of processing. Manual distance effects can be entered as well. In this case, you would enter the horizontal and vertical values directly. This effect can be disabled, but this is NOT suggested, especially for multi-base processing. To view the PPM values used, bring up the *Static/KAR Summary* file after processing and look for the *Dist. Effects* field. For very long spatial distances, consider using *Low* or *Very Low*. Otherwise, the Kalman filter may destabilize in these circumstances.

Ionosphere/L2 Options

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 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. Generally, ionospheric correction becomes beneficial on baselines greater than 10 km. The following options are available:

> *Use L2 carrier for dual frequency ionospheric processing*
> Two models are available for selection and they are listed in the shaded box.
>
> ⊠ It is often a good idea to try both models, because one sometimes works significantly better than the other.

The distance from the base station when the relative transfer starts can be set using the *Engage distance for relative ionosphere*. This is an advanced parameter and changing it causes little difference in the final solution. You may wish to lower this value during periods of high ionosphere activity.
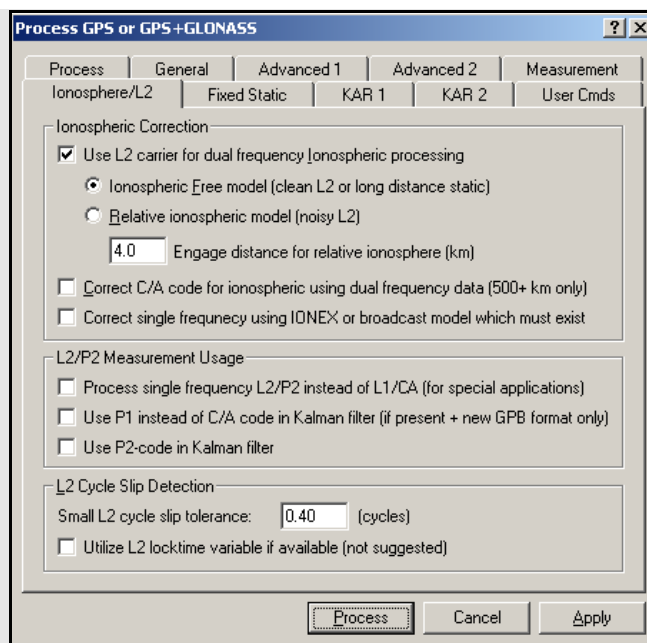
The models for L2 carrier for dual frequency ionopheric processing

Ionospheric Free Model
This can be used for static or kinematic data. This model does a better job of resolving the ionospheric error, but at the expense of being more sensitive to cycle slips. A cycle slip on L2 induces a total cycle slip for that satellite. However, for data sets where L2 is very clean and suffers few losses of lock, this model is strongly suggested. Furthermore, static baselines should use this method, because it aids the fixed static solution if the iono noise model is used. In general, this model works better with most GPS receivers.

Relative Ionospheric Model
This model is normally used for static initialization where the base and remote are close enough that the ionospheric error at that separation can be assumed to be zero. Using the relative transfer algorithm, the ionospheric error is accumulated as the separation grows. If a loss of lock occurs, this transfer cannot continue, and the solution becomes very similar to that achieved using the ionospheric free model. For this reason, the relative model can be used even if the starting point is far from the base. This model is suggested for data with frequent L2 cycle slips.
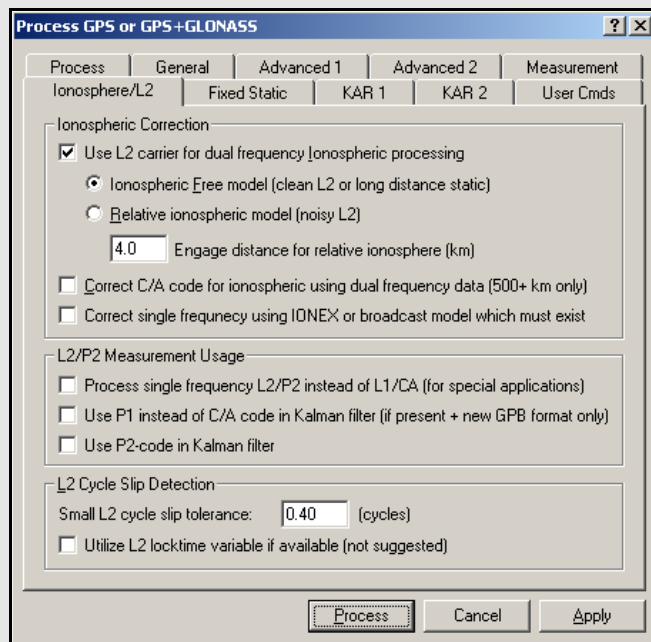
Correct C/A code for ionospheric using dual frequency data
By combining the C/A code and the P2-code, the ionospheric effect can be removed from the pseudorange measurement. However, this adds additional noise on the order of a few meters. Thus, baselines need to be very long before the effect of the ionosphere is larger than the additional noise induced. Generally, baselines need to be 500 km or more in length.

Correct single frequency using IONEX or broadcast model which must exist
IONEX files contain information relating to the ionosphere on a given day. It can be used with single frequency processing to assist in the ionospheric modeling process. They can be downloaded using the *Download Service Data* utility. See *Section 2.3.8* on *Page 38* for more information on how to add precise ephemeris, satellite clock, and IONEX files.

L2/P2 Measurement Usage
The following options are available:

> *Process single frequency L2 instead of L1*
> This mode uses L2 for carrier and P2 for code, and is most appropriate for special applications, including GPS simulator testing, P-Y code receiver testing, and operation of a P-Y code receiver during jamming. For civilian receivers, there is no benefit to using this mode of 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. Note that this requires the new GPB format. In addition, P1 code data must be present.

> *Use P2-code in Kalman filter*
> Under normal circumstances, P2-code measurements are not employed. This is because most dual frequency receivers use narrow correlators (or similar technology) for their C/A code measurements, and these tend to be more robust and reliable than the P2-code. Enabling this feature adds this measurement to the Kalman filter, thereby possibly improving convergence.

L2 Cycle Slip Detection
The following settings are available:

> ***Small L2 cycle slip tolerance (For advanced users)***
> Both KAR and relative ionospheric processing check for small cycle slips on L2 by comparing it against the L1 phase. Raising this value too high increases the chance of a half cycle slip being detected. Lowering this value might cause false cycle slips to be induced from noise. Changing this value requires the analysis of the results and should only be done by advanced users.

> ***Utilize L2 locktime variable if available***
> The default method of L2 cycle slip detection, which compares L2 against L1, is superior and gives less false detections. You have the option of using the L2 locktime variable. This Variable uses the cycle slip detection of the GPS receiver. If too many cycle slips are being detected, there are many warnings in the message log, assuming the *Write cycle slips to message log* option is enabled under the *Advanced 1* options. The estimated accuracy of the forward or reverse positions might also be higher if ionospheric processing is used.
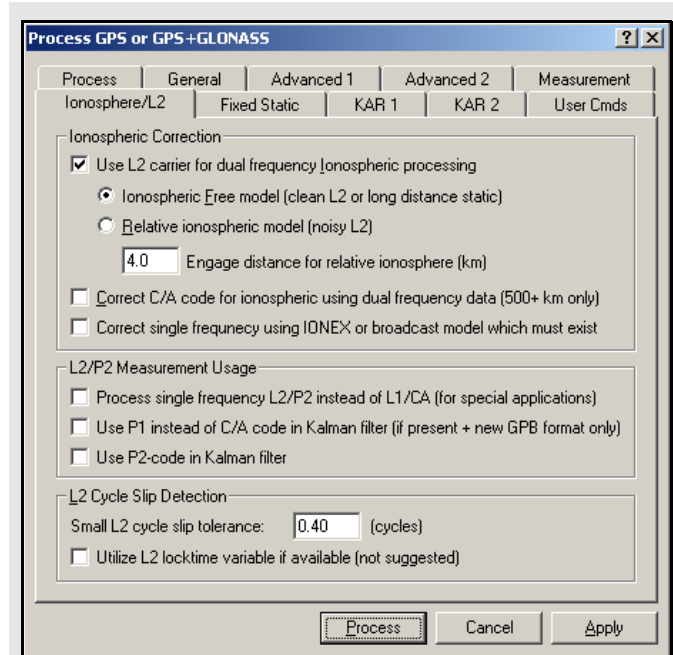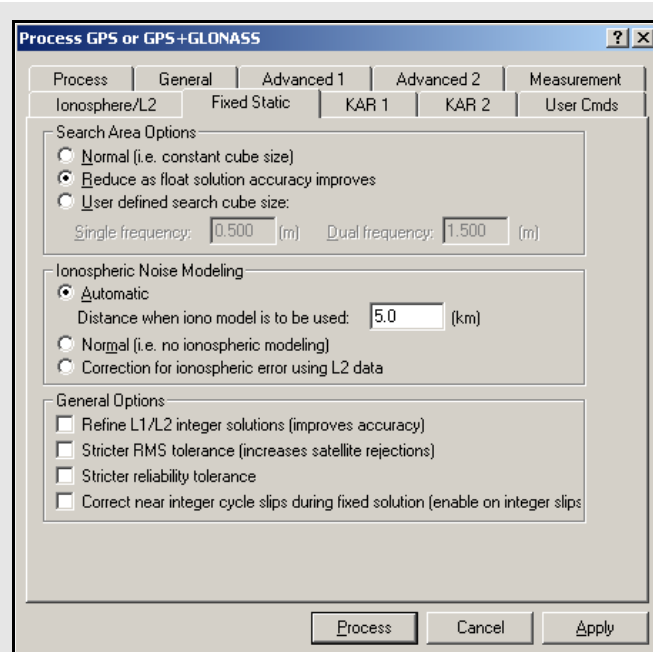
Search Area Option settings

Normal
This uses a constant search region size.

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

Normal
This is similar to the *High* noise model for KAR.

Correction for ionospheric error using L2 data
This noise model corrects for the ionosphere in its computation. This can improve accuracies, but noise might be higher on short baselines.

Automatic
This noise model chooses between the previous two based upon the distance tolerance entered.

Fixed Static Options

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 L1 (i.e. Normal L2 Noise) can deliver better results.

General Options
The following options are available:

> *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.

> *Correct near integer cycle slips during fixed solution*
> Carrier phase cycle slips are capable of nearing one or more integers. This can also be determined in static mode. In cases where the cycle slip real value is within 0.035 cycles of an integer, the fixed static solution can correct for this integer bias in future raw measurements, improving accuracies. Sometimes the computed cycle slip is close to integer, but the actual cycle slip is a non-integer value. This results in biased measurements that can cause the fixed solution to fail or result in this satellite's rejection in the NewFixed (multi-satellite) solution.

KAR 1 Options

Kinematic Ambiguity Resolution (KAR) is a technique that computes an integer fixed solution of 2 cm while the remote antenna is in motion. Applications of KAR include kinematic initialization and initialization after loss of lock.

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

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

As long as KAR 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, KAR resolves. The FSS or RSS file shows when KAR was engaged and when it was restored. Additional KAR statistics are also shown here.

Minimum Time

These values represent the minimum amount of time before KAR is invoked and can be customized depending on the type of data available.

In both cases, the values entered are added to the value in the *min/10 km* input box, which is applied for every 10km of baseline distance.

For example, dual frequency receivers with a baseline distance of 20 km, the minimum time required using the default values is the following:

1minute + [1.5minutes * (20km / 10km)] = 4 minutes.

Search Region

These setting options relate to the size of the search region used by KAR.

> *Single frequency*
> The default value is 8 minutes and should not be set to lower than 5 minutes unless azimuth determination is enabled with a < 2 m distance constraint in GrafMov.

> *Dual frequency*
> The default value is 1 minute. You might want to lower this value when fast ambiguity determination is very helpful, an example of this includes urban data. Airborne users with longer baselines might want to increase this number to minimize the effect of the ionosphere.

> ⊠ Fast KAR lowers this to 1 second.

Maximum Distance

The distance tolerance for engaging KAR in both single and dual frequency can be defined here. KAR does not engage if the remote is too far from the base station. This improves reliabilities. The default distance is 7.5 km for single frequency and 30 km for dual frequency. These values are designed for a period, like the year of 2000), where the ionospheric activity is high due to solar radiation storms. For later years, these tolerances can be increased.

Options for Engaging KAR
These options control when KAR is engaged.

> *Engage KAR while in STATIC mode:*
> Use this option to engage KAR in static. Be cautious when combining this with the fixed static solution because in certain circumstances, KAR's solution may supersede that of the fixed solution.

> *Engage if distance < tolerance1, reset if > tolerance2:*
> This option is very 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 KAR continuously (not recommended for airborne data):*
> This option engages KAR at a specified interval and is most often used for monitoring applications. This value is usually set around 5 to 20 minutes. Because this mode makes no attempt to check either baseline distance or data quality, it is the least desirable method for engaging KAR in airborne data.

> *Engage on event of poor DD_DOP:*
> 4 is the minimum number of cycle slip free satellites need to maintain lock. Even if this minimum is maintained, the geometry can be very poor, as shown by spikes in the *Double Difference DOP* plot.

> ⊠ If the DD_DOP is greater than 100, the epochs are not be plotted because GrafNav skips past them. This creates a gap in the data, so check the message logs for these instances.

> Setting this checkbox forces KAR to engage after the DOP recovers. The default tolerance is 25.

> ⊠ KAR engages automatically if the DD_DOP is greater than 100, regardless of this setting.

Fast KAR is reliable under the following conditions

- Relatively short master-remote separations (less than 7 km)

- Seven or more satellites in view above a 10-degree elevation mask

- Low multi-path environment

- Clean carrier phase measurements

KAR 2 Options

Control Settings

The following options are available:

> #### *Stricter reliability tolerance*
> The reliability is the ratio of the carrier RMS values between the second-best and best intersections. Larger values means greater reliability. The tolerance for accepting a reliability number is dynamic within GrafNav. This setting adds a bias to the existing dynamic tolerance to make the tolerance strict and reduces the occurrence of incorrect KAR intersections. Be aware that this option can cause KAR to take longer to resolve or not to resolve at all.
>
> #### *Stricter RMS tolerance*
> This option is similar to the *Stricter reliability tolerance* but it lowers the tolerance for the RMS value of the best intersection. The tolerance, normally 0.065 cycles, is lowered to 0.05 cycles. The tolerance can also be altered using the *KAR_RMS_TOL* command. This option reduces incorrect KAR intersections and is usually more effective than the *Stricter reliability tolerance* option. Both options can also be used.
>
> #### *Use Fast KAR*
> Fast kinematic ambiguity determination, while not necessary for most GPS work, can benefit certain applications, including the following:

- race car or rocket trajectory determination

- types of surveys under open conditions with scattered obstructions of the sky

- to independently verify a KAR solution if different fixes are obtained in forward and reverse processing.

This option is only available for dual frequency processing because *Fast KAR* with single frequency data is unreliable.

> ⊠ Be aware of its limitations and know that it is reliable under the conditions listed in the shaded box.

The Minimum Time defaults under the KAR 1 tab
gives enough data to reliably resolve satellite
ambiguities under reasonable GPS conditions. In
environments with signal obstructions, KAR might
not resolve because it could have less data between
successive losses of lock than this minimum time.
The *Use Fast KAR* option makes several internal
changes to accommodate this, including reducing
the minimum KAR time to zero, which tells
GrafNav to resolve the ambiguities as quickly as
possible. The maximum time before KAR restarts
is 8 minutes, which forces KAR to be recomputed
more often. This option also increases the amount
of data that KAR uses in its computations,
reducing the amount of time it takes to resolve.

Use fast KAR even for 5 SVs
Five satellites is the minimum required for
KAR computations. It is therefore risky to
use *Fast KAR* in this situation, as it tends to
be unreliable. However, given otherwise
favorable conditions (see above), it can be
used successfully.

Refine L1/L2 KAR search
Sometimes, ionospheric noise or carrier
multi-path can make it difficult to determine
the carrier L1/L2 ambiguities. This setting
applies an additional search and leads to
faster and more correct ambiguity resolution.
This setting also works well in combination
with the *Stricter reliability tolerance* and
Stricter RMS tolerance settings. See *Page 80*.
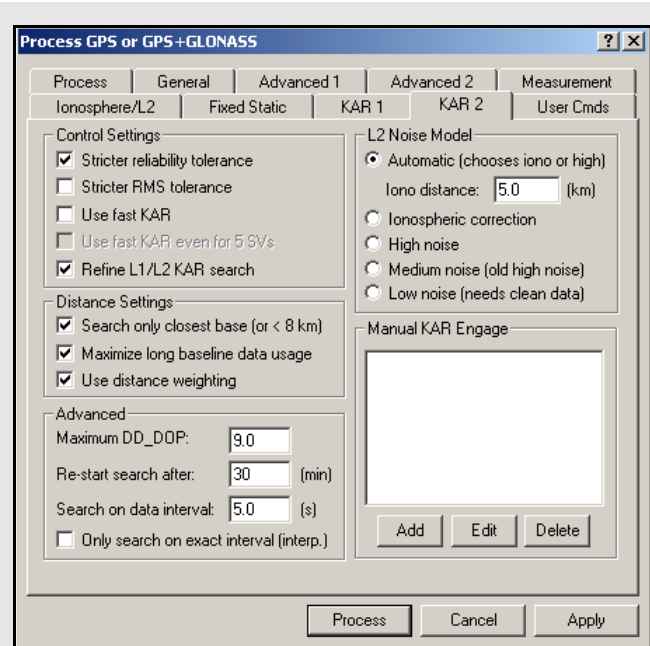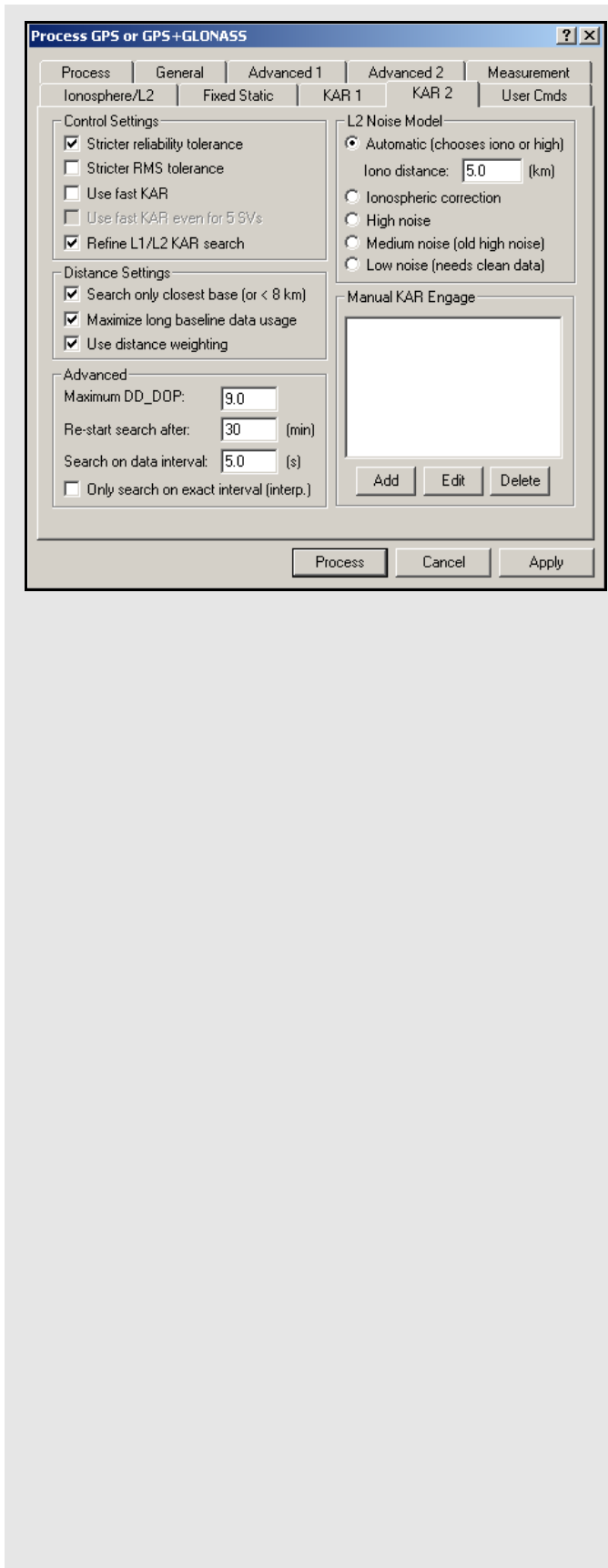
Distance Settings
The following options are available:

> ***Search only closest base (or < 8 km)***
> This option only applies for multi-base processing. It forces KAR to use the closest base station or those which are closer than 8 km. Disabling it causes all base stations to be used and is normally not desirable. If a certain base station causes suspect fixes due to poor quality data, consider disabling it using the *View | GPS Observations | Master | Disable* or omitting it from KAR usage.

> ***Maximize long baseline data usage***
> With this setting disabled, KAR stops using data as soon as the distance between the remote and master is significantly longer than the maximum distance. This can result in minimal data being used, causing lower reliability. With this setting enabled, all usable data less than the maximum distance is used by KAR.

> ***Use distance weighting***
> KAR has the ability to weight by the inverse of the base-remote distance. This helps with airborne data because the effect of the ionosphere is dependent upon distance.

> ⊠ Baselines shorter than 6 km are not affected.

Advanced
The following options are available:

Maximum DD_DOP
KAR will not search if the DD_DOP is greater than this tolerance. This preserves the reliability of the solution. Raising this value allows KAR to search data that the software would otherwise skip. The default value is 9.

Re-start search after
This is the time length before KAR starts searching over again. Lowering this value causes fixed integer gaps to be lower and prevents KAR from using more data than shown. This is more practical for dual than single frequency because single frequency KAR needs 15 or more minutes to resolve. The default value is 30 minutes.

Search on data interval
This defines the number of seconds between epochs that KAR uses for processing. If carrier phase errors are random, like in white noise, then using a lower interval improves results, but increases memory usage and computational time. If errors are systematic, like colored/ionospheric noise, than lowering this value has less effect.

Only search on exact interval
GPS data can be interpolated with the *Concatenate, Slice and Resample* utility or using the *Download Service Data* feature. In both cases, additional errors of 1 to 3cm can be added to the measurements and is enough to cause KAR not to fix. If this option is enabled and the *Search on data interval* option has been set to the original source data interval, then KAR is not affected. You can lengthen the minimum KAR time with the *KAR 1* tab to use more data, especially if the original interval is 30 seconds or less.
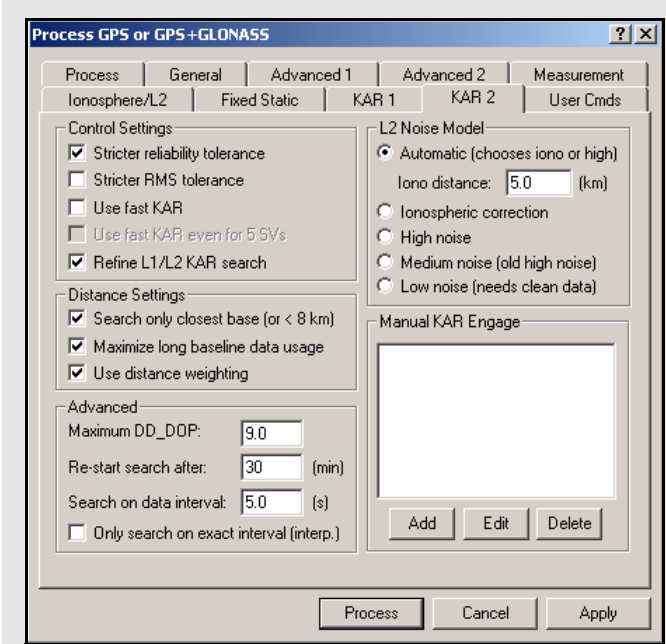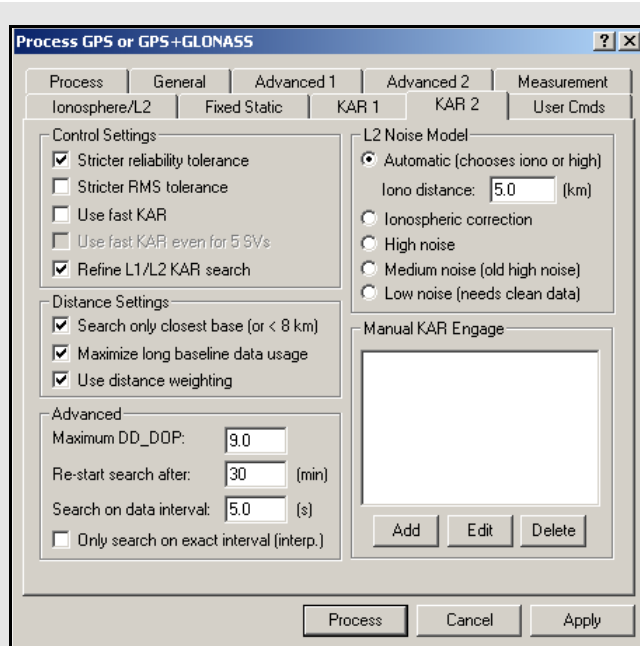
Noise models available for L2

High noise
Places more emphasis on L1 phase (although the widelane is used).

Ionospheric correction
This noise model corrects for the ionosphere and seeds the ionospheric correction algorithms, forming a more accurate KAR fix.

Medium noise
This is the previous *High noise* model from earlier versions. There should be few cases where it performs better than the new *High noise* model.

Low noise
This model places more weight on L2. It normally does not perform as well as the previous noise models, but it may be helpful for short baselines.

Automatic
This noise model is the default; it chooses between the *High nois**e** and the *Ionospheric correction* models depending on the current master - remote distance. The distance tolerance can be specified here.

L2 noise model:
KAR supports a number of L2 noise models to determine how GrafNav handles L2 data in KAR. Due to anti-spoofing, L2 can be significantly noisier than L1, and this difference must be taken into account. The noise models that are available for L2 are listed in the shaded box.

Manual KAR Engage
You can manually engage KAR when it is necessary. For example, when an airborne platform is very close to the base. In this case, you should also consider lowering the minimum KAR time. You must specify the duration as well as the process direction in which to apply it. This feature works well combined with the *Manual engage only* setting under the *Process* tab. This allows KAR to engage only at specified times.

GLONASS Options

These options govern the way GrafNav uses GLONASS measurements when computing a solution.

GPS-GLONASS *Clock State*
The following option is available:

> ***Solve for difference as Kalman Filter state***
> This option forces the time difference between the GPS and GLONASS time systems to be computed in the Kalman Filter. The difference between the two time systems is not more than a few meters. Corrections to the GLONASS pseudoranges are made using this time difference. The phase measurements are not corrected because they vary only by the change in this difference over time, which is extremely small. Computed ambiguities account for the remaining error. The option settings 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* on *Page 285* 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.
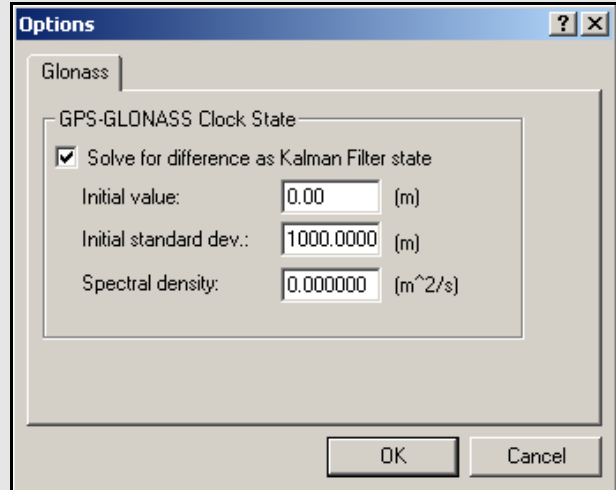
Initial value – If the initial value for the time difference filter state is known, it can be set here. If it is not known but you want to compute it, you should enter zero and set the standard deviation of the state to 2 metres or more.

Initial standard dev – This value describes the confidence that you have in the initial value that you have set. The standard deviation should range from a few centimeters to a few meters.

Spectral density – The spectral density is noise added to the computation of the time difference state. Since both the GPS and GLONASS time systems are very stable, this number is always small, from about $0.001 \text{mm}^2/\text{s}$ to $0.01 \text{mm}^2/\text{s}$.

⊠ If the spectral density is set too high, then the time difference computed fluctuates erratically and never stabilize.

2.5.2 *Process Single Point*

This feature allows you to process the raw measurements without using a base station. Currently, this feature uses only the code measurements. Generally, accuracies are poorer than differential (even on longer baselines), but this feature can be useful if the nearest base is very distant. Quality control and clock issues can also be addressed with this feature.

The *GPB file name* field at the top of the window shows the GPB file that will be processed. Load the file of interest into the project as the remote. The *Ephemeris* field shows whether a precise ephemeris or clock file is present and *Iono correction* shows the applied method of ionospheric correction.

Accuracies are improved with the use of precise ephemerides, IONEX files and satellite clock files. These can be defined via the *Change Precise Files* button. Downloading these files is very easy with the *Download Service Data* program, available under *Tools | Download Service Data*. By selecting the *Options* tab and enabling the *Precise Ephemeris File,* the most accurate precise ephemeris file is downloaded from the IGS FTP site. You can also get IONEX and satellite clock files here.

General Options
The following options are available:

> *Process Mode*
> Defines the type of data used for processing. The options are listed in the shaded box.
>
> *Elev. Mask*
> Satellites below this elevation value are rejected.
>
> *Interval*
> Only process epochs that fall on this data interval. Use a value of zero to process all epochs.
>
> *Accumulate static periods*
> Enable this option to compute a weighted average for static periods, improving accuracies. Otherwise, static data is treated as kinematic.

The different types of process mode

Automatic – Chooses between single or dual frequency depending on whether the GPB file has L1 only or L1/L2 measurements.

Single Freq. – Forces C/A-only processing. Currently, the only means of removing ionospheric errors in single frequency is to use the broadcast (ICD-200) ionospheric model (Alpha and Beta values in GpsIon record within EPP file).

Dual Freq. - Enables dual frequency ionospheric correction, which is computed from both the C/A or P1 and P2 signals. If L1 and L2 carrier are available, this correction is further refined.

Advanced
The following options are available:

> *Use broadcast iono model for SF*
> Uses the ICD-200 broadcast or IONEX
> ionospheric mode for single frequency
> correction (if it is available in the EPP file).

> *Use P1 instead of C/A*
> For some receivers, interchannel biases
> between C/A and P2 result in a less accurate
> ionospheric correction being computed. If
> these receivers also have a P1 signal, which
> can be checked via the *GPB Viewer*, then P1
> can be used to compute a more accurate
> correction and in the single point least-
> squares position computation.

> *Output epochs with high residuals*
> The single point processor normally rejects
> epochs with high residuals that cannot be
> fixed. Enable this option to always output
> solution data regardless of quality.

> *Correct time with solved clock shift*
> The single point processor uses the raw
> receiver measurement time stored in the GPB
> format but if the corrected time in the GPB
> file is deemed more accurate, then enabling
> this setting causes the use of the computed
> clock correction to compute a new corrected
> time not to be used. This can be helpful for
> processing some data sets with times
> problems, especially in the old GPB format.

Standard Deviation
The following settings are available:

C/A code standard deviation
This is the estimated accuracy of the C/A code measurement. An accurate number results in better estimates, but does not affect the trajectory.

C/A code rejection tolerance
This setting defines the tolerance above which measurements are detected as erroneous. The software attempts to fix these errors by identifying and removing erroneous satellite measurements. If this is unsuccessful, the entire epoch is rejected.

Account for atmos. and orbital errors
Adjust final accuracy estimate using nominal orbit, tropospheric, ionospheric and receiver clock errors. This does not affect the trajectory.

2.5.3   Combine Solutions

Forward and Reverse

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) and reverse (REV) 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).
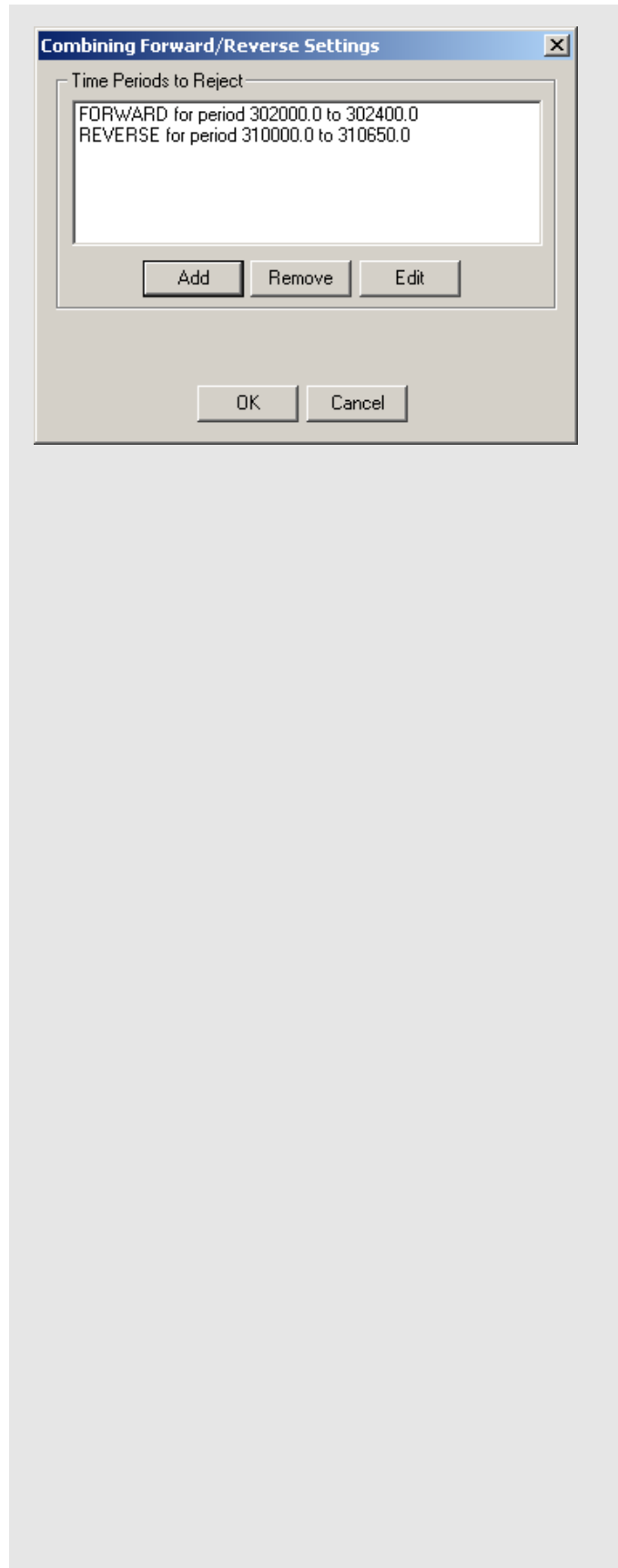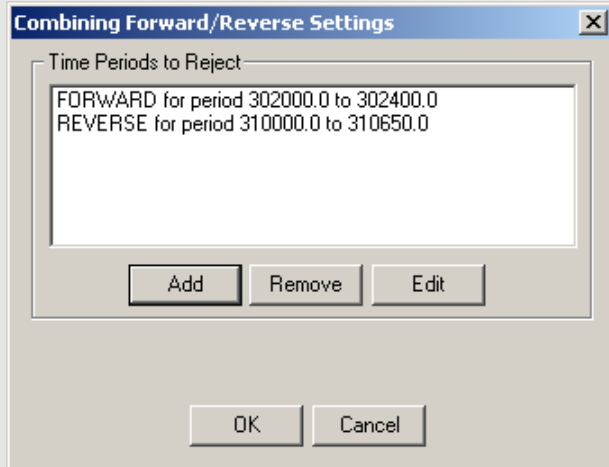
How to incorporate combined solutions

1. Export the combined solution for each project using *Output | Write Combined (.CMB) File*.

2. In the current GrafNav project, use *Process | Combine Solution | Combine Any Two Solutions*.

3. Select the CMB files when prompted.

Any Two Solutions

This feature is similar to the *Forward and reverse* option, except that any two solutions can be combined. This option combines created solution files using different processing settings. This is helpful for examining the effect of changing the processing options. It also allows you to compare a fixed solution to a float solution to detect a bad ambiguity resolution.

Incorporating any 2 combined solutions is also possible. While GrafNav Batch is preferable, you might want to use this feature. To do this, follow the steps in the shaded box.

⊠ 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.

Combine Settings

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.

2.5.4 Load Batch Processor

This options loads and runs GrafNav Batch. See *Chapter 4* on *Page 177* for information on how to use GrafNav Batch.

2.5.5 Stop Auto Run

If you are running the software from the command line (auto-run mode), this selection stops the auto-run. Depending on the quit mode selected, pressing *Stop* in the processing window may return control to the calling application. This selection just breaks out of auto-run. Run GrafNav with the *–h* command for a help screen.

2.5.6 Load Forward, Reverse, or Single Point Solution

This feature allows for the loading of GPS solution files. Choosing *Load Forward Solution* or *Load Reverse Solution* automatically loads the solutions most recently processed in the chosen direction. *Load Single Point Solution* is only be available if the single point processor has been engaged. See *Section 2.5.2* on *Page 86* for more information on single point processing.

2.5.7 Load Any Solution

This option allows you to load any solution file. This is useful if previously processed solution files have been saved to disk.

2.5.8 Import Solutions and Setting

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
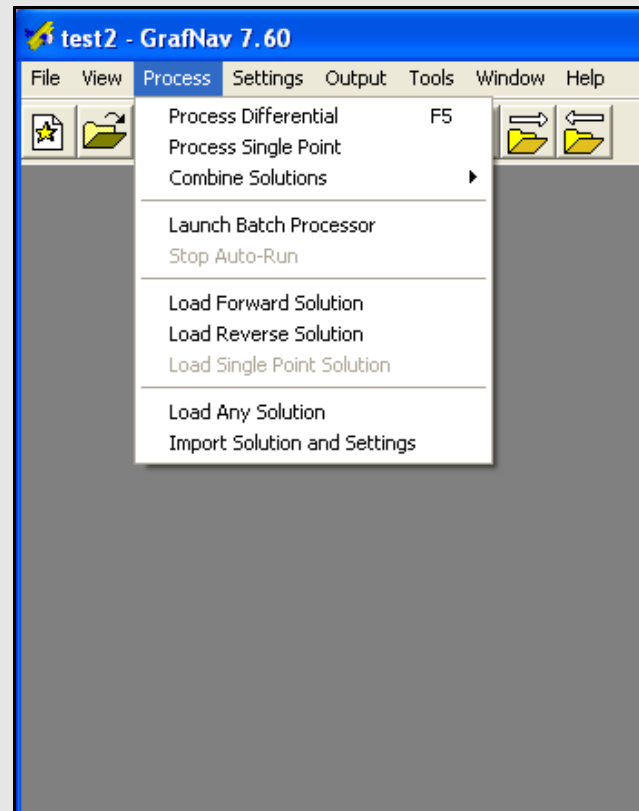
2.6   Settings Menu
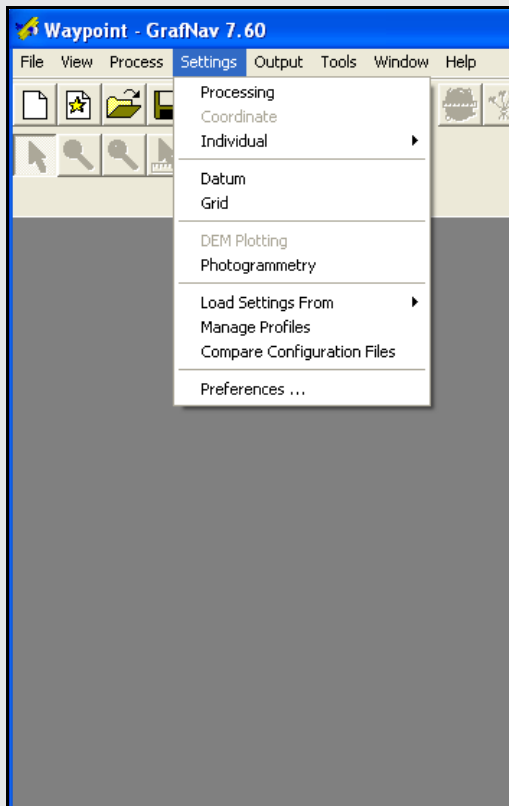
2.6.1   *Processing*

This option gives access to most of the differential processing settings without allowing you to begin processing. Data processing can only be engaged via the *Process* button under *Process | Process Differential* or *Process | Process Single Point*. See *Section 2.5.1* on *Page 61* for a complete description of all the settings available here.

2.6.2   Coordinate

Master Station Settings

This option lets you customize the master station coordinates. See *Section 2.3.6* on *Page 36* 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 37* for additional information.

Remote Initialization

In some cases, you may know the remote's coordinates at a certain epoch or location from some other means, such as a previous survey or from another base station. It can be very helpful to seed, or even "fix", the current trajectory using this known position.

One way to fix a position is to right-click on an object, for example an epoch, feature or static session, in the *Map Window* to bring up the *Object Menu*. With this menu, you can "fix" the remote position at any number of times or locations throughout the survey. This option works best with shorter baseline lengths and is intended primarily for surveyors. See *Section 2.4.7* on *Page 57* for more information on the *Objects Menu*.

Another way to "fix" a position is to use the *Manual Remote Initialization* window. With it, baselines can be "fixed" on long baselines combined with dual frequency receivers. The options in this window includes the following:

When?
This options allows you to select or enter the times where the initialization takes place. This is a point of known latitude, longitude and height. It could be a station name (as it appears on the GrafNav screen) or a specific time.

For kinematic trajectories, selection of a time is preferable to the start/end method because the software may not start processing on the very first epoch. Be sure to set a small enough time window. For stations or static sessions, ensure that the antenna height is correct.

Method for fixing position **settings**

Automatic – Selects one of the modes based upon baseline length, base/remote height difference and estimated accuracy of the current epoch.

Ambiguity Fix – Tends be the most robust method and does the best job of keeping the position selected, including any errors that might be present. Airborne applications should only use this method.

Snap to Integer – Practical for short baseline applications, like surveying. It selects the nearest integer position, which means that input position must be accurate to at least ½ cycle (10 cm for L1 and 40 cm for L1L2).

Position Fix – This works when the position's accuracy is suspect. Speeding up convergence does not always show that much improvement over not using a seed at all.

General Options
The following settings are available:

> *Direction*
> Defines processing direction in which the fix is to take place.

> *Method for fixing position*
> The different settings for this option are in the shaded box.

Advanced Options
The following settings are available:

> *Valid time window*
> In the *When?* section, select at which point the fix should be applied. This setting defines how close an epoch should be before it is used. For kinematic trajectories, this value should be half of the processing data rate.
>
> In instances where there is a data gap, use this setting to define how close a time can be and still perform a fix.

> *Antenna height*
> Height of the antenna above the marker position entered below.

> *Standard deviation*
> Estimated accuracy of the position supplied. This is important for the *Position Fix* or the *Automatic* modes because they use it to decide which method of fix to use.

Position
This is the marker position that is used for all of the modes of position fix. This height plus the antenna height is the location to be used for the antenna position. See *Section 2.3.6* on *Page 36* for more details.

2.6.3   Individual

This option accesses the tabs in the process menu. Please see *Page 61*.

2.6.4   Datum

These settings can also be accessing by the *More Datum Options…* button under *Settings | Individual | General* or through the *Datum Manager*, which has additional coordinate transformation capabilities. *Section 9.8* on *Page 277* offers more information on datums.

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. See *Section 9.8* on *Page 277* for more information.

> *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.
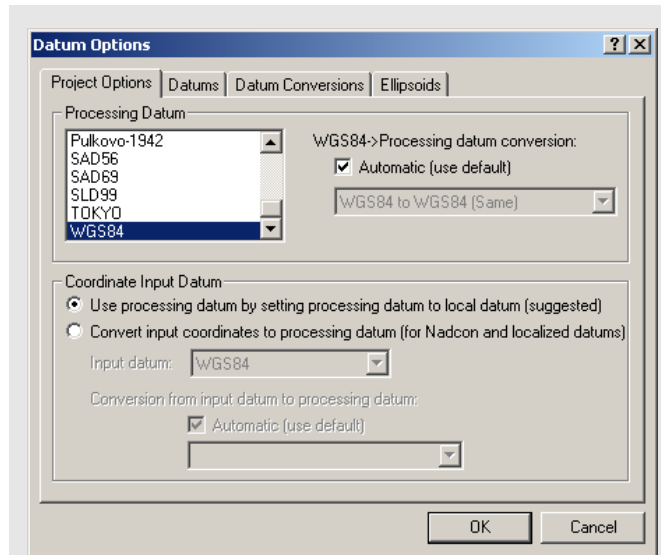
Reasons to use coordinate input datum

- 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. See *Section 9.8.5* on *Page 280* for more information.

- 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. See *Section 9.8* on *Page 277* for more information.
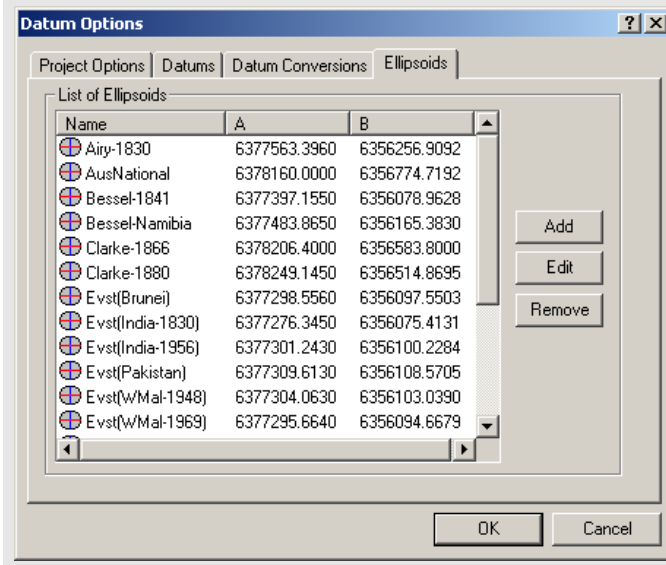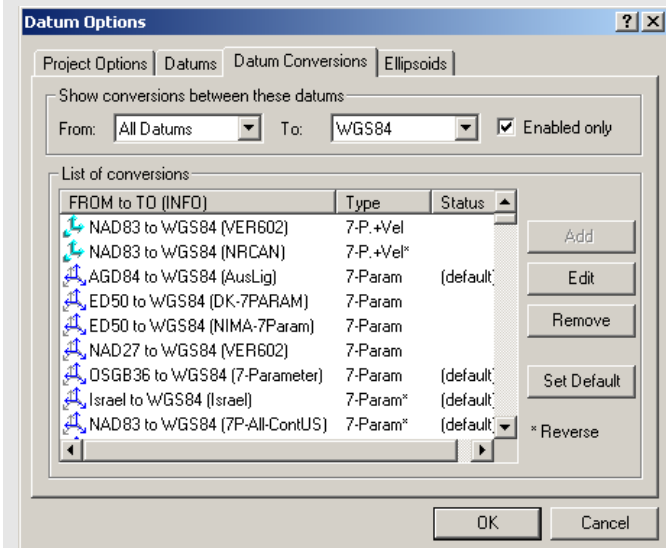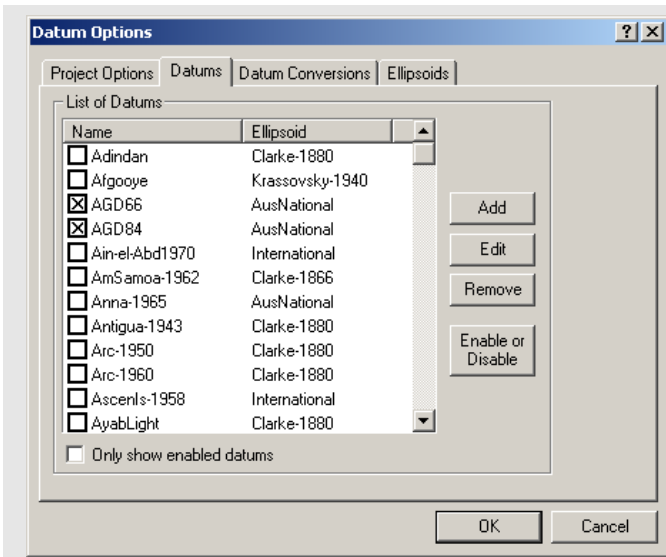
Datums

This page 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. See *Section 9.8* on *Page 277* for more information.

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. *Section 9.8* on *Page 277* for more information.

Grid / Map Projections

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 2.7.9* on *Page 122* for more details.

- DXF output uses these grid settings. See *Section 2.7.10* on *Page 123* for more information.

- *Export Wizard* can use a defined grid for coordinate output. See *Section 2.7.4* on *Page 107* 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 129* for more information.

2.6.5   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.
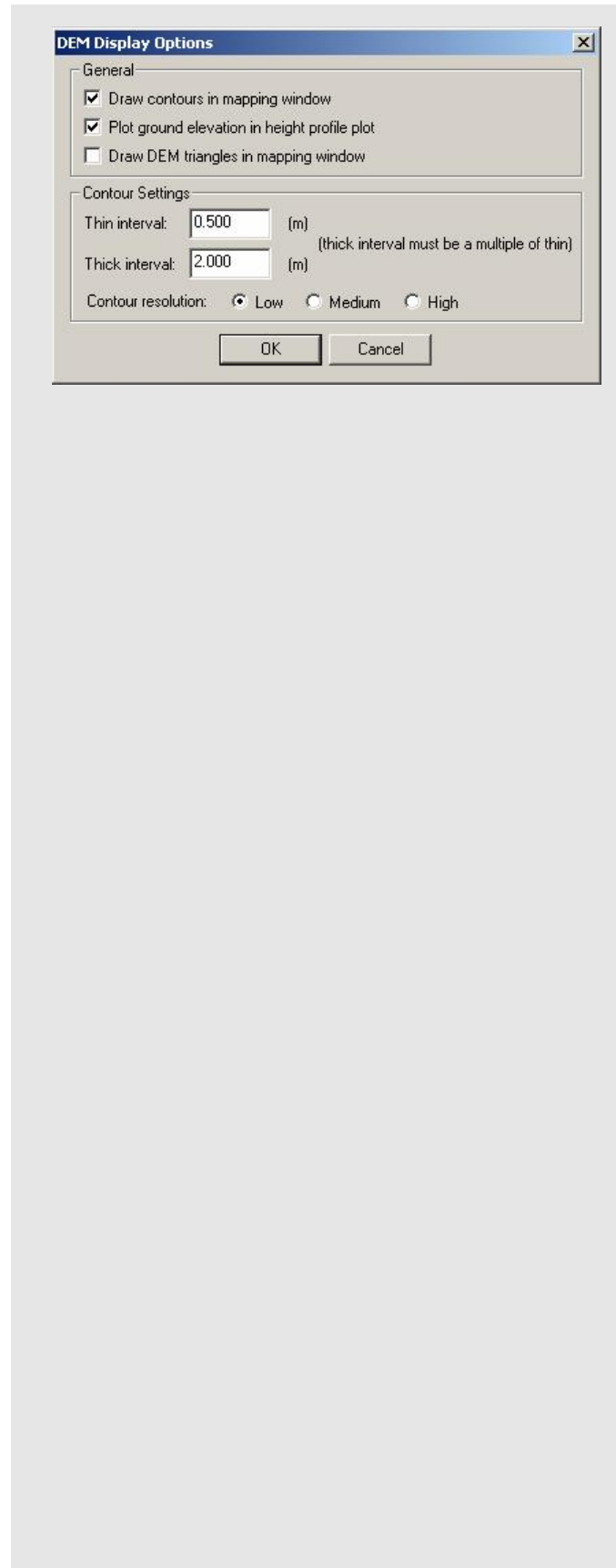
The methods of interpolation supported by GrafNav

Linear
This interpolation model is the simpler of the two and gives no RMS statistics. It fits a line between the two nearest epochs and places the camera mark on it. It is simple but effective.

Polynomial
This method uses a 2nd order polynomial and gives the best accuracies, but it can sometimes induce larger errors if epochs are missed or dynamics are very high. This can be detected by viewing the RMS value computed for each camera pulse. To do this follow these steps:

1. Click on the station or write the coordinates.

2. Select *Features* and use *no geoid correction.*

In such cases, the linear interpolation model deliver better results. You can also change the size of the window that the polynomial fits into. Ideally, this number should be kept at 4, but it can be increased for more averaging.

⊠ Only use this when very high data rates are available.

2.6.6 *Photogrammetry*

These options are useful to GrafNav for GPS-assisted aero-triangulation. This includes control over how interpolation is implemented and a special processing mode useful in conjunction with bundle adjustment drift parameters.

Camera Pulse Interpolation
These options determine how the camera marks are interpolated. See *Section 2.3.10* on *Page 41* for help loading camera marks. Since each photograph is seldom taken on the even epoch, it must be interpolated to compute a proper position. Two methods of interpolation supported by GrafNav are listed in the shaded box.

Photogrammetric Strip Processing
This option is no longer supported by the software.

Apply 3-D Offset
Lets you 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. See *Section 2.7.4* on *Page 107* for more information.

Load Settings From Profiles
This feature loads configuration settings from one of the following:

• **Factory Defaults**: Built-in default settings (cannot be altered).

• **GrafNav Defaults**: Start-up settings that can be altered. Otherwise, same as **Factory Defaults**.

• **Pre-loaded Profiles** (e.g. **Airborne**, **Low Cost**, **Tree Cover**, etc.): These are settings that come pre-loaded with the software.

• **User-created Profiles**: These are profiles that have been created by you.

⊠ When using a profile, all processing settings can potentially be edited, except those found in the *Process* tab. See *Page 61* for help with these settings.

2.6.7   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*
> 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.

2.6.8 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.
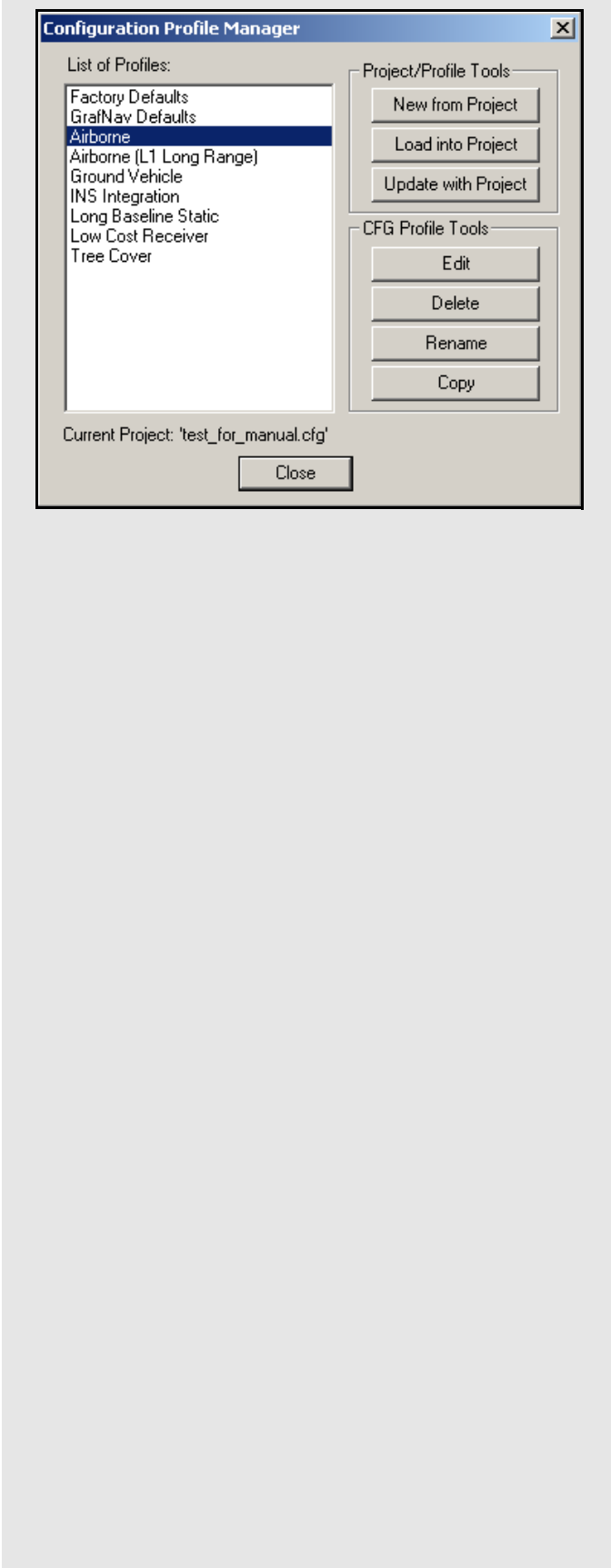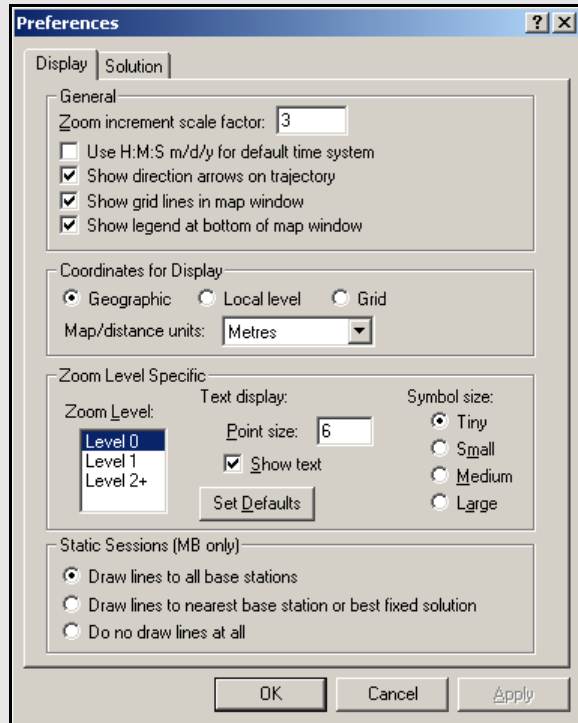
Geographic

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 most useful 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 2.6.4* on *Page 95* 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 125* for information.

2.6.9   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.
>
> ### Use H:M:S m/d/y for default time system
> Encourages GrafNav to display time in the described format instead of seconds of the GPS week.
>
> ### 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.

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.
>
> ***Combine forward/reverse after successful processing***
> Automatically loads the combined solution into the project after processing forward or reverse direction. A combined solution is always loaded after processing both directions.
>
> ***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.

> ***Process forward/reverse directions simultaneously***
> This feature cuts your processing time in half, 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.
>
> ***Prompt user when finished processing***
> 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.
>
> ***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.
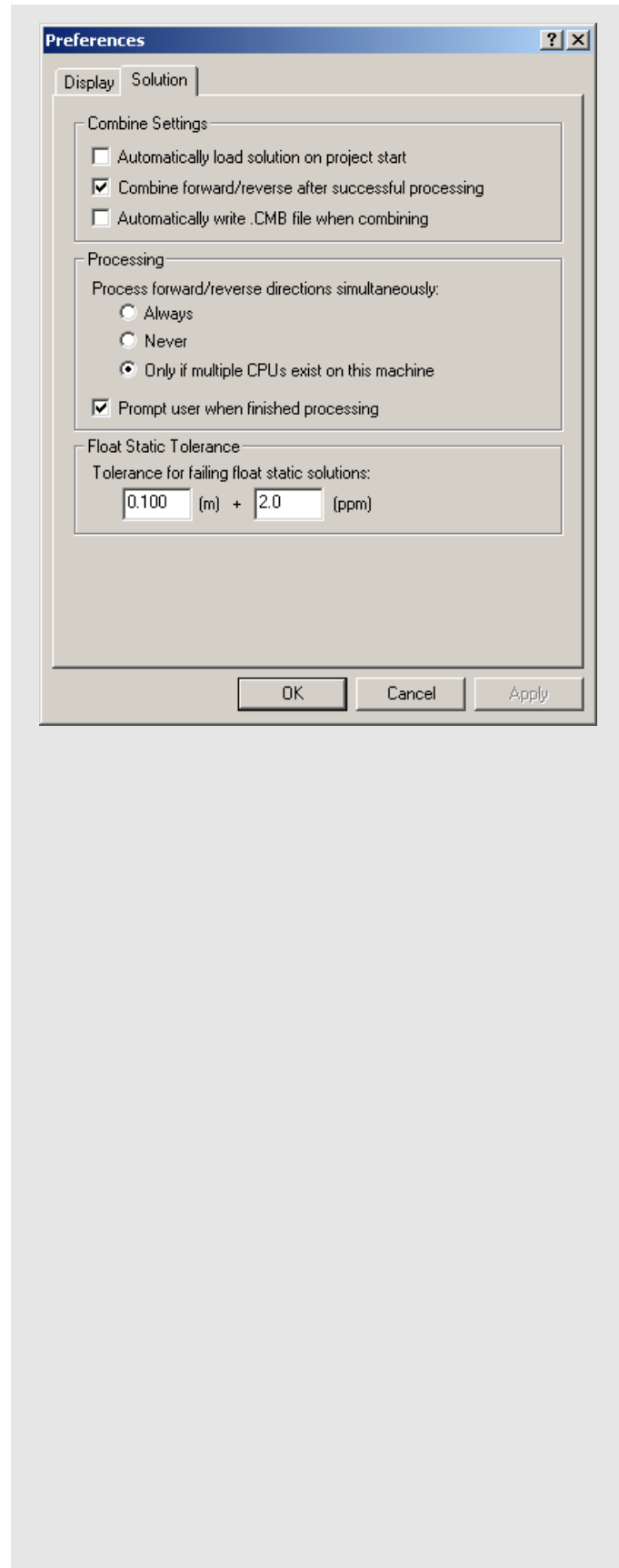
2.7 Output Menu

Property setting options

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

Auto-scale (X-Axis)
Shows the entire time range of the data.

Set Start Plot Time
Makes the current time the X-axis minimum.

Set End Plot Time
Makes the current time the X-axis maximum.

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

Auto-scale (Y-Axis)
Shows the entire value range of the data.

Set Maximum Plot Value
Makes the current value the Y-axis maximum

Copy
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.

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 KAR at Time
Engages KAR at the selected time.

2.7.1 Plot GPS Data

This feature is very useful for analyzing GPS 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 features are loaded, then there are vertical red bars along the top of the plot. Click on the feature to show solution status information.

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. Property setting options are in the shaded box.

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-P 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 *Page 73* 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 PRCNs.

Table 4: Common Plots con't.

Plot	Description
Separation	
Combined Separation	Requires forward and reverse solutions to be combined and displays the difference between the two trajectories. For multi-baseline combination in GrafNav Batch, this is the maximum minus minimum difference between baselines for each epoch and the number will always be positive.
Combined Number of Solutions	Shows the number of baselines that are used to form a combined baseline. This is useful for multi-base processing.
Combined RMS	This plot applies to multi-base processing. Instead of showing maximum minus minimum like the **Combined Separation** plot does, it shows the weighted RMS of the baseline. Thus, if one baseline does not fit well, but it is given a very low weighting, it will not affect this plot as much. It is a good idea to view both because this plot can be optimistic.
Quality Control	
DOP – 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).
DOP-DD_DOP	Indicates satellite geometry relating to position. Small values indicate better geometry. This value is the double difference DOP and is approximately $PDOP^2$, although, 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.
Static/Kinematic + Coverage	This plot shows if and when GPB files are static and kinematic. It can also 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.
Ambiguity drift	This value indicates solution stability for a float solution. The ambiguities should be driftless and have a drift of 0 cycles/sec. Normally, this number will be 0-0.03 cycles for very stable solutions, and 0.03-0.05 for quality 2 stability, and so on for Q3 and up. Most users rely on the quality number instead of this plot. The quality number is partially derived from this parameter.

Table 4:Common Plots con't.

Plot	Description
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.

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	See description of *DD_DOP* (above) for information.
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.
Ambiguity Drift	Plots the individual ambiguity drift for each baseline.

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 *Page 103* 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.
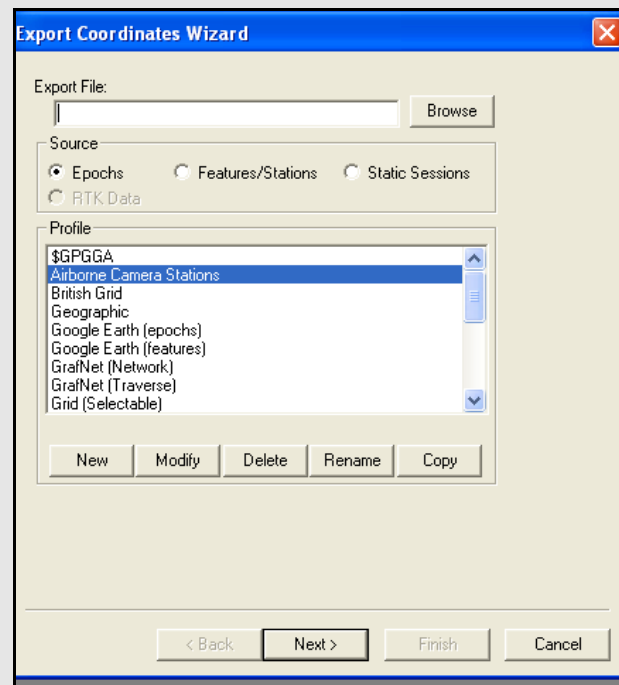
How to create a customized output file

1. 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* to add to bottom of list or *Insert* to add the variable above highlighted variable in list. See *Table 41* on *Page 285* for a list of variables available for output.

3. 3.Once you are finished adding all the necessary components of the profile, click *OK* to save the profile.
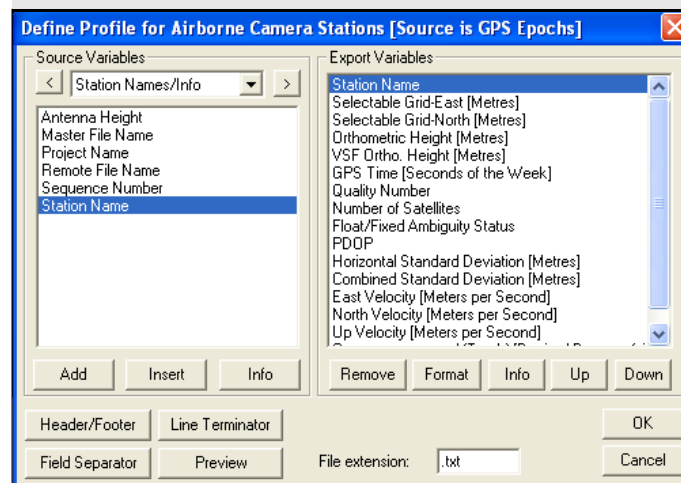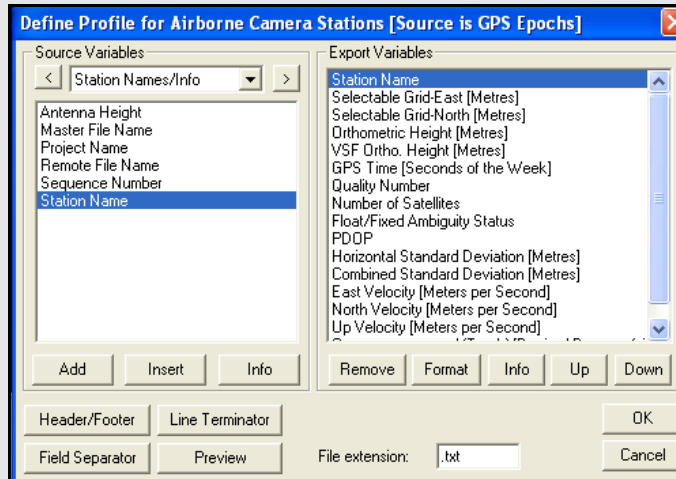
Header/Foote*r*
The following settings are available for the header:

> **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 2.4.4* on *Page 54* 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 a 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 (i.e. $--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 41* on *Page 285* describes the many variables that you can include your output profiles. Not all variables are available for use with each source.
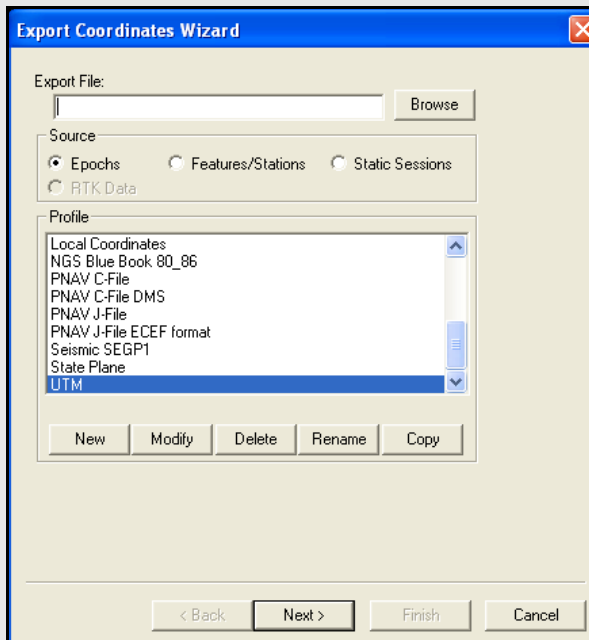
How to create an output file

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** to view the file before saving it to the file path name specified.

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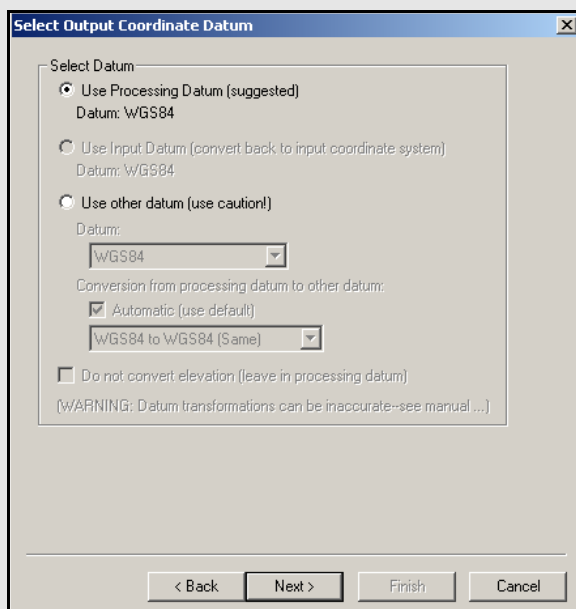
Creating an Output File

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 in *Section 2.7.4, Export Wizard*.

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 125*.

> ***Azimuth Correction***
> Allows you to enter a correction to be applied
> to the azimuth. In GrafMov, this applies
> when the two antennae 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 for UTC time when GPS time converts to UTC time. GPS uses a linear time scale that never misses or counts a second twice, as opposed to UTC time, which is not linear. UTC time holds a fixed relationship to the stars and many global effects that can change this relationship slightly. You can make these corrections as often as every six months but they are only necessary every twelve or eighteen months. To determine what the UTC correction should be at the time the data was collected, please consult the following website:

http://tycho.usno.navy.mil/leapsec.html

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.

⊠ The new WinCE data logger also creates these files if the appropriate station selection is used.

⊠ 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.
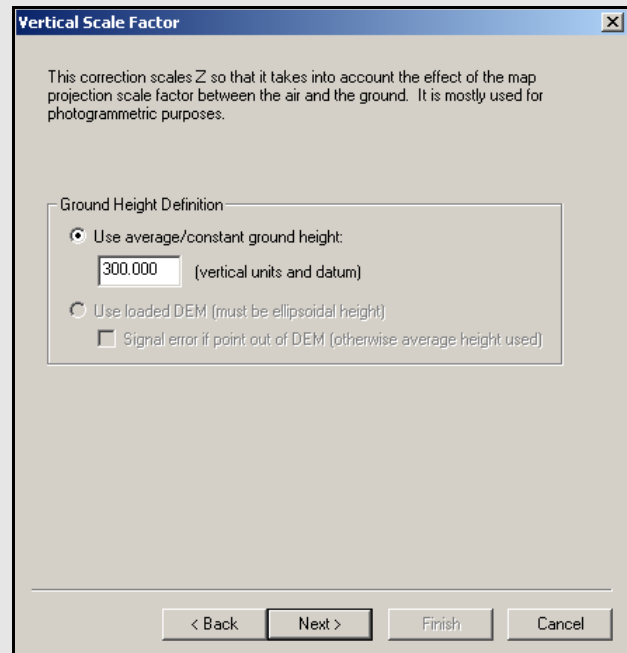
Table 6: Transformation Parameters

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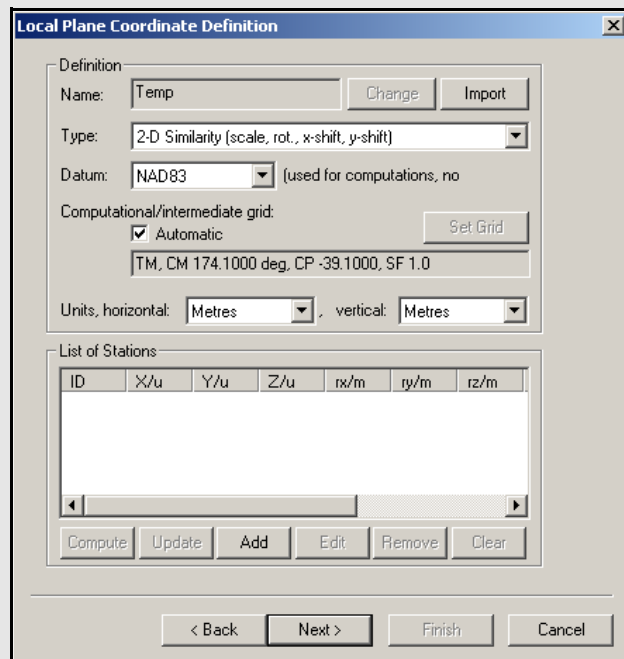
Local Plane Coordinates Definition Window
This feature reproduces localized coordinate systems. It rotates and scales processed coordinates for features or epochs into a local coordinate frame.

⊠   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.
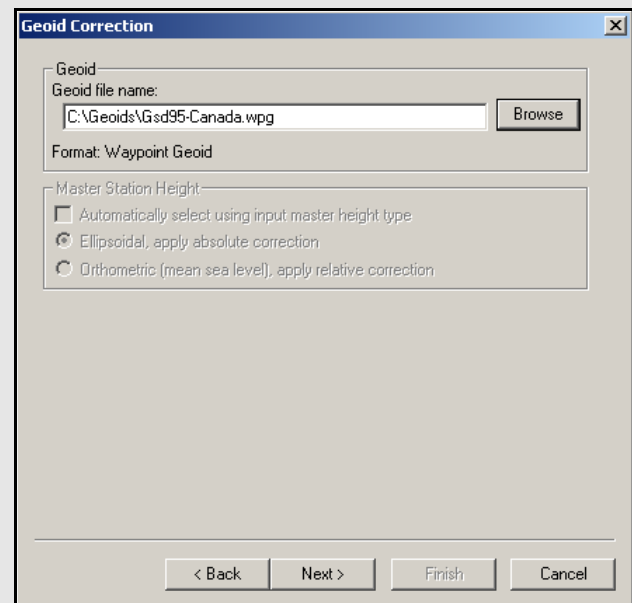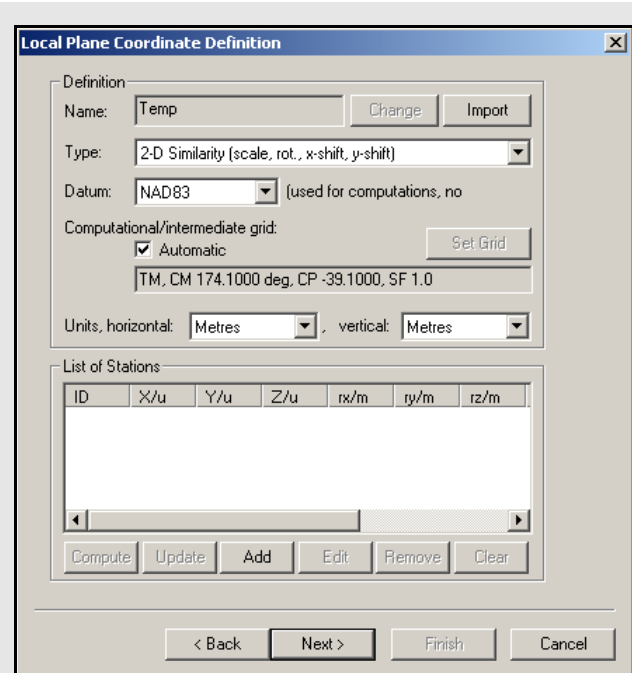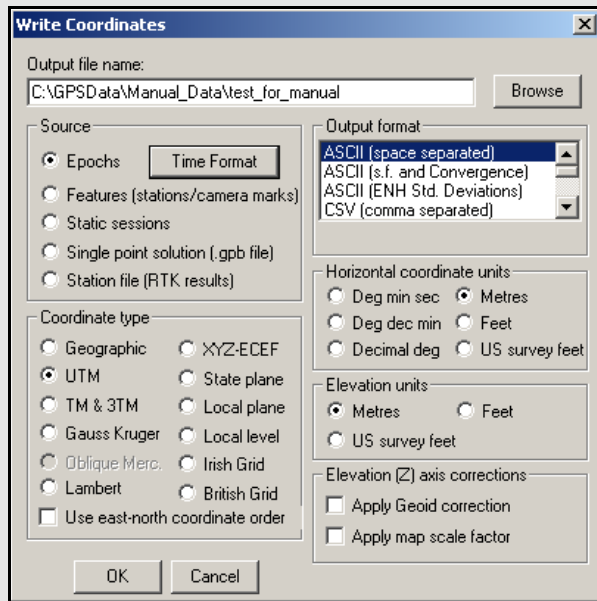
2.7.5 *Write Coordinates*

✉ *Write Coordinates* is the old way of exporting coordinates and is retained only for backward compatibility. You are urged to use the *Export Wizard*, as it has more grid, datum and transformation options and is much more user-friendly.

Output File Name
Type in a name for the file that stores the output.

✉ The program automatically assigns the extension.

Source
The following options are available:

Epochs
Outputs information for every epoch gathered by the GPS receiver.

Features
Only outputs information for stations or features, as marked in the STA file.

Static sessions
Outputs the final solution for each individual static occupation separated by kinematic occupation.

Single point solution
No longer supported.

Station file (RTK results)
Time Format - define the format of the time output. The format used for the time and time zone correction output can be adjusted in the window. If you are looking for UTC time, you can enter the offset here.

Correct time for receiver clock bias - applies the receiver clock bias to the GPS time. This corrects the time to the actual time that the receiver made the measurement. This correction can be as high as 1 millisecond and can be very significant in applications that require time synchronization between various instruments and devices.

Missing Epochs - linearly interpolates positions for missing epochs based on existing epochs.

Coordinate Type
Allows you to choose which grid to use for coordinate output. Depending on the selection made, you might be prompted for supplementary information. See *Section 2.8.7* on *Page 129* for details.

Output Format
The following formats are available:

> *ASCII*
> Data will be delimited by spaces. Scale factor and convergence information pertaining to the projection selected is available for output in this format. The standard deviations for the ENH positions can also be outputted, as well as the position with the distant-dependent component.

> *CSV (for EXCEL)*
> Data delimited by commas.

> *Waypoint OutRec (.CMB)*
> Prints a standard combined solution file. Also available via the *Output* menu.

> *INS/GPS Integrator*
> Produces a file with all data that would be useful in the integration of GPS with INS.

> *Itres Research data format*
> *GeoRearch's MSS*
> Data specially configured to be read by GEOLINK^{TM}.

> *Epoch Statistics (.dat file)*
> The epoch statistics generates a comma separated DAT file, containing the following information:

> - Time
> - Quality Factor
> - DD_DOP
> - L1 Phase RMS
> - CA Code RMS
> - Ambiguity Drift
> - Standard Deviation
> - PPM Trace
> - Number of Satellites

> *Local Level Vector*
> Outputs local level positions and velocities, standard deviation and quality factor.
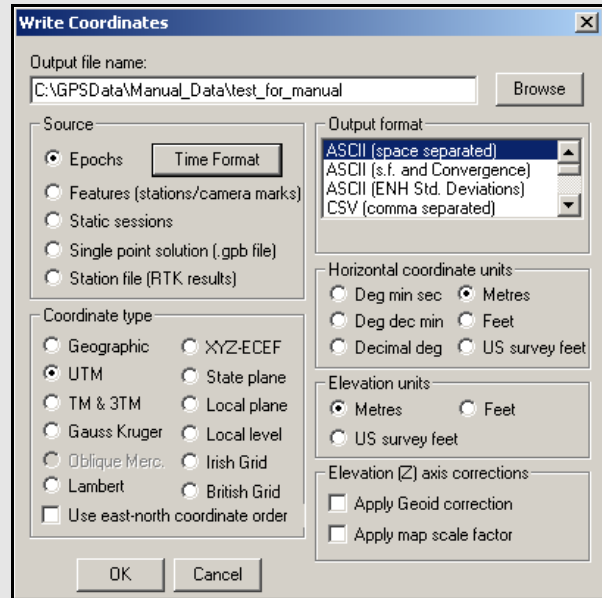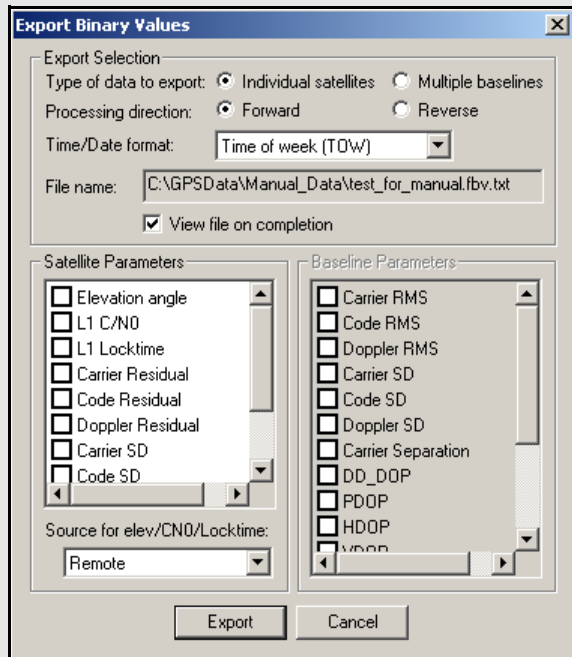
Export Selection options

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 107* 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 107* for a description of the available individual export values.

Horizontal Coordinate Unit
The units available for horizontal output will be dependent on the selection made under *Coordinate Type*.

Elevation Coordinate Units
The units available for elevation output, ellipsoidal or orthometric, are listed here.

Elevation Axis Corrections
See *Section 2.7.5* on *Page 118* for information on the two options available here.

2.7.6 *View Coordinates*

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

2.7.7 *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 *Page 66* 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.

2.7.8 *Write Combined (.CMB) File*

This feature writes the combined trajectory to disk in a format similar to that described in *Section 7.4.3* on *Page 216*. This CMB 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.
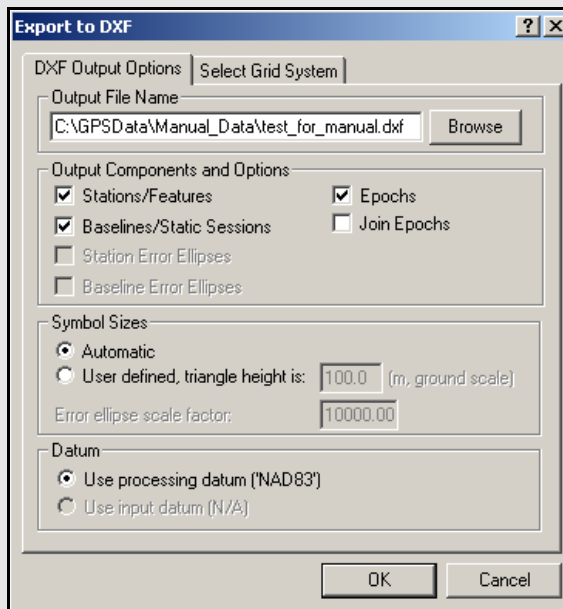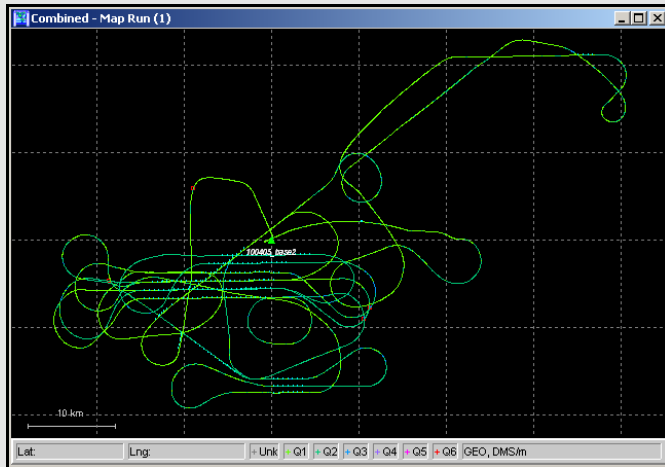
Table 7: Quality Number Description

Quality	Colour	Description	Accuracy
1	Green	Fixed integer	
2	Cyan	Converged float or noisy fixed integer	
3	Blue	Converging float	
4	Purple	Converging float	
5	Magenta	DGPS	
6	Red		
Unprocessed	Grey		

2.7.9   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. Please see *Section 2.6.9* on *Page 100* 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 57* for additional information.

See *Section 2.8* on *Page 125* for additional interactive mapping tools.

2.7.10 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 122* 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.

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 KAR solution. descriptions of the messages that are displayed are in *Table 10*.
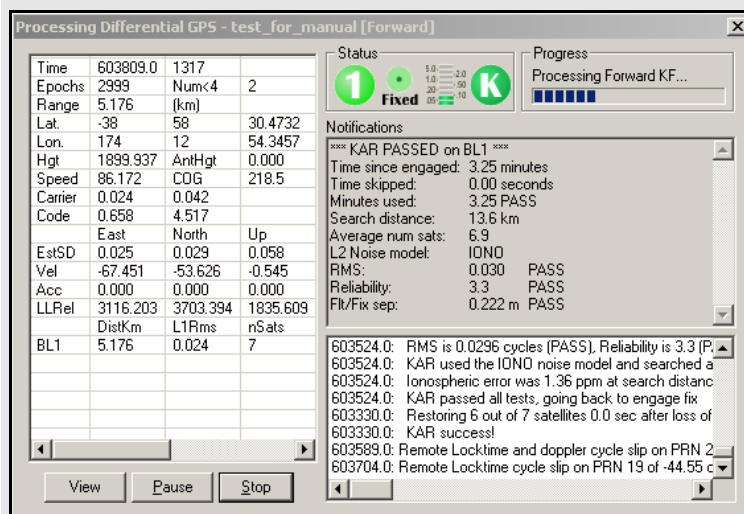
Table 8: Notifications Window Messages

Message	Description
Time since engage	Number of seconds or minutes since KAR was engaged.
Time skipped	Time that KAR was unable to restore. Once KAR has a successful solution, it tries to go backwards as far as possible. This is the difference between the restore time and the original cycle slip time.
Minutes used	Time that KAR used for a solution. It is not the time since engagement.
Search distance	This is the distance when the ambiguity search was performed. This is not the distance when KAR was restored.
Avgerage num sats	Average number of satellites used to compute KAR statistics. It is always be greater than or equal to 5.
L2 Noise model	Shows the model that KAR used for L2 during processing. See *Page 80* for additional information.
RMS	This is the RMS fit of the KAR 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.
Flt/Fix separation	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 data.
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.

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.

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.
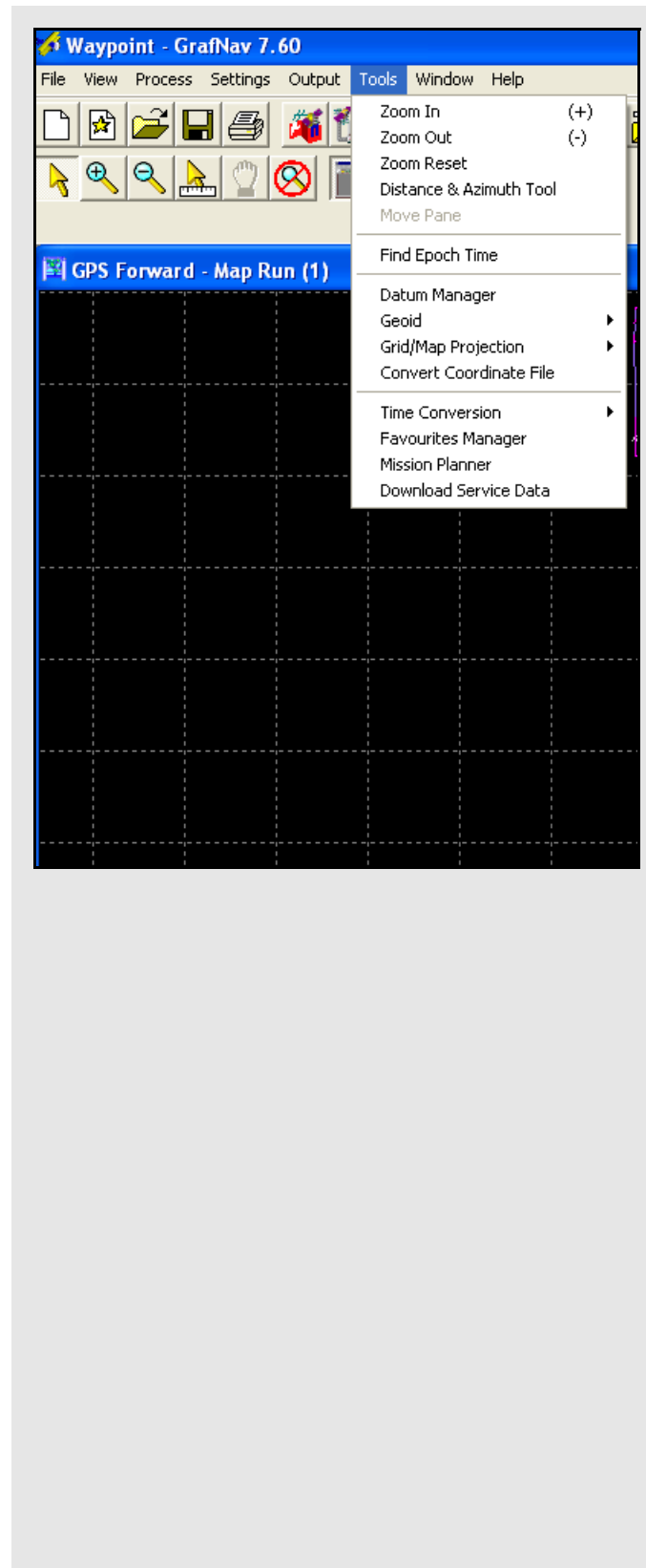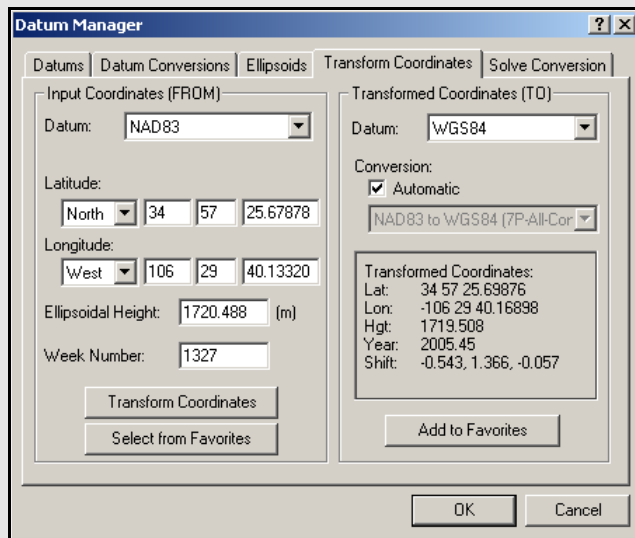
How to solve for a transformation or datum conversion

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 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

Please see *Section 2.6.4* on *Page 95* for information regarding the first three tabs available here. 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 their *Favourites Manager* to be converted and save any transformed point to your *Favourites*.

⊠ Specifying the week number of the coordinate will only have an effect on the final result if the selected conversion is a 10-parameter conversion.

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.

⊠ The 7-parameter 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.

⊠ In some cases, 7-parameter transformations are necessary due to a slope in the local datum. This is considered a very localized datum. See *Section 9.8* on *Page 277* for more information on datums.

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 the processing report:

Parameters
Reflects the input options used for the computation.

Raw Differences
These are he 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 (con't)

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 2.6.4* on *Page 95* 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.

Compute Geoid Height (Undulation)

Geoid File (WPG Format Only)

C:\Geoids\wpg\GPS-H-Canada.wpg   [Browse]

Geographic Position

Latitude: North ▼ [51] [06] [00.0000]
Longitude: West ▼ [114] [00] [00.0000]

Geoid height is -16.498 m [Ht(ell) = Ht(msl/ortho) + Ht(geoid)]

[Compute] [Geoid Info] [Close]
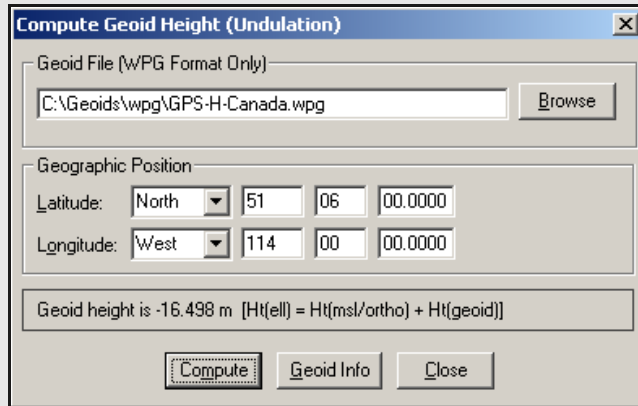
2.8.6   Geoid

Waypoint software supports the use of geoid files for orthometric heights. Waypoint's software supports geoids in three different formats including the U.S. National Geodetic Survey's GEO format, the Geodetic Survey of Canada's BIN/SLV format, and Waypoint's own WPG format.

When correcting ellipsoidal heights to produce orthometric heights, it is very important that the geoid and processing datums match. For example, if EGM-96 is used, then the base station coordinates should be in WGS84. This datum should also be used for processing. Use the same geoid model as used on the control sheets because it decreases differential.

Table 11 on *Page 141*provides a list of the geoids included on Waypoint's installation CD, the datum that each is based on, and websites for more information.

The geographic boundaries are displayed within the applied. 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. In the window that appears, there

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*.

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. Please see *Section 2.6.9* on *Page 100* and *Section 2.7.9* on *Page 122* 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.
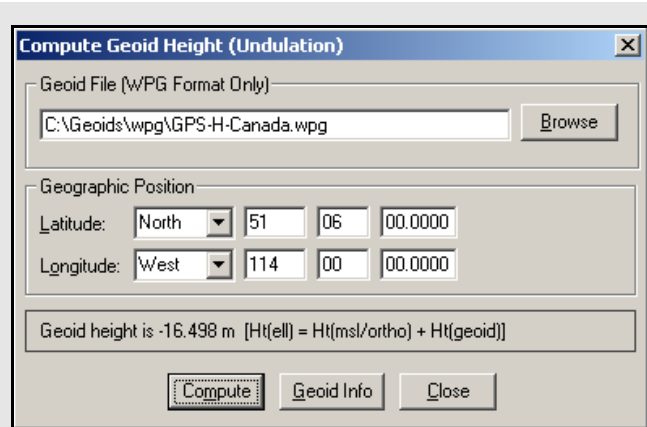
How to define a new grid

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.

⊠   *Chapter 9* on *Page 257* provides additional help concerning the definition of local grids.

How to convert a coordinated file

1. Identifying 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 in to HMS (hours, minutes, seconds) and vice versa.

2.8.10   Favourites Manager

Use this feature to avoid unnecessarily retyping coordinates that are used often. It can be accessed 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.

⊠   *Previous_Fav* also exists if you have *Favourites* from an earlier installation of the software.

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.

Follow the steps in the shaded box to manually copy your *Favourites* into the new version:
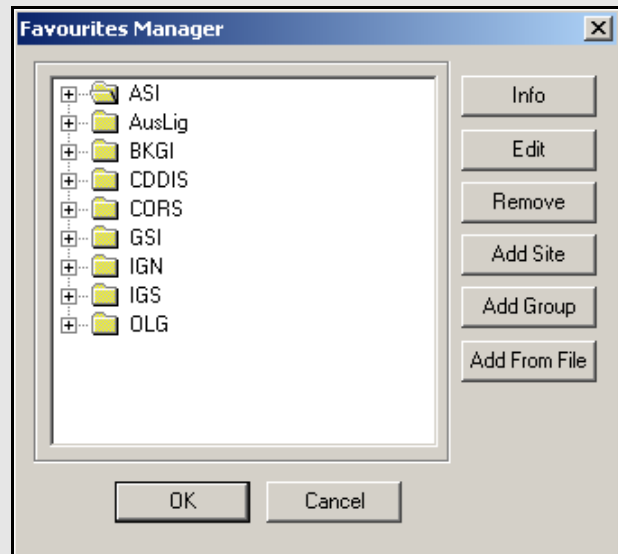
How to convert from 6.02 to 7.50

1. Copy the file *MASTER.FAV* from the 6.02 (or earlier) installation directory.

2. Paste it into the new 7.60 installation directory.

3. Load the *Favourites Manager* in version 7.60 via the *Tools* menu.

4. Upon loading the *Favourites Manager*, a message appears warning you that the old *Favourites* are being read in the WGS84 datum and height coordinates as ellipsoidal. If this is not the correct coordinate format, you must change them individually via the *Edit* button.

How to convert from 6.03 to 7.60

1. Copy the file *user.fvt* from the 6.03 installation directory.

2. Paste it into the new 7.60 installation directory.

3. Load the *Favourites Manager* in version 7.60.

4. Upon loading the *Favourites Manager*, the *Favourites* from version 6.03 loads into the new version.
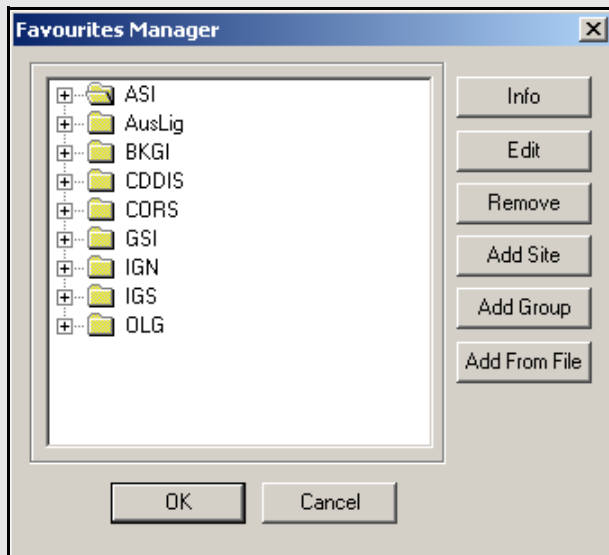
The following options are available in the *Favourites Manager* via the buttons on the right-hand side:

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
Allows for either the renaming of a group, or the editing of individual site information.

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
A list of coordinates can be directly read in from a file using this feature. Simply browse to the file, specify the input height type and format of the file.

Users who are adding stations via the **Add from File** feature, should take note of some potential issues. If some sites are being rejected, it could simply mean that the lines in the header were rejected. The program has no way of knowing what header information is, and so rejects lines that do not conform to the expected input format. However, if no points were accepted, this is an indication of a problem in the format of the input file.

Input coordinates must be signed to show hemisphere, and must not have N/S or E/W preceding or following the coordinates.

Station names should precede the latitude, longitude, and height in the input file. If the station name does not contain spaces, enable *Use first continuous word*. But if spaces are present in any of the station names, there are two alternate choices available. The first requires that a comma be placed after all stations names, and the file read in as CSV format. This option is recommended if the station names are of variable length. If the station names are all of a set length, the *Use first n columns* option is recommended. In this case, all the station names must be fixed at *n* characters or less and all other fields should be separated by a space.

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.

Examples of acceptable input file formats

Use first continuous word (no spaces):

POINTONE 34 26 09.98731 -114 26 09.98731 12.01

POINT2 36 12 56.12154 -114 12 56.12154 14.23

POINTTHREE 52 12 00.00000 -56 00 23.01213 1112.45

Comma separation (csv format)

POINT ONE,34,26,09.98731,-114,26,09.98731,12.01

POINT 2,36,12,56.12154,-114,12,56.12154,14.23

POINTTHREE,52,12,00.00000,-56,00,23.01213,1112.45

Use first n columns (where n=7 for this example):

POINT 1 34 26 09.98731 -114 26 09.98731 12.01

POINT 2 36 12 56.12154 -114 12 56.12154 14.23

POINT 3 52 12 00.00000 -56 00 23.01213 1112.45
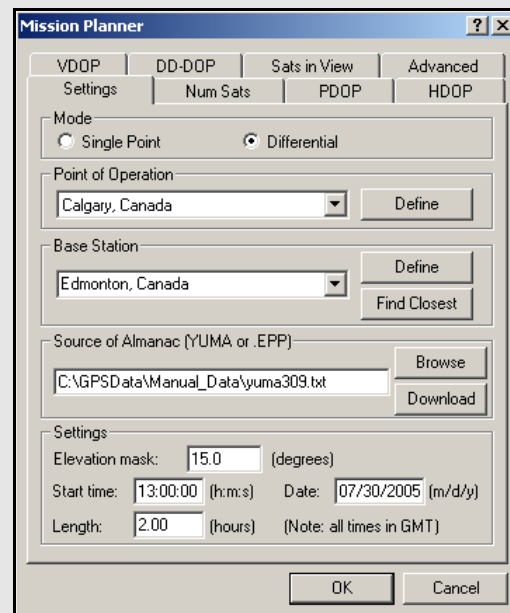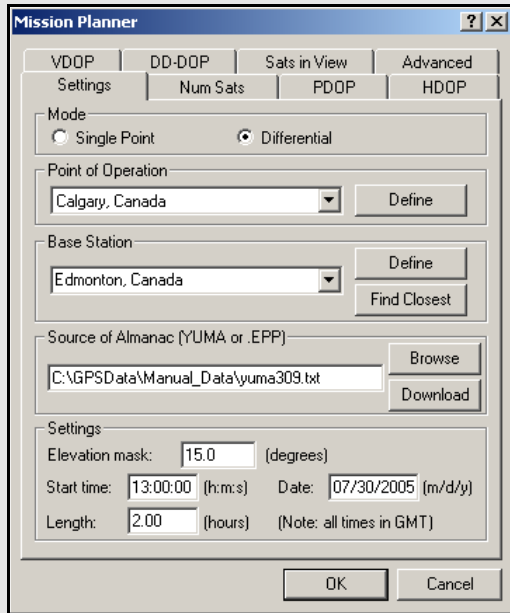
Base Station

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.

Source of Almanac

An almanac file is required in order for *Mission Planner* to access the orbital parameters of each satellite needed for its computations. Such information can be found in two locations. The first is via YUMA almanac files, which are readily available from the NAVCEN website (http://www.navcen.uscg.gov/ftp/GPS/almanacs/ yuma/). Direct access to this website can be attained by clicking on the *Download* button. Once it has been downloaded, it must be loaded by clicking the *Browse* button.

The second source of almanacs is those Waypoint ephemeris files (EPP) containing almanac records. This option only applies to users of NovAtel receivers, as they are the only type whose almanac records are supported by Waypoint.

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.

Length

Length of the mission and determines the time span that is covered by the displayed plots.

Num of 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.

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.
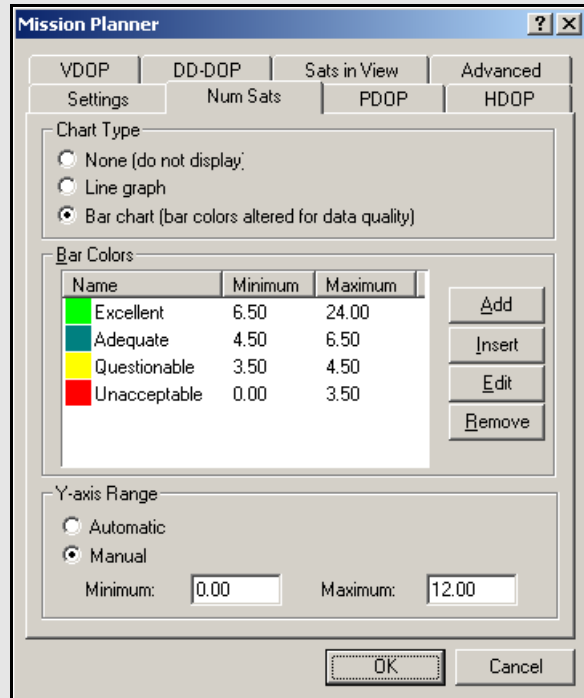
Num of Sats PDOP, HDOP, VDOP, and DD-DOP Options

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 *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.
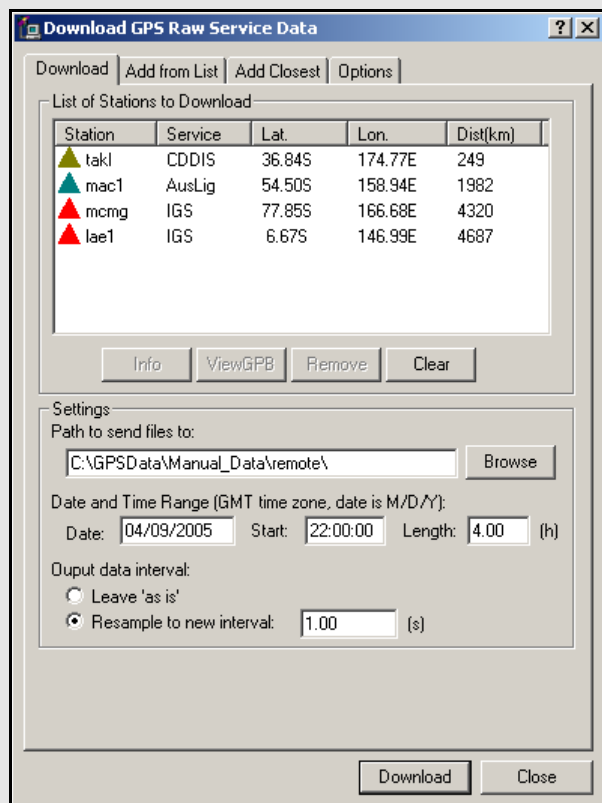
2.8.12   Download Service Data

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. The services currently included are CORS, IGS, AUSLIG, IGN, GSI, BKGI (EUREF), ASI, CDDIS, and OLG. 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 48 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 8.5.2* on *Page 222* 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.
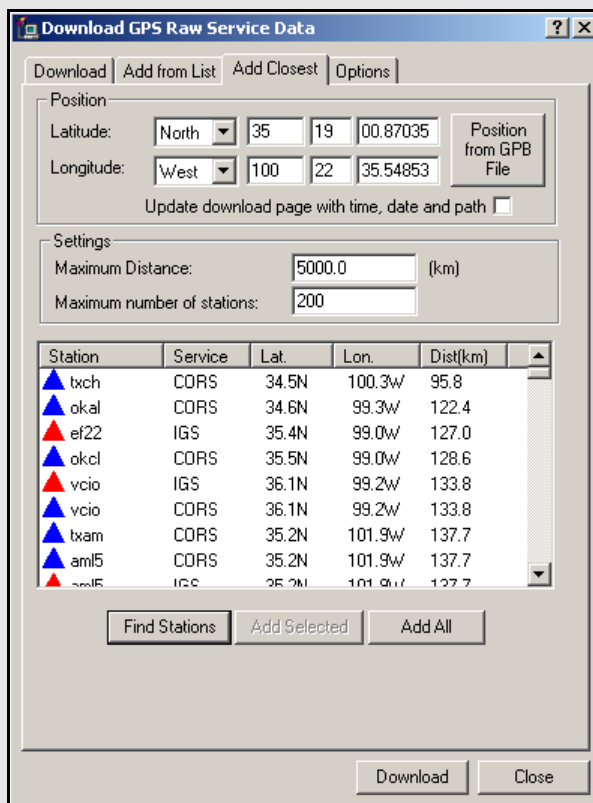
Two settings that constrain the station search include the following:

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.
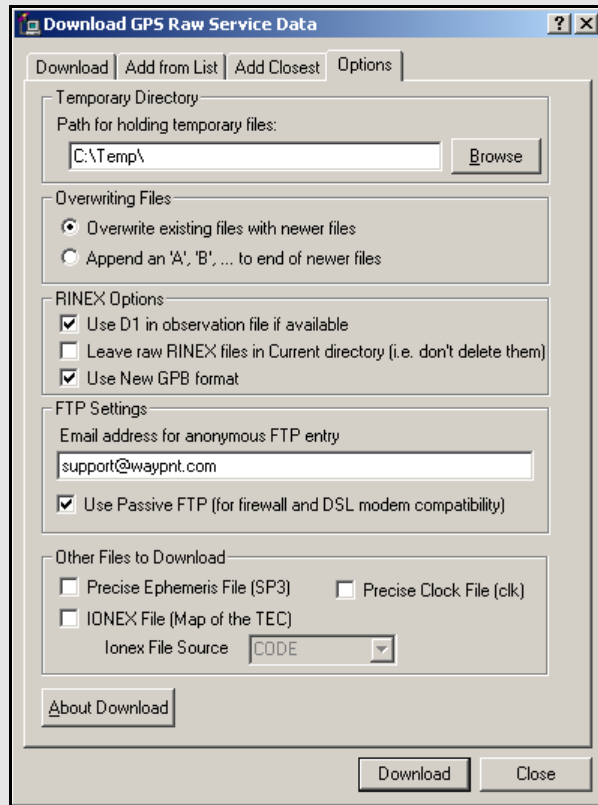
RINEX Options

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.

Specified correction files

Precise Ephemeris File
Final precise ephemerides, available at 12 days latency, are prioritized. If it is unavailable, the rapid orbit, available at 17 hours latency, is used instead.

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.

Precise Clock File
Contains information regarding clock biases in all GPS satellites. It is particularly useful for single point processing.

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
The three options available here are listed in the shaded box.

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. See *Table 11* on *Page 141* for additional information. 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 that recently added to one of the services, add them manually. You can also add a service to use in the utility.

⊠ Only services which provide their data through public FTP sites that permit anonymous logins can be added. The *Download Service Data* utility cannot be configured to connect to FTP sites using non-anonymous logins.

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 box.

⊠ 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.

⊠ The *Download Service Data* utility only supports the download and decompression of Z, GZ, and ZIP files.

Table 12 on *Page 141* contains a list of the producers of the correction files for download with website addresses.

Station record format

Station {   sName: *Four-character station name as saved on FTP server. See Note 1.*

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 2.*

}

⊠ This field is case-sensitive.

⊠ 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 *.dn1* file.

An example station record

Station {   sName: prds
lat: 50 52 16.8672 N
lon: 114 17 36.5856 W
ht: 1247.94
serv: IGS

}

Service records must conform to the format in the shaded box.

Service record format

Service { ServId: *Name of service, up to a maximum of 8 characters. See* ***Note 1***.

   ftpAd: *Address of the FTP server.*

   oFile: *Generic path to the observation file. See **Note 5**.*

   dFile: *Generic path to the compressed observation file. See* ***Note 3***.

   nFile: *Generic path to the navigation file. See **Note 5**.*

   hoFile: *Generic path to the hourly observation files. See **Note 3**.*

   hdFile: *Generic path to the compressed hourly observation files. See **Note 3**.*

   Ftype: *Type of compression used for files. See **Note 2** and **Note 3**.*

   Datum: *Datum in which the station positions for this service are defined.*

   color: *Color to use for symbols in utility's interface. See **Note 3** and **Note 4**.*

}

⊠   1.   This field is case-sensitive.

⊠   2.   Only the Z, GZ, and ZIP formats of compression are supported. Field no longer requires as of 7.6

⊠   3.   This field is optional and, thus, does not need to be present.

⊠   4.   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.

⊠   5.   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 made 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*
<yy>   *Last two digits of the year*
<d>   *Day of the week*
<MN>   *Month number*
<DM>   *Day of the month*

An example service record

Service {ServId: igs

   ftpAd: lox.ucsd.edu
   oFile: /pub/rinex/<YYYY>/<JJJ>/<XXXX><JJJ>0.<yy>o.Z
   nFile: /pub/nav/<YYYY>/<JJJ>/<XXXX><JJJ>0.<yy>n.Z
   dFile: /pub/rinex/<YYYY>/<JJJ>/<XXXX><JJJ>0.<yy>d.Z
   Ftype: Z
   Datum: WGS84
   color: red
   }

Data Sources

Table 11 contains a list of the services available with website addresses.

Table 12 contains a list of the producers of correction files for downloading with website addresses.

Table 11: Service Websites

Service Name	Web Address
IGS	http://sopac.ucsd.edu/
CORS	http://www.ngs.noaa.gov/CORS/cors-data.html
AUSLIG	http://www.ga.gov.au/
IGN	http://lareg.ensg.ign.fr/RGP/index.html
GSI	http://www.gsi.go.jp/
BKGI (EUREF)	http://www.epncb.oma.be/
ASI	http://geodaf.mt.asi.it/
CDDIS	http://cddisa.gsfc.nasa.gov/
OLG	http://gps.iwf.oeaw.ac.at/olgdc1.htm

Table 12: Correction File Producers

File	Producer	Wed Address
Precise ephemerides	IGS	http://igscb.jpl.nasa.gov/
Precise clock files	NGS	http://sopac.ucsd.edu/
IONEX files	CODE NRCAN ESA JPL UPC	http://www.aiub.unibe.ch/igs.html http://www.geod.nrcan.gc.ca/ http://www.esa.int/ http://www.jpl.nasa.gov/ http://gage1.upc.es/

2.9   Window Menu
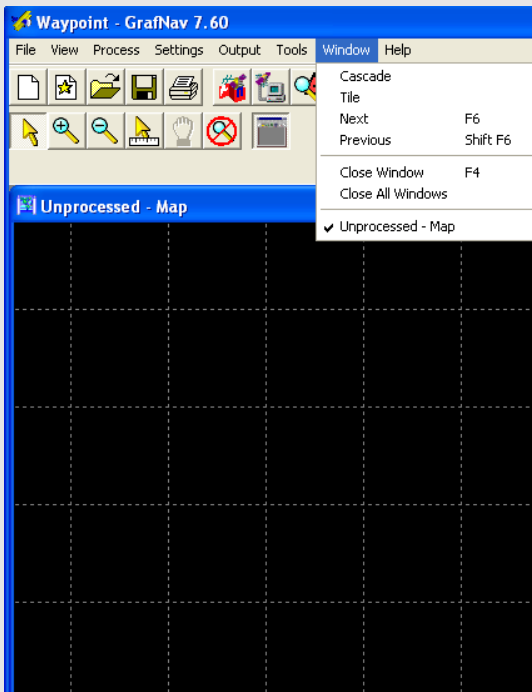
This menu option displays the GrafNav windows in different ways.

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

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.

2.10.2 www.waypnt.com

This option opens a web browser to the Waypoint Product Group's page on NovAtel's website, where details on the latest versions, patches, information on GPS/INS, and technical reports can be found.

2.10.3 About 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.

Files to download from Waypoint's FTP site

manufact.adf
List of antenna profiles. See *Page 36* for more details.

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. See *Section 9.8* on *Page 277* for details.

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 136* for more information.

manufact.grd
List that contains available grids such as UTM, US State Plane, Gauss Kruger etc. *Section 2.8.7* on *Page 129* for more details.

manufact.svi
A file that associates a PRN number with a satellite type (Block II, Block IIA etc.) for purposes of determining the center of mass of the satellite. It assists in single point processing. This file should not be modified.

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.
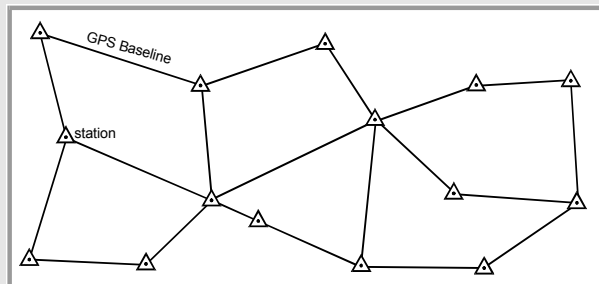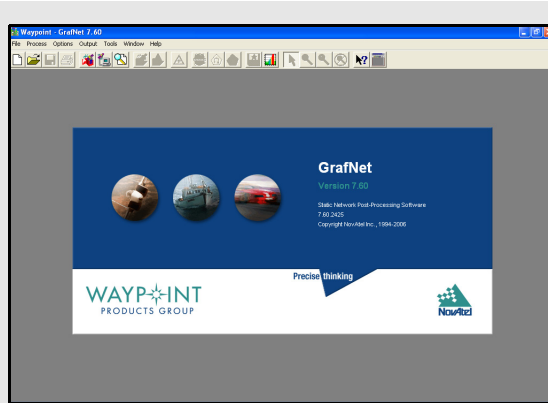
Figure 1: Closed Loop Network

✉ 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.
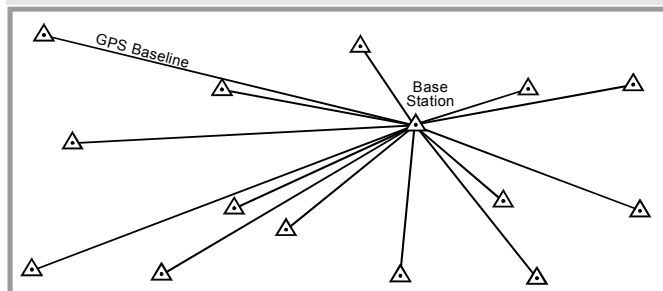
Figure 2: Radial Network

Table 13: 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 (i.e. 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 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 20 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 13*, 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 150* 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 24* for installation instructions.

Create a Project
Follow the instructions in the shaded box.
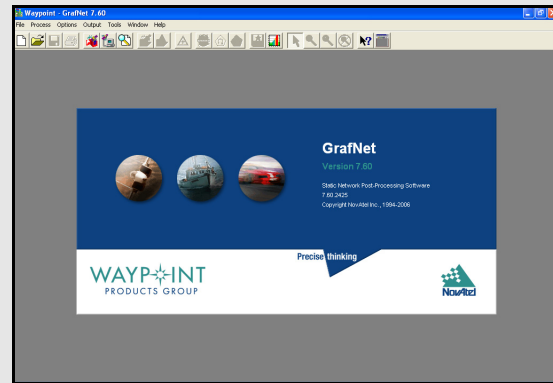
How to Install
1. See *Section 1.2.2* on *Page 24* for installation instructions.

How to create 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 will overwrite 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 on the **OK** button.

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. Press **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 146*.

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. See *Section 2.7.4* on *Page 107* for help.

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.

⊠   See *Section 9.5* on *Page 264* for tips on dealing with these baselines.

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.

Precise Ephemeris
For long baseline dual frequency processing, the iono-free solution combined with a precise ephemeris can be a benefit. For shorter baselines that are better off using a fixed solution, try to re-process them separately.

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.

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 *Session*s 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 con't

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.

See *Section 9.5* on *Page 264* for help with static processing.

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.

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*.
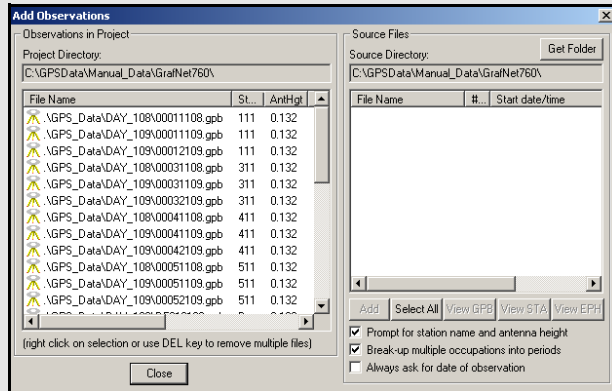
3.3.6 Add / remove Observations

This feature adds observation files to GrafNet projects. These files must be converted to GPB files using *File | Convert | Raw GPS to GPB*. GPB are already created if you used Waypoint's data logging software and choose to log into GPB format.

GrafNet automatically extracts the station name and antenna height values from the STA file, which is created during the conversion process.

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 to be added 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 36* 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 same 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 38* for more information.

It is important that the precise ephemeris file covers the entire time span for each session. Although more than one SP3 file can be loaded, only one can be used for processing each session. GrafNet will pick the proper file but if a session spans more than one SP3 file, the SP3 files must be concatenated together. If a session is not fully covered by one SP3 file, a message will appear providing the percentage covered by the precise ephemeris. Unless the percentage is in the high nineties, this baseline should be processed with start/end times. To do this, right-click the session in the *Data Manager*, and selecting *Process*. Look for the *Time Range* options on the first tab.

⊠ 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 7* on *Page 205*.

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 2.3.13* on *Page 51* for details.

3.3.11 Import Project Files

See *Section 2.5.8* on *Page 91* for information regarding this feature.

3.3.12 View

ASCII File

See *Section 2.4.8* on *Page 60* for information regarding this feature.

Raw GPS Data

See *Section 2.4.9* on *Page 60* 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 8* on *Page 219* 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 163* 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 2.5.3* on *Page 89* for more information.
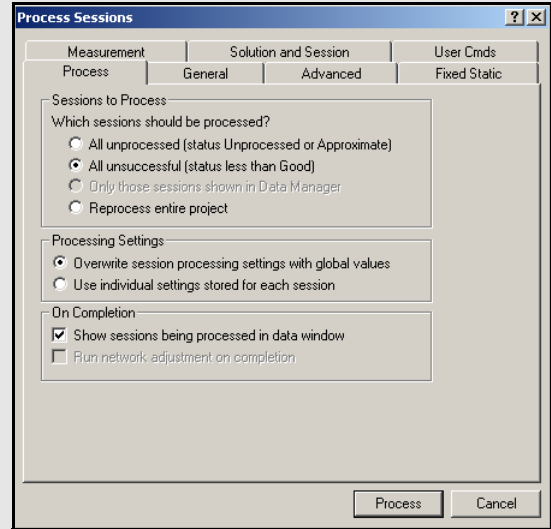
Sessions to process

All unprocessed
Processes all session listed as either *Unprocessed* or *Approximate* (i.e. blue or purple in *Map Window*).

All unsuccessful
Processes sessions that do not have a *Good* status (i.e. 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 14: Processing Modes

Mode	Frequency	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
Automatic	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 (i.e. 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 155* for information.

Static Solution Type
See *Table 13* on page 146 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 65* 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 61* for information regarding all the settings on this tab.

Measurement Options

See *Section 2.5* on *Page 61* for information regarding all the settings on this tab.
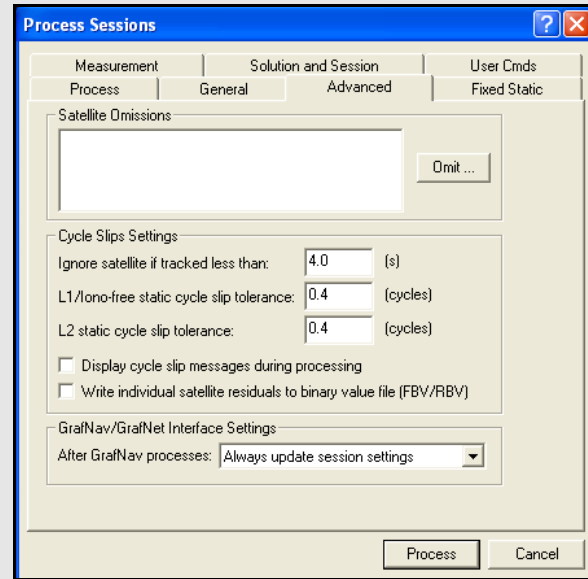
Cycle slip settings

Ignore satellite if tracked less than
See *L1 carrier locktime cut-off* in the *Advance 1*options tab on *Page 66* for more information.

L1/Iono-free static cycle slip tolerance
See *Static cycle slip tolerance* in the *Advance 1*options tab on *Page 68* for more information.

L2 static cycle slip tolerance
See *Small L2 cycle slip tolerance*in the *Advance 1*options tab on *Page 68* for more information.

Display cycle slip messages during processing
See *Write cycle slips to message log* in the *Advance 1*options tab on *Page 66* 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 *Page 66* 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.
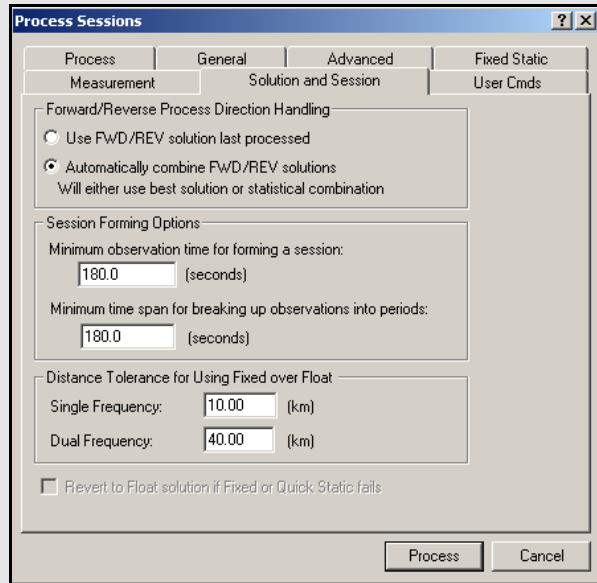
Minimum observation time for forming a session
Controls the minimum number of seconds necessary to declare concurrent observation files as a session. The default value is three minutes. For dual frequency data, this time can be reduced, while for single frequency data, this value may have to be lengthened 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.

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
There are two settings available here:

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 *Page 85* for more information on this tab. The list of available commands can be found in *Appendix A* on *Page 289*.

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.
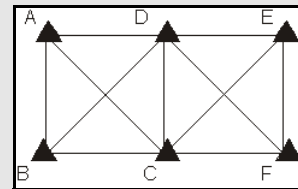
Figure 3: Trivial Baselines
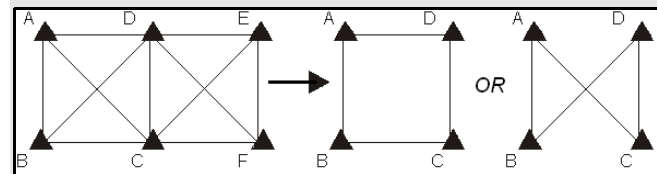
Figure 4: Removal of Trivial Baselines
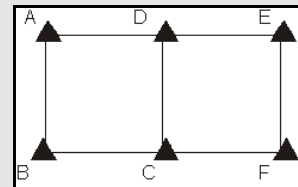
Figure 5: Network with Trivial Baselines Removed

```
Compute Loop Tie                                          ×

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    ]
```
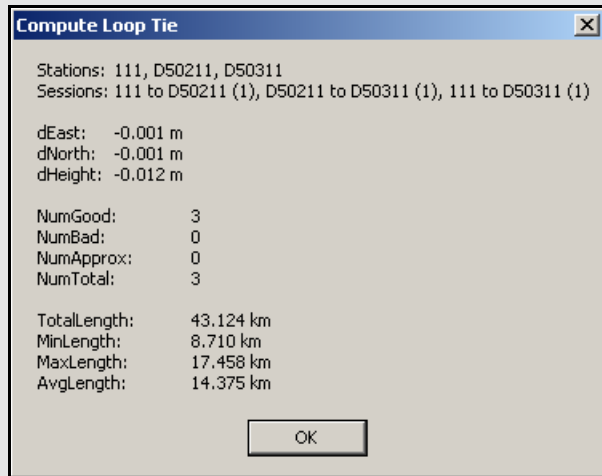
3.4.4   Unignore All Sessions

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 155* or *Section 3.6.6* on *Page 170* 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 160* 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.
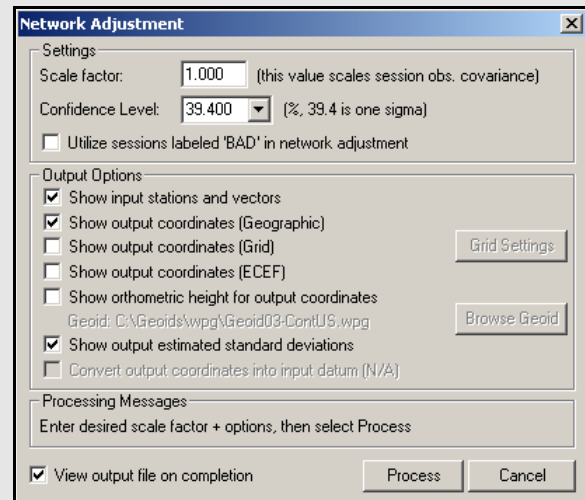
How to process with the Network Adjustmnet

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 165* 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 con't...

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 165* 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 2.6.4* on *Page 95* for help with this feature or see *Chapter 9* on *Page 257* for a discussion on datums.

3.5.4 Grid Options

See *2.8.7* on *Page 129* 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 *2.6.9* on *Page 100* 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

See *2.6.9* on *Page 100* for information regarding these settings.

3.6 Output Menu

3.6.1 Export Wizard

See *2.7.4* on *Page 107* for information regarding this feature.

3.6.2 Write Coordinates

See *2.7.5* on *Page 118* for information regarding this feature.
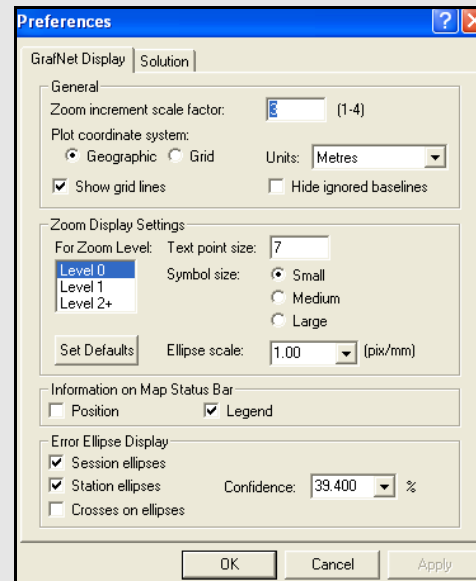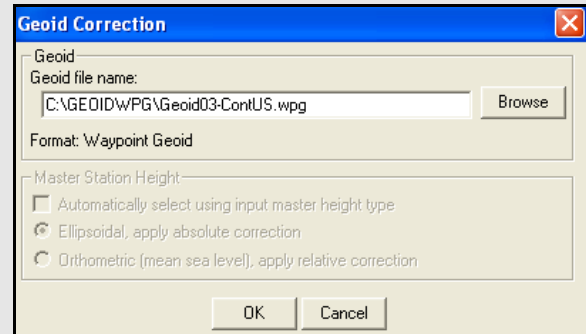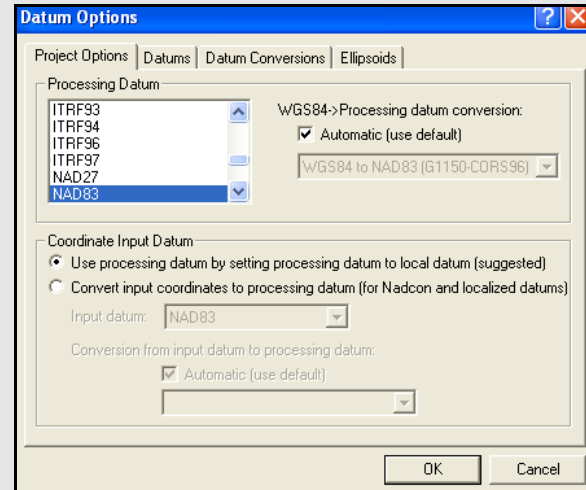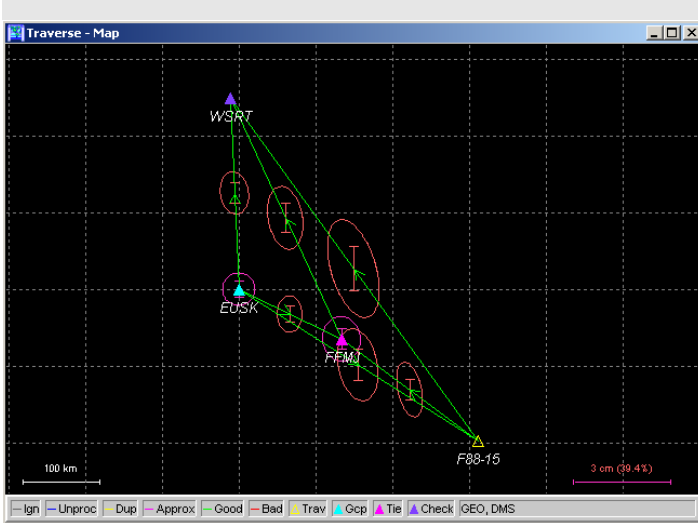
Table 15: Station Colour Legend

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.

3.6.3 View Coordinates

See *2.7.6* on *Page 120* for information regarding this feature.

3.6.4 Export DXF

See *2.7.7* on *Page 120* 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.

3.6.5 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 3.6.6* on *Page 170*.

⊠   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 3.6.6* on *Page 170* for more information.

3.6.6 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 *Static/Kinematic and Coverage* plot for all observations in the project. See *Table 4* on page 103 for information regarding this plot.

Plot L1 Satellite Lock

Launches the *L1 Satellite Lock/Elevation* plot. See *Table 4* on page 103.

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 15* on page 170 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 103.

Options
Allows access to the processing settings so that they can be set individually for this session. See *Section 3.4* on *Page 157* for additional information.

Override Status
Manually sets the status of the session. See *Table 13* on page 146 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 61* 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 125* for help.

Show To/From Stations
Displays both stations in the *Stations* window. See *Page 172* for information.

Show To/From Observations
Displays both station *Observations* window. See *Observation Window* on *Page 171* 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 13* on page 146 for a full description.

Time
Length of session, in *hh:mm* format.

Dist
Baseline distance, in km.

Status
Solution status. See *Table 13* on page 146 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 Window
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 *Page 172* 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.

3.6.7   Baselines Window

The *Baselines Window* displays information regarding all the sessions in the network. See *Columns in the Sessions Window* on *Page 173* 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.

3.6.8   Processing Window

See the *Process* menu on *Page 61* for information regarding this window.

3.7   Tools Menu

See *Section 2.8* on *Page 125* for information regarding the features available through this menu.

3.8   Help Menu

See Section 2.10 on *Page 143* for information about these features.

Table 16: 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*.

Chapter 4 | GrafNav Batch

4.1 Overview of GrafNav Batch

GrafNav Batch accompanies the GrafNav / GrafNet and GrafNav Lite software packages. It batch process both kinematic and static baselines using the GrafNav processing options including float-only, fixed static, and KAR solutions. With GrafNav Batch, you can easily load observation files (GPB), process multiple baselines, process multi-base baselines and export the output of numerous sessions into separate or integrated files.

⊠ Static-only baselines/networks are best processed using GrafNet.

4.1.1 Getting Started with GrafNav Batch

This section contains a tutorial to help you process multiple baselines. Each menu is defined in detail later in this chapter.

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

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 24* 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 8* on *Page 219* 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 2.3.1* on *Page 33* for more information on the Auto Start feature.
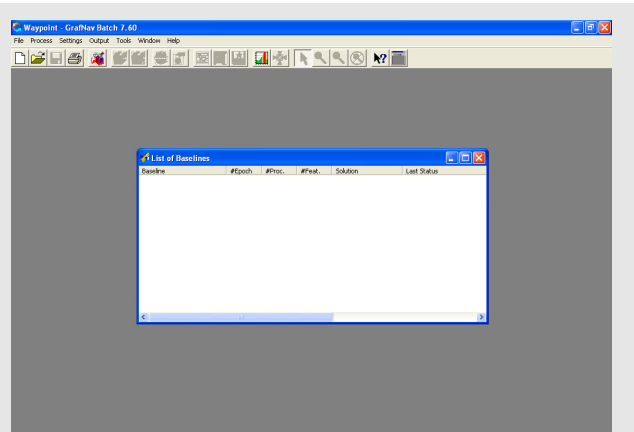
How to install

1. See *Section 1.2.2* on *Page 24* 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. Select *File | New Project | File Name* in GrafBatch.

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 add many Baselines

1. Select *File | Add Baselines*.

2. Select the appropriate directory containing the observation (GPB) and ephemeris (EPP) files.

3. Select the *One base many remotes* or *One remote many bases* option depending on whether the base or remote file is common to all baselines.

4. Highlight one or more GPB files for the master station(s) and click *Add Base(s)*. You are prompted for coordinates and antenna information for each base being added.

5. To specify remote antenna heights, enable the *Prompt for remote antenna height* option.

6. Highlight all the remote station observation files and click *Add Remote(s)*.

7. Click *OK*.

How to add multi-base baselines

1. Select *File | Add Multi-Base Baseline*.

2. Click *Add* to add the master files.

3. Click Browse to add the remote file.

4. Click *Plot Coverage* to display the *Static/ Kinematic + Coverage* plot of the files added.

5. Add coordinates antenna height information when you are prompted.

6. Add remote antenna height when you are prompted.

7. Click *OK*.

How to export data output into files

1. Select *Output | Export All | ASCII, Use Wizard*.

2. Select the source for output and select a profile. Click **Next**.

3. Choose the **Break-up batch sessions into separate files** *Batch Output* if the output for each baseline is required in its own ASCII file.

Add Many Baselines

GrafBatch requires baselines for batch process. To add baselines, follow the steps in the shaded box.

Add Multi-base Baselines

To add Multi-base Baselines, follow the steps in the shaded box.

Set Processing Options

If you do not wish to specify individual processing options for each baseline, select *Process | Process All Baselines*. A warning will appear indicating that all baselines will be processed using the same option.

Baselines requiring processing options that differ from others can be customized by right-clicking the baseline(s) in the *List of Baselines* and selecting *Process*. Select all of the baselines and go to *Process | Process Selected*. This processes all the baselines, while preserving processing options for each individual baseline.

Combine Baseline Solutions

When there are many base stations and one remote, or multi-base baselines, a combined file can be created that uses weighted observations from all of the baselines. See *Section 2.5.3* on *Page 89* for information regarding combining baselines.

Export data output into files

To export coordinates and other information from processed baseline sessions to ASCII text files, follow the steps in the shaded box. During this procedure, you can also control how the output files are named and what file extension is to be used.

Save Project

To save the configuration, select *File | Save Project*.

4.2   File Menu

4.2.1   New Project

To process multiple baselines for the first time, start a new project. To do this, use *File | New Project*.

> ✉   GrafNav Batch's project configuration files carry a BNV extension.

4.2.2   Open Project

To open an existing project, follow the steps in the shaded box.

4.2.3   Save Project

The program automatically saves the project file (BNV) prior to processing. Any changes made to the observations are also saved.

4.2.4   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.

4.2.5   Print

See *Section 2.3.5* on *Page 35*.

4.2.6   Add Baselines

Use this feature to add independent single baselines to the project. Before added single baselines, specify whether this project will contain *One base many remotes* or *One remote many bases*.

Under the *Source Files* window, select which GPB files to add as masters and remotes and click *OK*. You will be prompted to enter base station coordinates. You will also be prompted for antenna information at all base stations and remote stations. Please see *Section 2.3.6* on *Page 36* for additional information regarding antenna measurements.
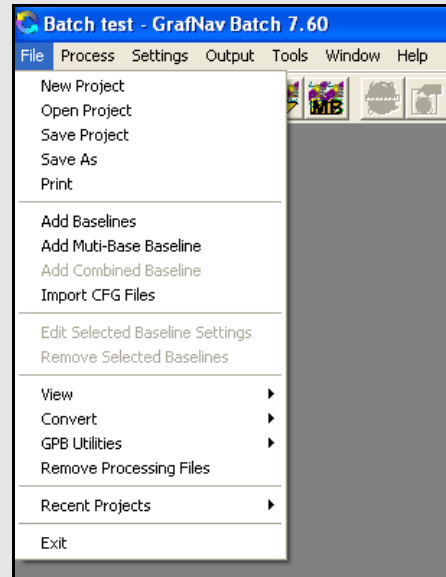
How to open a project

1. Choose *Open Project* from the *File* menu.

2. Choose the name of the project from the dialogue box (BNV file).

3. Click *OK*.
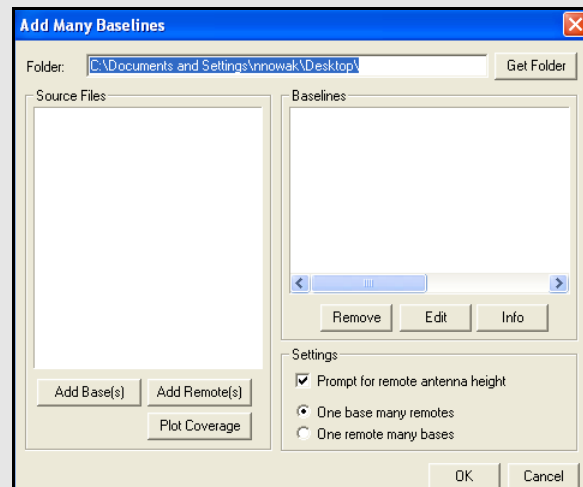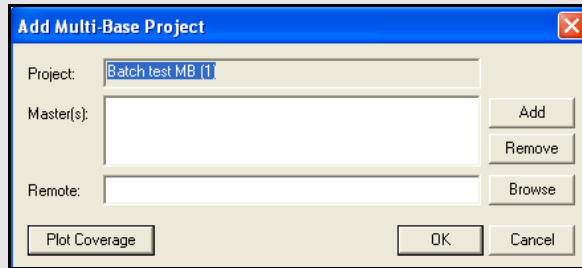
How to combine baselines

1. Highlight two or more baselines from the *List of Baselines* window.

2. Select *Process | Combine Selected Multi-Base*. The window that opens contains settings regarding the combining process.

3. Specify the *combined* baseline from the pull-down menu.

How to import CFG Files

1. Click the *Browse* button to locate any CFG files to add to the current project. If a multi-base baseline is being imported, you have to following options:

   • Enable the *Break MB projects up into separate baselines* option to create an individual baseline for each base station in the project.

   • Enable the *Keep MB baseline in project* to add the multi-base baseline as-is to the project.

   • Use the *Skip disabled base stations* option in conjunction with the first option to determine whether or not disabled bases in an imported multi-base baseline will be used when creating individual baselines.

4.2.7 Add Multi-Base Baselines

This option adds multi-base baselines, where the observations from all the stations will be processed in the Kalman filter. The best time to apply this feature is after single base baselines are added because it prevents you from having to enter base coordinates twice. See *Section 4.2.7* on *Page 180* to add multi -base baselines.

4.2.8 Add Combined Baselines

This option adds a *combined* baseline to the list of baselines in order to combine more than one pair of baselines in one project. Combined files as well as multi-base baselines can be combined. The steps to do this are in the shaded box.

4.2.9 Import CFG Files

This feature allows you to import baselines, as well as their solutions, from other projects. The steps are in the shaded box.

4.2.10 Edit Selected Baseline Settings

This option gives you the ability to edit the base station information, as well as antenna information at the base and remote. If more multiple baselines are selected, then any shared information can be changed. Please see *Section 2.3.6* on *Page 36* for information on the *Base Station* and *Remote Antenna* tabs. See *Page 62* for information concerning the *Initialization* tab.

⊠   Only the *Solution* and *Combine* tabs will be discussed here because they are unique to GrafNav Batch.

Solution

Solution to Load

This setting selects which solution to use after processing. Automatic is the default, but select the forward or reverse solution if one is deemed most optimal. To do this, right-clicking on the baseline, and selecting *Solution Usage*. See *Section 2.5.3* on *Page 89* for a description of the options available with the *Combine Settings* button.

Satellite System Type

This only applies to data logged using GLONASS-enabled receivers.

Automatic
Enables the usage of GLONASS data if it is available.

GPS only
Disables GLONASS processing. This option is useful if GLONASS data is causing problems.

GPS+GLONASS
Forces the usage of GLONASS data if it is available. Should be used if automatic detection fails.

Combine
Weighting Factor
The *Weight* value can increase or decrease the weight applied to an individual baseline. The *Additive PPM* value can increase or decrease the distance dependency. These are advanced features that are difficult to use. It is better to just leave out a baseline that is determined to be unreliable.

Maximum Distance
This omits baseline epochs in a combined solution if the base-remote separation is too long. By default, all epochs from all selected baseline are used during a combination.

Reject Bad Epochs
Epochs with high estimated standard deviations, poor geometry, high carrier phase RMS or poor quality can be rejected. In addition, this feature can be used to only utilize fixed integer solutions.

Time Range
Once a good time range is known, it can be used to reject any data before the start and after the end times. If a period within the data needs to be rejected, the *Combine Settings* button should be clicked on under the *Solution* tab.

4.2.11   Removing Selected Baselines

This feature removes any baselines that are highlighted in the *List of Baselines* window from the project. If the project is not saved afterwards, it will still retain the deleted baseline(s).

⊠   Configuration and processing files will be left over unless they are manually removed.

4.2.12   View ASCII Files

See *Section 2.4.8* on *Page 60* for information regarding this feature.
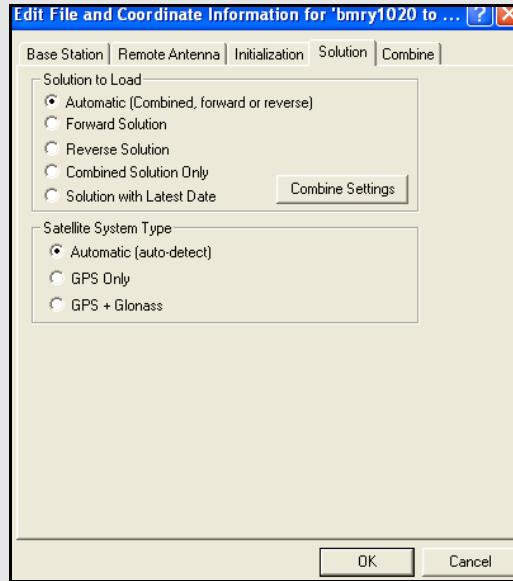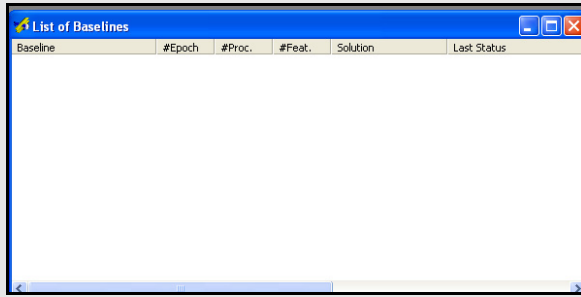
4.2.13   View Raw GPS Data

See *Section 2.4.9* on *Page 60* for information regarding this feature.

4.2.14   Convert GPS Data

See *Section 2.3.11* on *Page 49*.

4.2.15   GPB Utilities

See *Section 2.3.12* on *Page 49*.

4.2.16   Remove Process Files

See *Section 2.3.13* on *Page 51* for information regarding this feature.

4.2.17 Recent Projects

This option allows you to access recent saved projects.

4.2.18 Exit

Exits the program.

4.3   Process Menu

4.3.1   Process All Baselines

This feature forces all baselines in the project to be processed using the same options. Any options that were customized for individual baselines are over-written with these global settings.

See *Section 2.5* on *Page 61* for information regarding all the processing options available.

4.3.2   Process Selected

To specify individual options for troublesome baselines, select the desired baseline(s) from the *List of Baselines* window and select *Process | Process Selected*. Any options set here will only be applied when processing the baselines selected. All other baselines will continue to be processed using the global settings.

To process all the baselines in the project without having individual options over-written with the global options, highlight all the baselines in the *List of Baselines* window and select *Process | Process Selected*.

4.3.3   *GrafNav on Selected Baselines*

For additional options, tools, plotting and printing capabilities, or the baseline solution needs improvement, GrafNav can be opened and used for processing. Simply highlight the baseline from the *List of Baselines* window and select *Process | GrafNav on Selected*.

4.3.4   *View Selected Processing Summary*

See *Section 2.4.4* on *Page 54* for information regarding this feature.

4.3.5   *Load All Solutions*

This option loads all existing solutions for all baselines into GrafNav Batch, allowing you to plot and export output files.

4.3.6   *Load Selected Solutions*

This feature is identical to the previous one but applies only to those baselines that are highlighted in the *List of Baselines* window.

4.3.7   *Combine Multi-baselines*

This feature combines baselines, whether they are single-base, multi-base or combined. To add an additional combined baseline, select *File | Add Combined Baseline*.

Once a project has been created and properly set up, follow the steps in the shaded box to combine baselines.

4.4   Settings Menu

4.4.1   *Global*

These options apply to all the baselines in the project and any baseline settings that were individually customized will be over-written.

Process Settings
This feature is similar to that in *Section 2.5* on *Page 61* except that you may not actually engage processing through here. See *Page 61* for information regarding all the processing settings available.

Datum Settings
The datum set here will be applied to all baselines in the project. See *Section 2.6.4* on *Page 95* for information regarding this feature.

How to combine multi-baselines

1. Add a *combined* baseline via *File | Add Combined Baseline*. To change the name on this baseline, right-click it in the *List of Baselines* window and selecting *Rename*.

2. Reject epochs that have poor statistics, specify remote initialization, or specify the solution to load before combining baselines. All of these options are available via *File | Edit Selected Baseline Settings*. An additive PPM and weighting value can be added with this option and used to change the weighting with distance. See *Section 4.2.10* on *Page 180* for information.

3. Select *Process | Combine Selected Multi-Base* with all of the baselines still highlighted. This combines these baselines into a single solution.

⊠   Outliers can be rejected based on the following parameters:

Error Tolerance – the minimum error before an outlier will be detected. Setting this correctly is important to prevent false errors from being detected. The default value is 0.500 m.

Sigma Tolerance – the number of standard deviations (of the computed position standard deviation) before an error is deemed an outlier. you may wish to use 3-sigma to reduce the number of errors detected, although the default is 2-sigma.

4. Press *OK*. The additional *Combined* baseline added in Step 2 will be used as a holding place for the combined solution. When complete, the *Combine Multi-Base* window appears, displaying statistical information regarding the combination. This window gives an indication of how many epochs were rejected. Monitor these values, those concerning the epochs that were rejected as outliers.

Grid Settings

The grid selected here is used as the project grid and affects all baselines. See *Page 112* for information concerning this feature.

Alternate Files

This feature allows for the addition of ephemeris or correction files to be used during processing. Any files added here will be used for all the baselines in the project. See *Section 2.3.8* on *Page 38* for more information.

4.4.2   Selected

These options are only applied to the baselines highlighted in the *List of Baselines* window at the time that this feature is invoked.

Processing Settings

If this feature is selected, the options defined here will be copied only to those baselines highlighted in the *List of Baselines* window. See *Section 2.5* on *Page 61* for information regarding all the processing settings available.

⊠ This feature allows the editing of the processing settings only. To process the baselines once their settings have been edited, highlight them in the *List of Baselines* window and select *Process | Process Selected*. This ensures that selected baselines are processed using their customized settings, instead of being over-written with the global settings.

Baseline Settings

Please see *Section 4.2.10* on *Page 180* for information regarding the use of this feature.

Alternate Files

This feature allows for the addition of ephemeris or correction files to be used during processing. Any files added here are used only for those baselines highlighted in the *List of Baselines* window. See *Section 2.3.8* on *Page 38* for more information.

4.4.3   Copy Processing Options

This feature lets you copy the processing options from one baseline to another.

⊠ Once the settings have been transferred, the baselines will have to be reprocessed in order for the new options to take effect.

4.4.4   Load into Selected From

This feature loads the settings defined in the chosen profile into the selected baseline(s). See *Section 2.6* on *Page 92* for more information.

4.4.5   Manage

See *Section 2.6* on *Page 92* for information on this feature.

4.4.6   Preferences

See *Section 2.6.9* on *Page 100* for information regarding the options available here.

4.5   Output Menu

4.5.1   Plot Selected GPS Data

This features plot GPS data from a selected baseline. See *Table 4* on page 103 for information concerning all the plots available.

4.5.2   View Selected Map

This feature allows you to view a trajectory or static representation of the GPS data for any individual baseline. Note that only one map may be viewed at a time.

4.5.3   Export All

This feature writes output files for all baselines in the project. If you select *CMB File*, the software will write a separate combined file for each baseline. *Chapter Chapter 7<Default ¶ Font> on Page 205* for a description of the format used for this file.

Selecting *ASCII, Use Wizard* launches the *Export Wizard* utility to create output files in a pre-defined or user-defined format. See *Section 2.7.4* on *Page 107* for information on this utility.

    ⊠   When using this feature for all baselines, you are prompted with an additional window during the export process.

Disabling the *Break-up batch sessions into separate files* option exports the solution data from all the baselines into one output file. Each baseline's solution output will be exported sequentially into the file. This option also creates a separate output file for each baseline in the project. The convention used for naming each of these files can be selected from the list of choices in the *File Naming Convention* box.
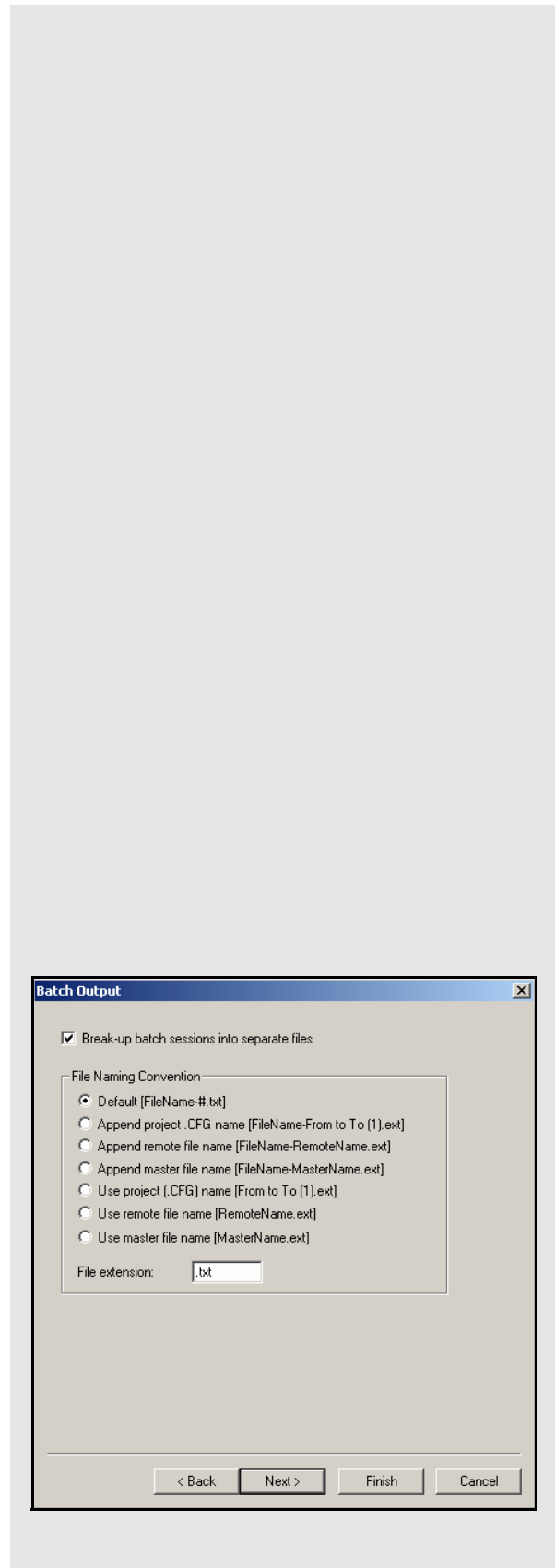
4.5.4   Export Selected

This feature exports only those baselines which are highlighted in the *List of Baselines* window. If you select *CMB File*, the software writes a separate combined file for each of the selected baselines. See *Chapter 7* on *Page 205* for a description of the format used for this file.

Selecting *ASCII, Use Wizard* launches the *Export Wizard* utility to create output files in a pre-defined or user-defined format. See *Chapter 2.7.4* on *Page 107* for information.

If multiple baselines have been selected for export, you will be prompted with the *Combine Multi-Base* window. The options available in this window are described in the shaded box.

View Export Files

This option opens the ASCII viewer to view the last output file that was written using the *Export Wizard*. If the *Break up batch sessions into separate files* option was selected in the *Export Wizard*, this feature will return an error since it looks for an output filename corresponding to the name of the project. In this situation, select *File | View | ASCII File* and then browse to the output file of interest. See *Section 2.4.8* on *Page 60* for more information.

4.6   Tools Menu

See *Section 4.6* on *Page 186* for information regarding the features available through this menu.

⊠   The *Mission Planner* and *Download Service Data* features are described in *Section 2.8.11* on *Page 133* and *Section 2.8.12* on *Page 136*, respectively.

⊠   Some features will only be accessible if a *Map Window* has been opened for a particular baseline.

4.7   Windows

Map Window

See *Section 2.7.9* on *Page 122* for information regarding the *Map Window.*

Processing Window

See *Section 2.7.10* on *Page 123* for information concerning this window.

List of Baselines

This window contains a list of all the baselines included in the project, regardless of whether or not they have been processed.

The columns listed in the shaded box are displayed in this window.

Several options are available by right-clicking on a baseline in the *List of Baselines*. Only those not previously discussed or referenced in this chapter are described.

Rename
Rename the baseline. The processing files corresponding to the baseline being renamed will not be over-written or deleted because this option creates a new CFG file for the baseline, which replaces the previous one.

Solution Usage
Selects which solution to load into the project.

View GPS Observations
Views all information concerning the master and remote observations being used in the baseline. See the options listed under the *View/Edit GPS* in *Section 2.4.1* on *Page 52* for information regarding the options available.

View Forward/Reverse Solution
See *Section 2.4.2* on *Page 52* for information regarding the options available.

View Processing History
See *Section 2.4.3* on *Page 54* for information regarding this feature.

View Processing Summary
See *Section 2.4.4* on *Page 54* for information regarding this feature.

Digital Elevation Model
See *Page 47* for information regarding this feature.

View/Edit Features
Opens the *Feature Editor.* See *Section 2.4.6* on *Page 55* for information regarding this feature.

Load Features
See *Section 2.4.6* on *Page 55* for help loading features.

View Objects
Opens the *Object Menu*. See *Section 2.4.7* on *Page 57*.

4.8   Help Menu

See *Section 2.10* on *Page 143* for information regarding the features available via this menu.
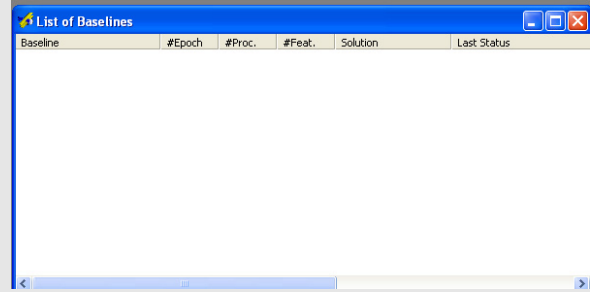
List of baseline columns

Baseline
Name of the baseline. An icon appears beside each to indicate the status of that baseline. Icons containing question marks indicate that the baseline has not been processed. Any arrows within the icon indicate the directions that the baseline has been processed in. The same logic applies to icons containing the letters *MB*, which are used only to indicate that the baseline contains multiple bases.

#Epoch
The number of epochs in the remote GPB file.

#Proc
The number of epochs processed in the loaded solution.

#Feat
The number of features present in the baseline.

Solution
Indicates which solution is currently loaded.

Last Status
Indicates the status of the solution most recently processed.

Chapter 5 | GrafMov

5.1 Overview of GrafMov

GrafMov is a moving baseline upgrade that can be added on to Waypoint's GrafNav / GrafNet GPS post-processing software package. The purpose of the 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.

5.2 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 24* 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 8* on *Page 219* 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 32* for more information on the *Auto Start* feature.

How to install
1. See *Section 1.2.2* on *Page 24* 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. See *Section 9.8* on *Page 277* for more information on datums. 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

5. Select *Output | Export Wizard*. Select the source for the solution. *Epochs* will output the trajectory, while *Features/Stations* will export any loaded features

6. 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 *Page 192* 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 *2.5* on *Page 61* 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 2.7.10* on *Page 123* 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 103* 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 107* for help.

5.3   File Menu

See *Section 2.3* on *Page 33* for information regarding all of the features available via this menu. This section provides only a few points relevant to GrafMov.

5.3.1   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 8.2* on *Page 219* 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 8.2* on *Page 219* 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 better to make the entire file kinematic.

5.4   View Menu

See *Section 2.4* on *Page 52* for information regarding all of the options in this menu.
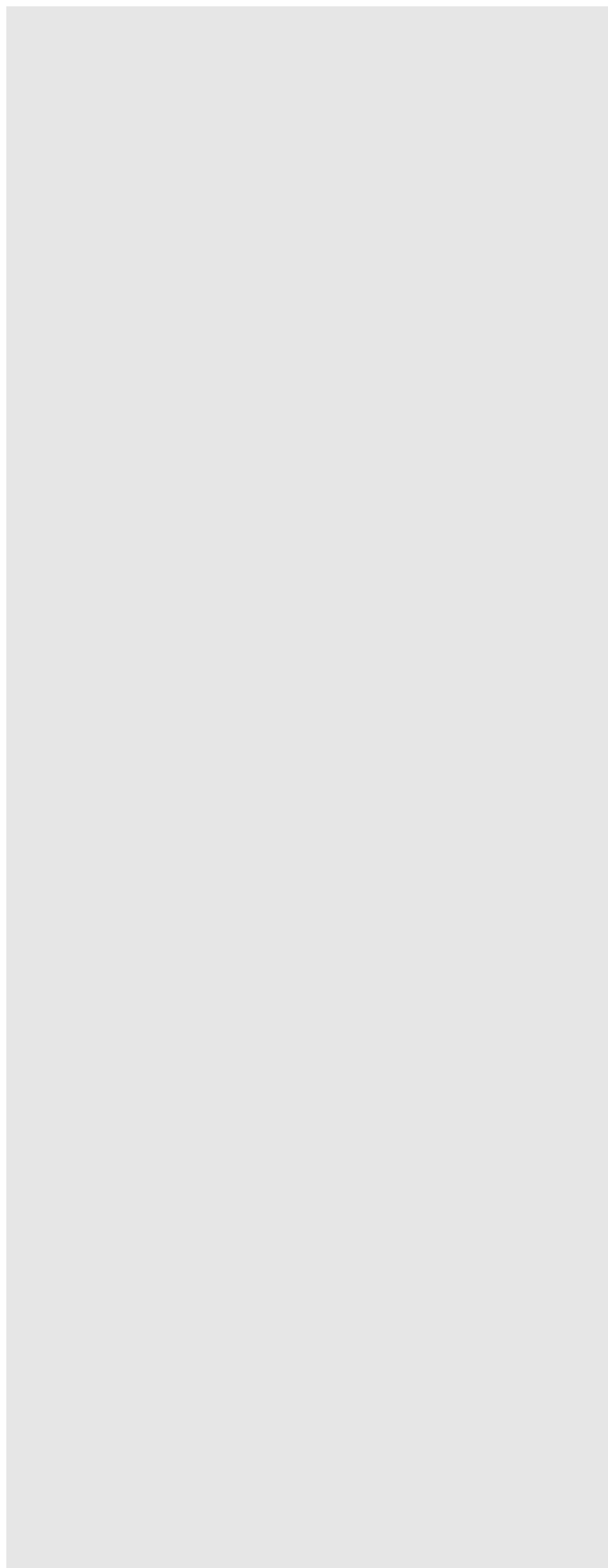
5.5   Process Menu

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 KAR and engage KAR 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 KAR 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 KAR usage or if the distance is not known or unstable.

4. **On, but only use distance constraint to engage KAR if out of tolerance** - Dual frequency users should 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 33* or information regarding all of the options available via this menu.

5.6   Setting Menu

See *Section 2.6* on *Page 92* 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.

5.7   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 KAR if the distance between the two antennas becomes too large or too small. Using a strict tolerance might cause GrafMov to engage KAR 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.

5.8 Output Menu

See *Section 2.7* on *Page 102* for information regarding all of the options available in this menu. This section only has a brief point relevant to GrafMov.

5.8.1 Plot GPS Data

Table 16, in the shaded box, contains a description of those plots available only through GrafMov. See *Table 4* on *Page 103* for a list of other plots available.

5.9 Tools Menu

See *Section 2.8* on *Page 125* for information regarding all of the options available via this menu.

5.10 Interactive Windows

See *Section 2.9* on *Page 142* for information regarding all of the options available via this menu.

5.11 Help Menu

See *Section 5.11* on *Page 193* for information regarding the features available via this menu.

Table 17: 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 *Page 192* for more information.
Estimated Azimuth/ Heading Accuracy	Shows the standard deviation of the azimuth computation. Only available if azimuth determination has been enabled. See *Page 192* 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.

6.1   Overview of AutoNav

AutoNav is an automated differential GPS processing program that is capable of handling static or kinematic data. AutoNav is intended for processing multiple remote files that use the same processing options and / or base configurations.

The benefit of using AutoNav, which employs the same processing engine as GrafNav, is that it allows for large amounts of data to be converted, have its base files downloaded, resampled, processed, and exported in a single operation. Once processing begins, no user interaction is required. For example, if processing is started at the end of the day, the results should be available by morning. While some initial work setting up the project is required, time will be saved in the long run. AutoNav can be used with projects that span multiple days, such as deformation monitoring.

The first step when creating an AutoNav project is to define the base stations and their coordinates. Bases can be either files, meaning the raw data is readily available from your computer, or Internet stations, which the program will download automatically. All of the stations that are available in the *Download Service Data* program are supported in AutoNav.

> ⊠   An unlimited number of base stations and remote files can be added, but a maximum of 8 base stations can be used with each remote.

Once the remote files and base stations are input, the processing options and output format need to be set. The processing options will be applied to all of the remote baselines that are to be processed. If two remote files require different processing or output options, then they must be in separate AutoNav projects. An output file containing trajectory information is created for each of the remote files.

This chapter describes how to get started with AutoNav, goes through each menu of its interface and provides step-by-step instructions for first-time users.
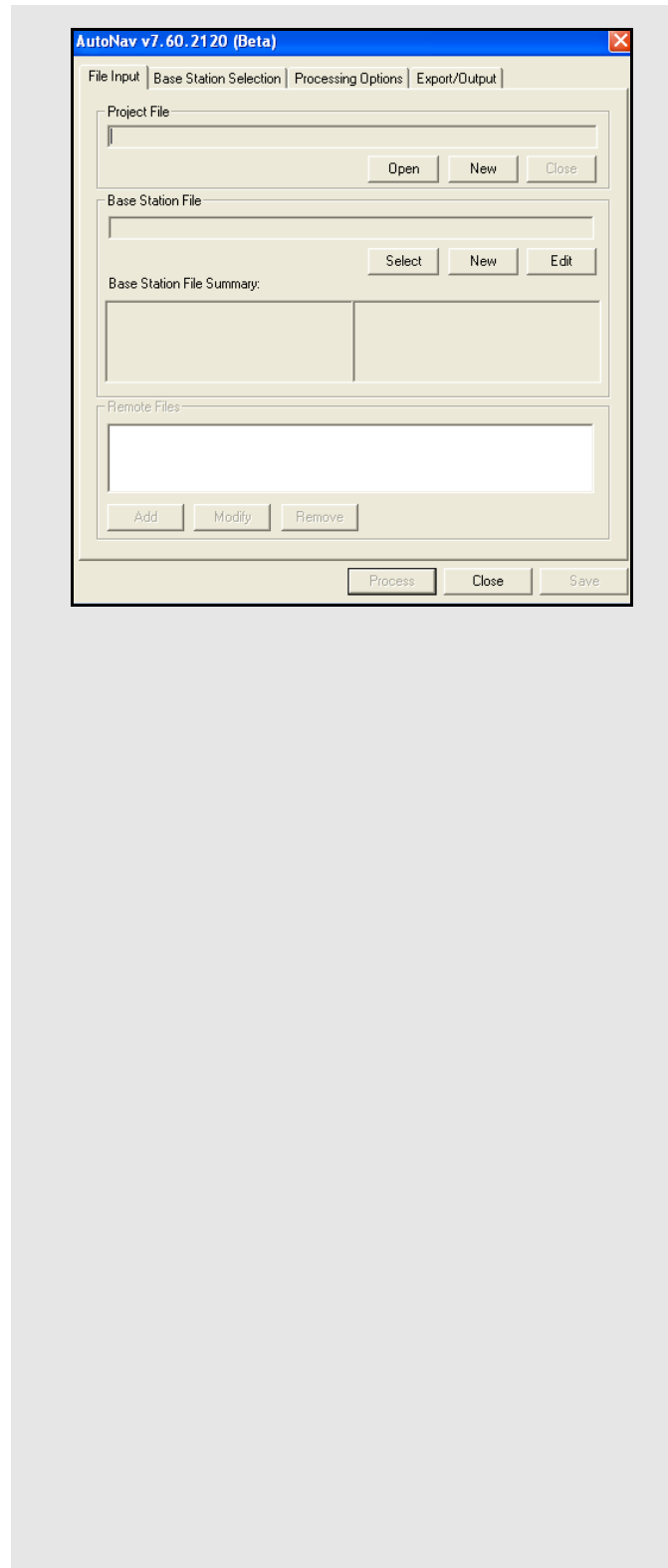
6.2 Getting Started with AutoNav
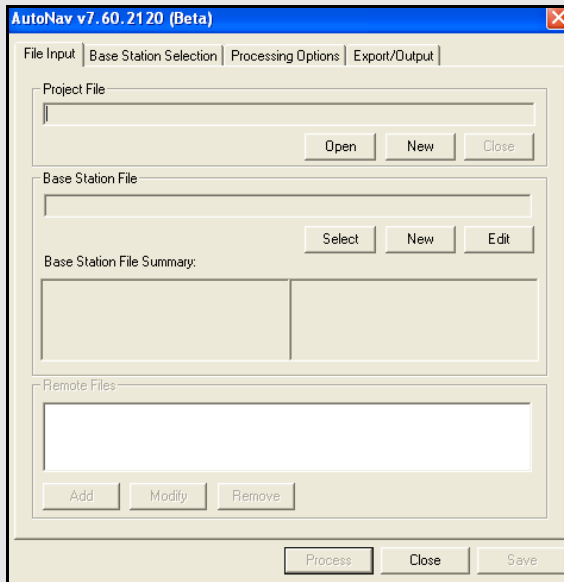
How to create a new project

1. Select *AutoNav* in the Waypoint program group.

2. Click the *New* button in the *Project File* box under the *File Input* tab.

3. Provide a name and destination folder for the project file (ANP).

4. Click *Save*.

How to set up a base station file

1. Click the *New* button in the *Base Station File* box.

2. Provide an appropriate name and destination folder for the base station file (ANB).

3. Click *Save*.

4. Click the *Edit* button in the *Base Station File* box under the *File Input* tab to add base station data to the ANB file. To add data files that are already on disk, click the *Add File Base* button. To add base stations that are available online, click the *Add Internet Base* button and then click *Find Internet Station*. In either case, base station coordinates must be provided.

Before you start a project in AutoNav, 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 24* 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 Chapter 8* on *Page 219* for a complete description of the *Convert* utility.

Start AutoNav
The first step to get started with AutoNav is to create a new project. To do this, follow the steps in the shaded box.

Set Up a Base Station File
The steps to set up a base station file are in the shaded box.

Add Remote Files

To add remote files, follow the steps in the shaded box. Be sure to specify the receiver type and data type.

Select Base Stations for Processing

To select base stations for processing, follow the steps in the shaded box.

Set Processing Options

Select the options most suitable to the application. Generally, both directions should be processed, and KAR should be enabled. Set the *Static Initialization* to *Float solution or KAR*, unless there is sufficient static data for a *Fixed static solution*.

> ⊠   Be sure to select the proper datum, as well as the processing profile most appropriate for the application.

Set Exporting Options

The steps to set the exporting options are in the shaded box.

Process

Click the *Process* button to allow the software to begin processing the data. No further user interaction should be required as the program will automatically download any required base station data, and create the desired output upon successful completion of processing.

File Input

The *File Input* tab allows for the selection of the project (ANP), base station (ANB), and remote files.

Project File

Use the *Open* button to select an existing project file. Otherwise, the *New* button creates a new project. To close the active project, use the *Close* button without quitting the application.

Base Station File

You can choose to either select an existing base station file, or else create a new one. In either case, you may make changes to it via the *Edit* button. See *Section 6.3* on *Page 198* for information regarding base station files. You can also share ANB files among projects.

How to add a remote file

1.   Click the *Add* button in the *Remote Files* box.

2.   Click the *Browse* button n the window that appears to locate the remote data files to be processed.

How to select base stations for processing

1.   Select *Automatic Base Station Selection* under the *Base Station Selection* tab to allow the software to decide which base stations are for processing.

> ⊠   This decision is based on the criteria outlined under the *Automatic Selection Options* box.

How to set exporting options

1.   Specify the data desired for output by selecting the appropriate *Export Profile* under the *Export/Output* tab.

2.   Select *Epochs* under the *Export Type Source* to obtain the coordinates of the remote trajectory

3.   Select *Features/Stations* for any loaded points of interest such as camera or station marks, or *Static Sessions* if static data was processed.

> ⊠   Depending on the profile chosen, some of the options available on this
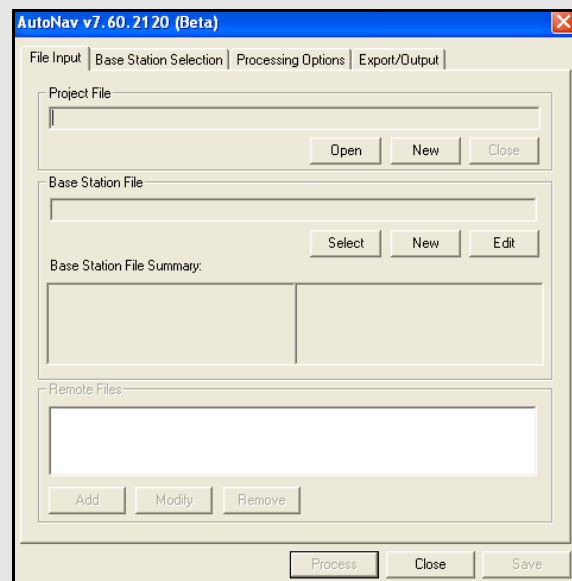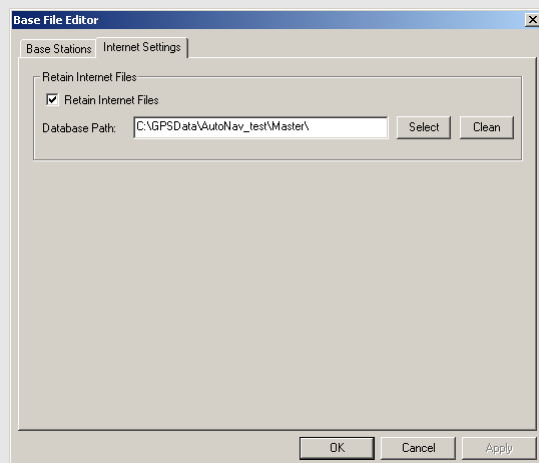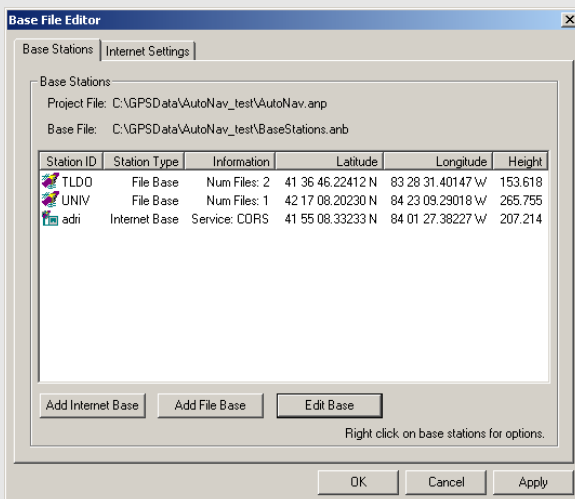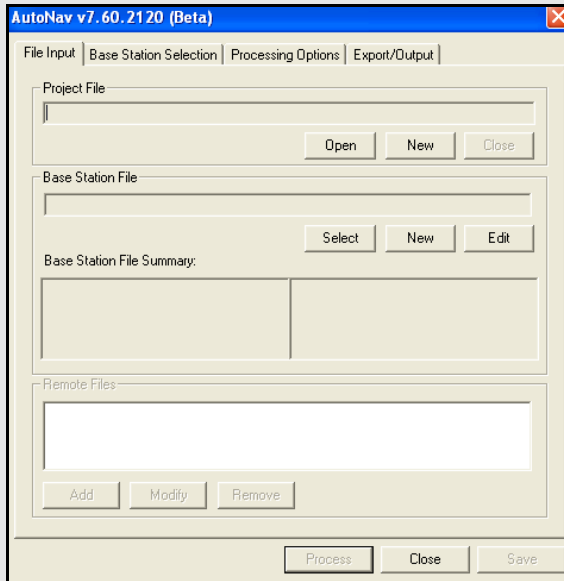
Base Station File Summary

This window is used to display information regarding the selected base station file. The left-hand side of the window features the number of base stations contained within the current ANB file, while the right-hand side displays the path to which any stations downloaded from the Internet will be saved, if the appropriate option is enabled.

Remote Files

You may add or remove remote files to the project, or else edit any existing ones. See *Section 6.3* on *Page 198* for more information about adding and modifying remote files.

6.3   Base Station Files

For every project, AutoNav requires a base station file (ANB) from which to obtain important information regarding the master stations to be used for processing. These can be shared among multiple projects.

Base File Editor

This window shows a list of all base stations currently in the ANB file.
To remove a station from an ANB file, simply right-click on it and select *Delete File Base*.

You can choose to add either Internet or file base stations. The former requires clicking on the *Add Internet Base* button, which will open the *Download Service Data* utility. Here, select the desired base station. See *Section 2.8.12* on *Page 136* for help using this utility.

If a file base station is desired, click on the *Add File Base* button. You can edit any existing files using the *Edit Base* button.

Users with Internet base stations should consult the *Internet Settings* tab of the *Base File Editor* window for additional options.

Under this tab, you have the option to save any downloaded RINEX files. Otherwise, they will be deleted after the conversion to GPB. The *Clean* button available under this tab should only be used if you is wishing to delete all GPB, EPP and STA files in the specified path.

If the *Retain Internet Files* option is enabled, the software will use the following naming convention in the shaded box when saving the GPB, EPP, and STA files to disk.

Base Editor

Base Type
Lists the type of station.

Station Information
Enter a station name, as well as the coordinates for the point.

> ⊠ The coordinates can be loaded via the *Select From Favourites* button if they have been previously stored.

If available, the antenna information should also be provided here. See *Section 2.3.6* on *Page 36* for information regarding antenna models.

For users adding an Internet base station, consult the *Internet Base* box to ensure that the proper station and service names are loaded.

The *List of Base Files* box is only relevant to those users looking to process data that is already stored on their computer. In such cases, click on the *Add Files* button to locate the raw data. If the data has been divided into several files (i.e. hourly or daily files), you are free to add them all.

> ⊠ The files added here do not need to be in GPB format. The program will attempt to automatically detect the receiver type and convert any raw data files that may be added here. However, should the auto-detect fail to correctly identify the data type, you will be forced to convert the files manually. See *Section 8* on *Page 219* for help.

File naming convention

SSSSSSSS_HHHHHH_hh_iiii

> Where:
>
> | | |
> |---|---|
> | *SSSSSSSS* | Station ID (8 characters) |
> | *HHHHHH* | Number of hours since 1980 (6 characters) |
> | *hh* | Number of hours in the file (2 characters) |
> | *iiii* | Data interval (4 characters) |
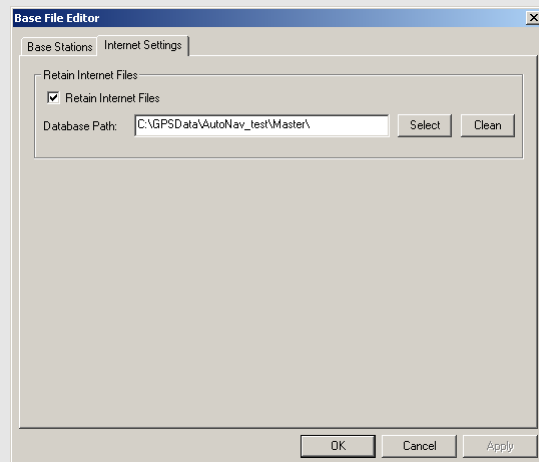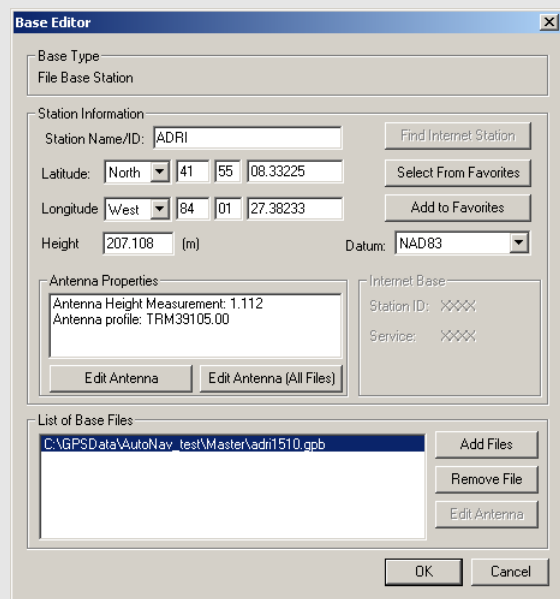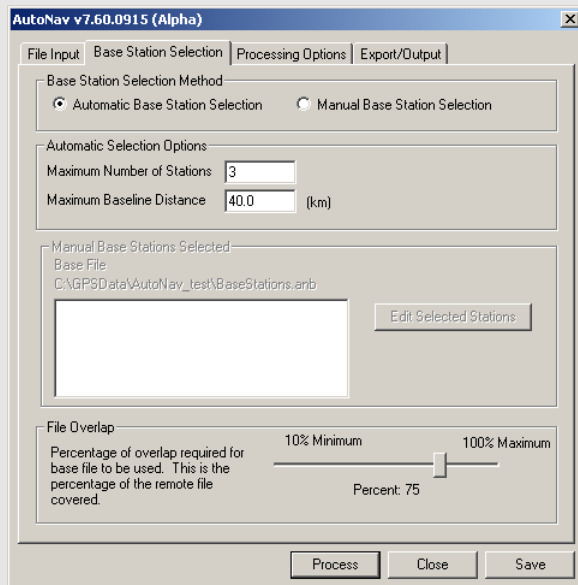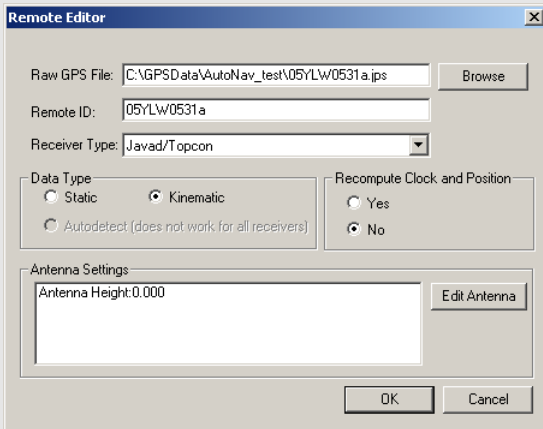
6.4   Remote Files

AutoNav also requires that the remote files be specified before processing can begin.

The entire remote file will be used for processing, as a time range cannot be specified. The *Remote Files* box provides a way of adding or removing remote files, or editing any existing ones.

When adding remote files with the *Browse* button, you are not limited to GPB files. AutoNav will automatically convert data from any of the supported receivers before processing. If the receiver type is known, it should be specified under *Receiver Type*. Otherwise, select *Unknown/ AutoDetect* to have the program attempt to identify the receiver type automatically. If the file has already been converted to Waypoint's proprietary format, select *WAYPOINT GPB*.

If raw data files are being added, indicate whether the file is of static or kinematic nature. There is also an option available for the recomputing of clock and position records.

⊠   Remote positions are required for automatic base selection.

Regardless of the data type, the antenna settings should be provided if possible. See *Section 2.3.6* on *Page 36* for information regarding antenna models.

Base Station Selection
This tab contains settings to determine which of those stations within the previously selected ANB file are used for processing.

Base Station Selection Method
You have the choice between allowing the program to automatically select which base stations to use, or choosing them manually.

Automatic Base Station Selection
When this option is chosen, the software will use the constraints in the *Automatic Selection Options* box to determine which stations to include. Priority is given to those stations which are closest to the averaged coordinates of the remote file.

Manual Base Station Selection
This option gives you the power to enable or disable any base stations in the ANB file as he or she sees fit.

In either case, if an Internet base station is chosen from the ANB file, the software will automatically download the data for the day(s) of interest and concatenate and/or splice it, keeping only the data required for overlap with the remote file. Furthermore, the program will also resample any Internet or file base station data to the same interval as the remote file.

Automatic Selection Options
These settings are only available for those users who have opted for *Automatic Base Station Selection*. The values entered here govern the program's choice of base stations for processing. Limit the total number of base stations allowed in the project with the *Maximum Number of Stations* setting.

A maximum of eight base stations can be included in any given project. However, only those stations that are within the *Maximum Baseline Distance* are included.

Manual Base Stations Selected
This box is only available if you have selected the *Manual Base Station Selection* option. The currently loaded ANB file is displayed above the window, and the *Edit Selected Stations* button gives you access to the list of base stations included within it. From here, enable or disable base stations, as deemed necessary. All enabled base stations appear in the window.

File Overlap
This setting acts as an additional constraint in the base station selection process. It requires that any given base station overlap with the remote by the specified percentage before being allowed in the project. This setting applies primarily to file base stations since Internet base station data is automatically downloaded to overlap the entire remote file. This setting acts as a safety check to help ensure that the bulk of the remote file's data will be processed.
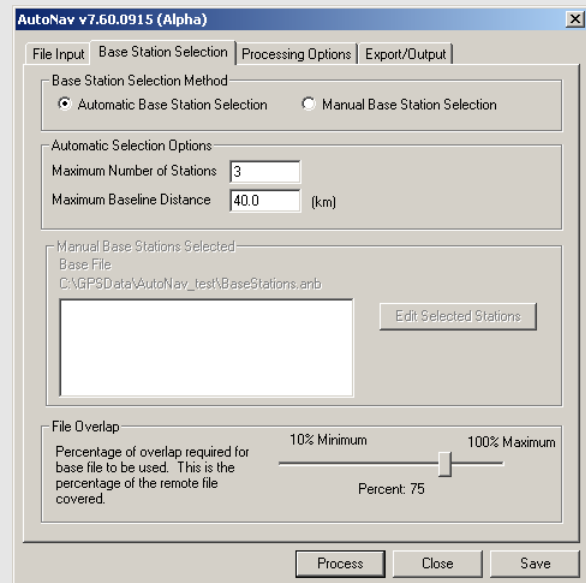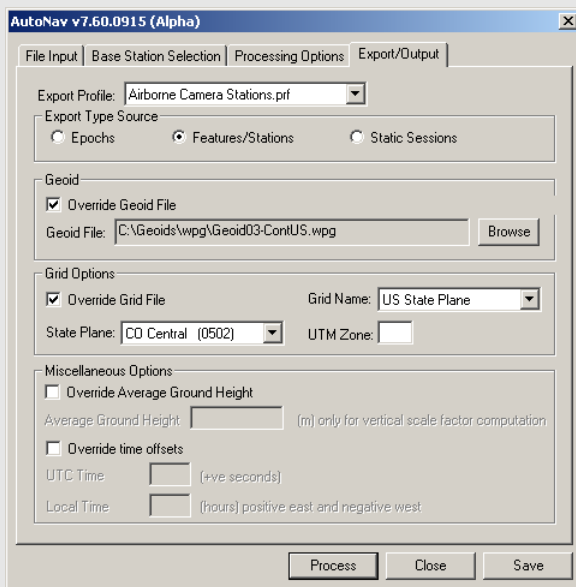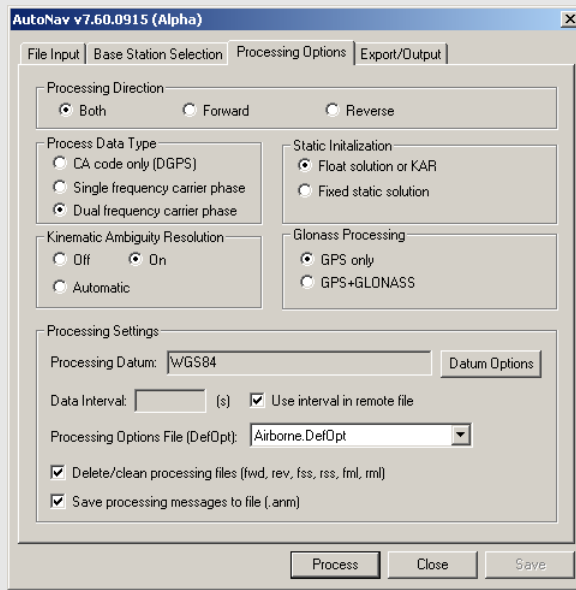
Processing Options

The options available on this tab pertain to the differential processing of the data. Only those options not previously discussed in *Section 2.5* on *Page 61* will be described here.

Processing Settings

> ### *Delete/clean processing files*
> This option forces the program to delete all of the listed file types upon completion of processing.
>
> ### *Save processing messages to file*
> This option ensures that the ANM file is stored to disk once processing is finished. This file contains all the messages displayed in the *AutoNav Processing* window. The ANM file can be very useful for troubleshooting any problems which may occur.
>
> ⊠   Users cannot specify a time range for processing and, therefore, the entire remote file will be used.

Export/Output

The *Export/Output* tab allows you to control the parameters pertaining to the creation of the output file that is written once processing is complete.

See *Section 2.7.4* on *Page 107* for information regarding the settings available here.

> ⊠   The output file created will be given the same name as the project. The file extension, however, is dependent on the *Export Profile* selected.
>
> ⊠   The *Geoid*, *Grid* and *Miscellaneous Options* must be set if the selected profile requires these parameters for input.

6.5   Interactive Windows

AutoNav Processing

Once the project has been successfully set up, and the *Process* button clicked, the *AutoNav Processing* window appears to keep you informed on the status of the program.

Processing Information
The *Remote* field in this box indicates which remote file is currently being processed. The *Stage* field indicates which step the program is at. The *Information* field indicates how many base stations are being used for processing.

The *Messages* window contains information being relayed from the program. Before processing begins, this window displays messages to inform you the current stage of the program is at. For example, if data is being obtained from the Internet, the percentage of data downloaded will be displayed.

Once downloading is complete, additional messages appear regarding the decompression and interpolation of the data. Once processing has started, this window echoes all the messages appearing in the *Processing Window*, called from GrafNav. All the messages displayed here are stored in the ANM file, and can be saved to disk under the *Processing Options* tab. This file should be consulted if any problems arise during processing.

Processing List of Remotes
This window displays the list of remote files to be processed, along with a status indicator to inform you whether or not processing has been successfully completed.

Chapter 7   File Formats
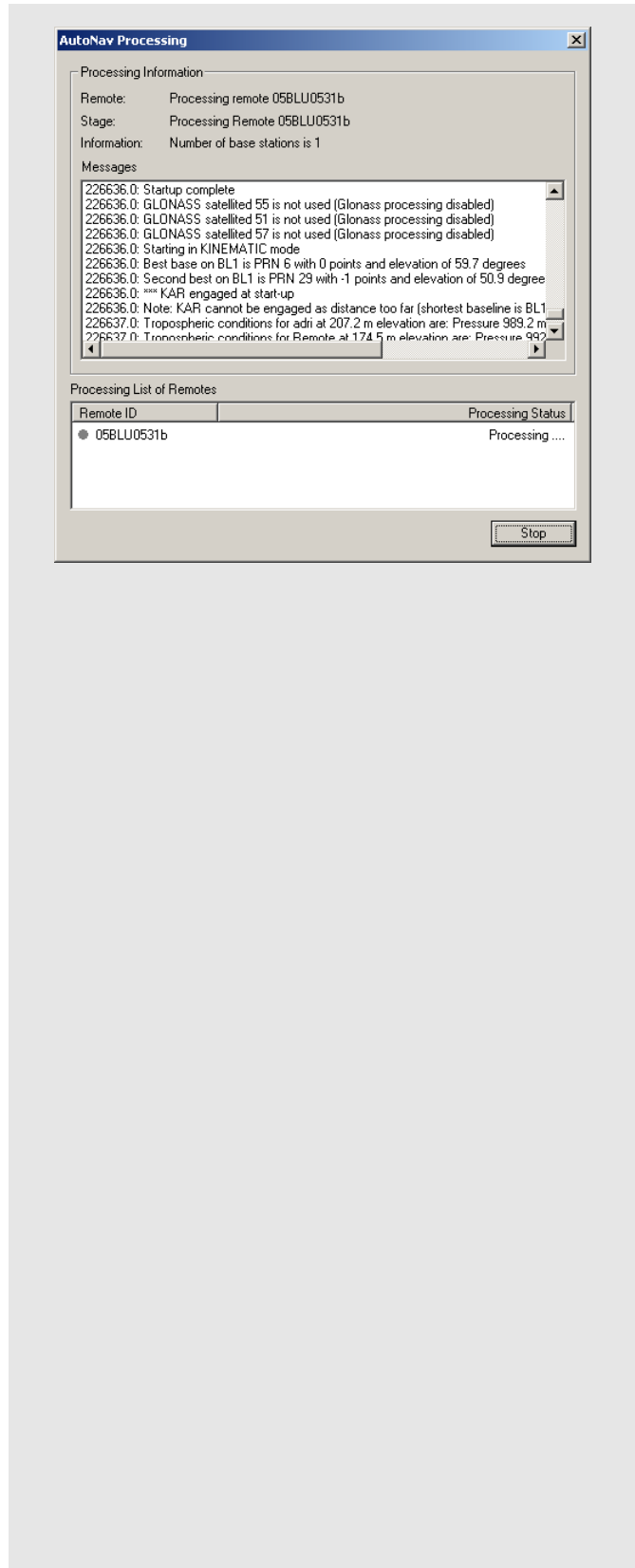
7.1   Overview of the File Formats

7.2   CFG File

The configuration (CFG) file stores all the options in a project. It is rare to need to edit a CFG manually. However, such a situation arises when using callgps, which is the command-line processor. When editing a CFG file, the user must be careful to follow the exact syntax. To learn the commands of CFG files, the user should look at those created by GrafNav and refer to Appendix A for a list of all the commands and their meanings.

7.3   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.

7.3.1   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, as well as additional header information (i.e. receiver information, software name, and version number). *GPBView* is a useful utility for inspecting and modifying GPB files.

Users can export this file to ASCII from the *GPBViewer*, or convert to RINEX via the *GPB to RINEX* utility.

Information contained in the records

Position Record
Contains the receiver-computed latitude, longitude, height and clock offset. It also contains the correct GPS time (seconds since Sunday), and status bits for position validity and process mode (static or kinematic). The new format handles times not on the whole epoch better.

Measurement Record
Contains the measurements for each satellite, including the PRN number, C/A code range, L1 phase, L1 phase rate (Doppler), L2 phase, P2 code range and locktime. For those fields that do not exist, zero is present. The new format also contains space for C/N0 of L1, C/N0 of L2, L2 locktime and P1 range.

7.3.2   STA File

New Station File Format

As of Version 6.03, the format of the station files has changed.

⊠   The old station file format remains compatible with the new software. However, any changes to such a station file will be saved in the new format. The new format has two possible file extensions: NST or STA. The new station file format is described here:

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, RTK=float/fixed not known, SP=single point, DGPS=DGPS, FIX=known)
Std:	*SdE SdN SdH*	Standard deviation in meters
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,
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)
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
}		

Another new data type handled in the station format is an RTK epoch, where every epoch can be recorded.

RTK {

*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, 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
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.

7.3.3   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

7.3.4   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.

7.4   Output Files

This section discusses some of the different output files that are created when processing with Waypoint's software.

7.4.1   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 61* 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 61* 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 8.5.5* on *Page 222* 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 61* 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 92* for help.

7.4.2   FSS & RSS Files

The *Static Session Summary* files present a summary of the float, fixed static and KAR 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 processing settings will not be displayed if *Print input settings to static/KAR summary* is disabled. See *Section 2.5* on *Page 61* for help. 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 KAR summary record is the only output. When doing kinematic processing without the use of KAR, 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 KAR summary record as shown below. Note that if kinematic processing is used without KAR, 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!"
    }
```

7.4.3   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 61* 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-height*	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
}

7.4.4   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 61* 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 107* for additional information.

8.1   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.
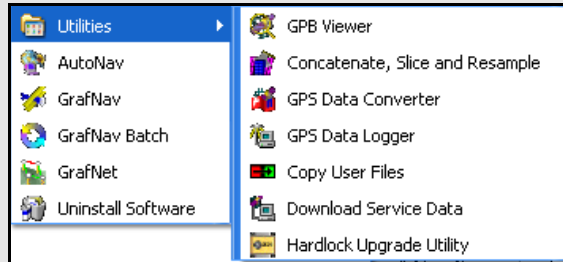
8.2   GPB Viewer Overview

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.

8.3   File

8.3.1   Open

Any GPB file can be opened with this feature.

⊠   If the GPB file is corrupt, *GPBViewer* will prompt you for permission to fix the file.

8.3.2   Close

This feature will close the GPB file without exiting from *GPBViewer*.

8.3.3   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.

8.3.4   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 four 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.

8.3.5 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.

8.3.6 Exit

Exits the program.

8.4   Move

This menu provides various options to move through the GPB file. These methods are listed in the shaded box.

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 Chapter 7* on *Page 205* for a definition of the format.

Move Menu Options

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.

> ⊠   You will find it easier to scroll through the GPB file using the shortcut keys, which are 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.

8.5   Edit

Several options under this menu make permanent
changes to the GPB file. You will be 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 7.3.1* on *Page 205* for additional
information.

8.5.1   *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 following 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.

Start Location
Use in conjunction with *All epochs* and *Specified
Epochs*, under *Epochs to Convert*. Determines the
starting point of the conversion.
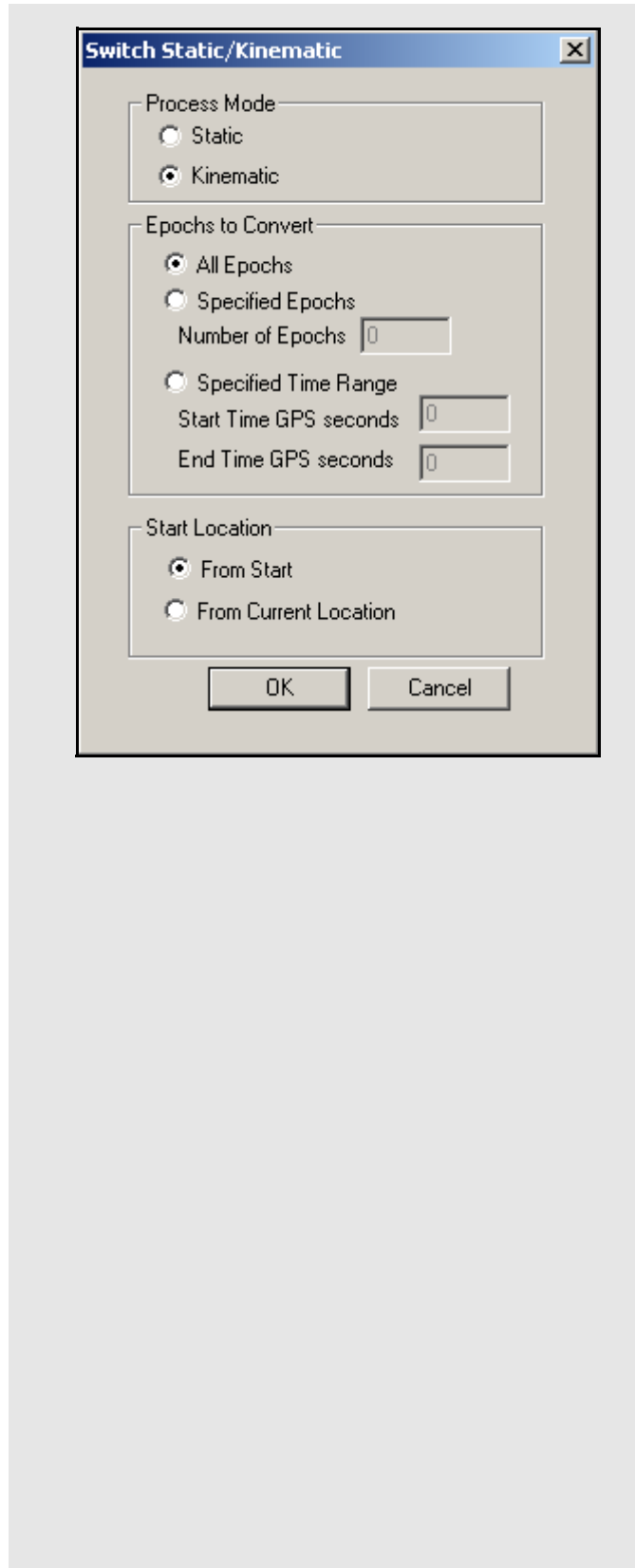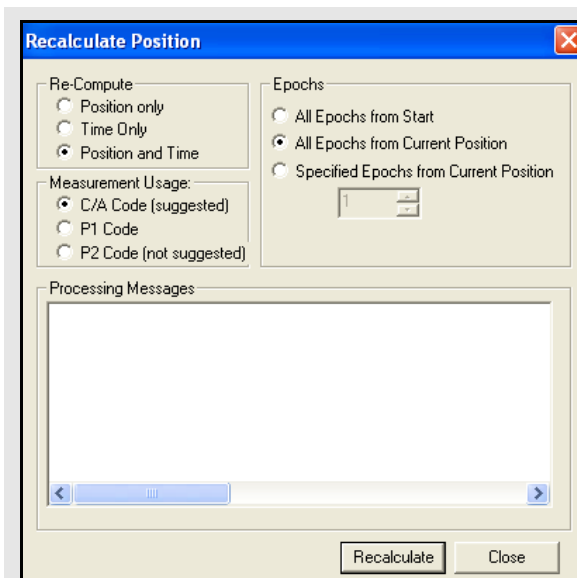
When to recalculate position and time:

- 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.

8.5.2   Recalculate Position and Time

Instances where this feature is useful are listed in the shaded box. It allows for a cycle slip to be removed or induced on any or all satellites at a given epoch. If adding a cycle slip, the locktime for the specified satellite(s) will be set to zero. This can be done at any epoch where a locktime is greater than zero.

8.5.3   Adding or Removing Cycle Slips

Only remove cycle slips at an epoch where the locktime is zero and there is a valid locktime for the satellite of interest at the previous epoch. Using this feature increments the locktime appropriately for the current epoch onwards, until the next loss of lock.

⊠ Use this feature carefully because the changes can cause problems during processing.

8.5.4   Disable Satellite (s)

If a data record is corrupt, it can be eliminated with this feature. When this option is engaged, the program will zero the pseudorange, removing the satellite from any subsequent processing that might take place using this file.

8.5.5   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.

8.5.6   Align Epoch Time

This feature lets you specify 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.

8.5.7   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 regarding 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.

8.6   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.

8.6.1   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.

Enabling the *Copy ephemeris files* and *Copy station files* options creates output EPP and STA files identical to those associated with the input GPB file.

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 should only be performed on static data. Vehicle motion is not well characterized by the polynomials used so its interpolation is unreliable.
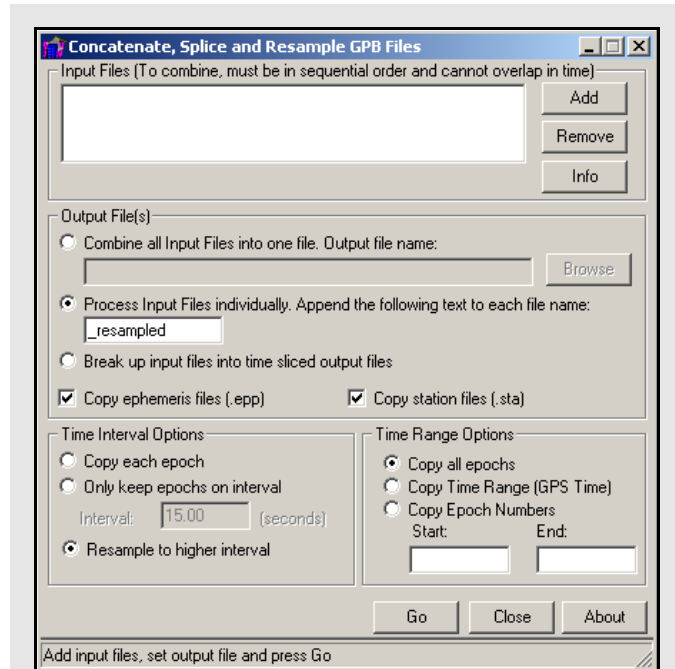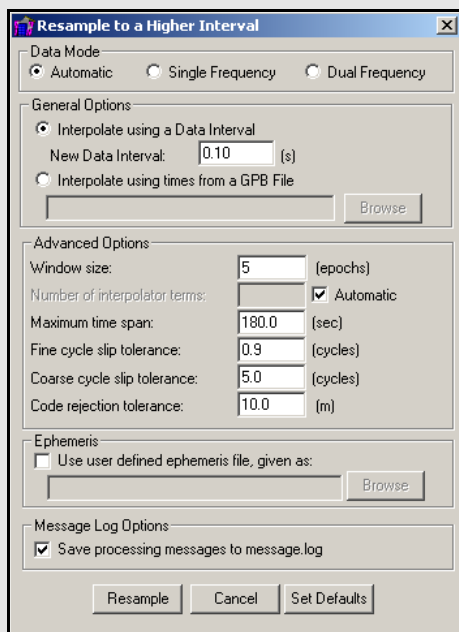
Advanced options:

Window size
Defines the range of data used for interpolation. Should normally be set between 4 and 6 because very large windows could cause problems, especially data files with large intervals.

Number of interpolator terms
Defines the number of Chebychev polynomial coefficients used for the interpolation. Normally, a value close, but not larger than, the *Window Size* is acceptable.

Maximum time span
Prevents the interpolator from using data across too high of an interval. Currently, three minutes is the default but higher values are required for large interpolation windows with coarse input data rates.

Fine Cycle Tolerance
If a cycle slip larger than the value specified here is detected, then the interpolation is not performed on this satellite.

Coarse Cycle Tolerance
Cycle slips can cause the interpolation to have problems so a coarse detector is implemented. This value should not be lowered too much because pseudorange noise could be mixed up with carrier phase errors.

Code Rejection Tolerance
Any satellite with a code residual greater than the value specified here will not be interpolated. This value may need to be increased for noisy data sets, or for receivers which do not make accurate pseudorange measurements.

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 selected for resampling purposes. Splicing a file would require the selection of either *Copy Time Range* or *Copy Epoch Numbers*.

Resampling a file will prompt the *Resample to a Higher Interval* window, shown the shaded box.

⊠Resampling should only ever be performed on static data.

Data Mode
Defines the measurement quantities to be interpolated.

General Options
There two choices for determining the interval of the output file include the following:

Interpolate using a Data Interval
Defines a specific interval for data resampling.

Interpolate using times from a GPB File
To have the output file contain data at the same epochs as a different GPB file, select this option. This selection is particularly useful for receivers that do not make their measurements on the whole epoch, such as Sirf or Parthus GSU-II.

⊠Any gaps in the chosen file is also reflected in the output file.

Advanced Options
The following settings are available:

Ephermeris
Ephemeris data is required to resample a GPB file. Normally, use the EPP file associated with the input. If this file does not exist, or is incomplete, specify an alternate EPP file.

⊠Interpolating 30-second data adds 1 to 2 cm of noise. Interpolation of 5-second data or higher adds almost no error. When processing data interpolated from its original interval of 30 second, KAR may not work. Regardless, when processing, enable the *Only search on exact interval* option and set the *Search on data interval* setting to the data interval of the original source file, under the *KAR 2* tab of the processing options. See *Page 77* for more information.

8.7   GPS Data Converter Overview

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 GPS data from numerous receivers and is available in all of Waypoint's programs. The supported receivers are listed in *Section 8.7.2* on *Page 226*.

8.7.1   Convert Raw GPS data to GPB

Receiver Type
Choose the receiver used to collect the data. Otherwise, leave the selection at *Unknown/ AutoDetect.*

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.*
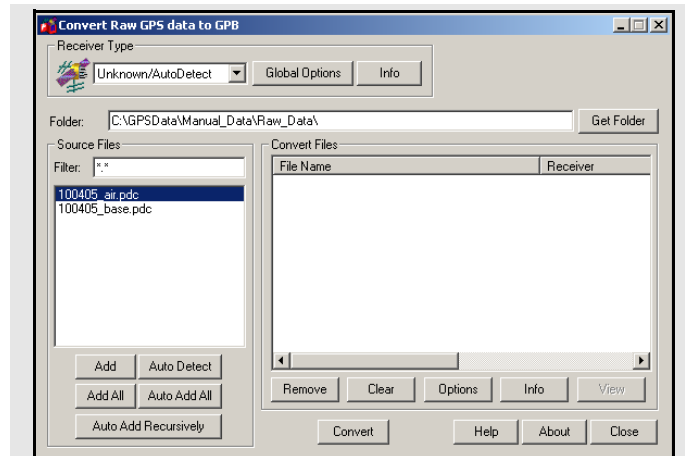
Receiver type options:

Global Options
These options depend on the type of receiver. Options Selected options are applied to all 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.

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 detectable.

Auto Add Recursively
Auto-detects on all files in the immediate folder and its subfolders. A maximum of 128 files can be added.
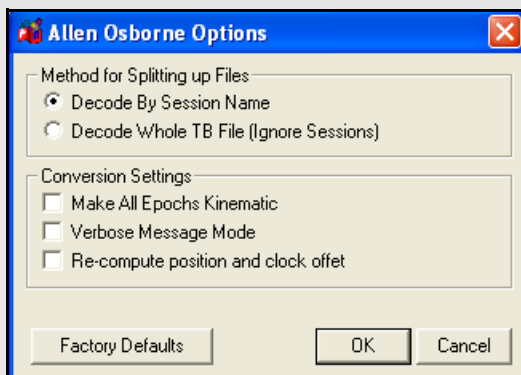
AOA methods for splitting up files:

Decode my Session Name
Decodes the TB file based on session marks inputted into the receiver.

Decode Whole TB File
Decodes the entire TB file with the assumption that all the data collected was from one session

AOA conversion settings:

Make All Epochs Kinematic
Entire file is set to kinematic mode.

Verbose Message Mode
Alerts you of additional warnings and errors that have occurred.

Re-compute position and clock offset
Enable this option if the clock shift data is corrupt, or positions records are not present.

Conexant Jupiter general options:

Make all epochs Kinematic
Entire file will be set to kinematic mode.

Re-compute position and clock offset
Enable this option if the clock shift data is corrupt, or if positions records are not present.

Keep epochs where recalculation failed
If time recalculation failed, the measurements may cause problem. Enable to ignore records in this case.

Do not check data record checksum
Enable to ignore record integrity checks.

Conexant Jupiter ephemeris options:

Use alternate ephemeris file
Use EPP file from another source.

Ignore Jupiter ephemeris records
If many corrupted records exist, the ephemeris record, #1102 might be unusable.

8.7.2 Supported Receivers

This section discusses the receivers that are currently supported by the *Raw GPS Data to GPB* converter. This information includes the conversion options, as well as the supported formats and records for each receiver.

Allen Osborne Associates (AOA)
⊠The converter for this receiver is only available in the AOA version of the software.

Turbo Binary (TB) files can be converted to GPB using this utility. Normally, one TB file will contain data from many sessions (or even days) so the decoder must split the files up to be compatible with the software and look at the Begin Session and End Session marks within the TB file. These are created when you mark the beginning and end of a session. The session name entered in the receiver will be used to name the file, with the Julian day number appended to it.

Method for Splitting Up File
The two choices are listed in the shaded box.

Conversion Settings
The three options are listed in the shaded box.

Conexant Jupiter
Due to timing issues, the carrier phase on this receiver is not usable so this is a code-only receiver. Ephemeris measurements are in record #1102, use record #1000 for position measurements.

The following options are available:

Time Skewing
The following options are available:

Leave measurements raw
Use time data as it is found in the raw data.

Skew to whole second using linear interpolation:
Shift to integer second.

Skew to whole second using polynomial
Shift to integer second.

Ephemeris Options
The options are in the shaded box.

Conexant NAVCOR

Make all epochs Kinematic
Entire file will be set to kinematic mode.

Skew measurements to whole second
Shift to whole second.

Ignore data from secondary (alternating) channel
Fifth channel on this receiver alternates between remaining satellites. Enable this to ignore.

Correct measurements for satellite clock
Should be disabled.

Use alternate ephemeris
Enable if ephemerides data missing.

Corrected ranges for dual antenna window placement
For CSSI users only.

CSI SLX and DGPS-MAX

Table 18 describes the supported records.

Make all epochs kinematic
Enabling this option sets the entire output GPB file to kinematic mode. Otherwise, it will be set entirely to static mode.

Javad & Topcon

⊠ This converter supports GLONASS-enabled receivers.

Table 19 describes the supported records.

The following describes the options available for this converter:

Decode GPS Only
This option forces the decoder to ignore all GLONASS data.

Make all epochs kinematic
The entire file will be set to kinematic mode.

Use code and carrier from P1 instead of C/A
Measurements from P1 can be used instead, but this is not recommended.
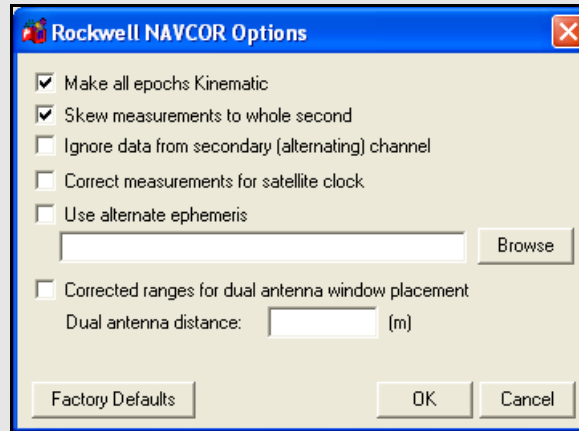
Table 18: Records Supported for CSI SLX and DGPS-Max

Record	Type	Comment
96	Measurements	Required
95	Ephemeris	Required
1	Position	Recommended for GrafNet users

Table 19: Records Supported for Javad & Topcon

Record	Type	Comment
RC, rc	C/A Code Measurement Block	RC suggested
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
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	
OEM	Measurements	Compressed record; more robust

Table 20: Files Supported for Leica SR

File	Type	Comment
DS*.obs	Measurements	Required
DS*.eph	Ephemeris	Required
DS*.cmp	Position	Recommended for GrafNet users
DS*.ttp	Station	See **Notes**
DS*.evt	Event Mark	
DS*.chn	Static Chains	
*.TDU	Event Mark	Produced by TDU units running with SR series; read in directly by software

Table 21: Records and Files Supported for Leica MX

Record/File	Type	Comment
2	Measurements	Required for 6 channels
3	Measurements	Required for 12 channels
8	Position	Recommended for GrafNet users
200 201 202 203	Ephemeris	One of these records is required
*.EV0	Event Mark	Produced by ASCOT system with MX series; read in directly by software

⊠   One limitation of the SR decoder is the inability to copy alphanumeric station names properly since only the numeric index is retained. This occurs in the newer firmware versions (i.e. Version 3.0 and on). The value retained is in an index of a list of station names that are contained in the Leica file system. To circumvent this, an IDEX file can be loaded directly into GrafNav for kinematic processing, or else into the decoder directly for static chains. See *Page 46* for help creating an IDEX file.

Use JPS locktimes 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.

Ignore entire epoch if check failed on element
GPS data for the entire epoch is ignored when a checksum error is reported for any of the incoming records. Otherwise, only the affected data is ignored.

Use SAVE marker to store sites to .sta file
Markers are saved to STA file.

Reject entire record if L2 phase is missing
Enable if logging rate is high.

Verbose messaging mode
Alerts of additional warnings and errors that have occurred.

If GRIL and OEM Format are Mixed
Allows you to choose which format should be used in the event that both are mixed.

Leica SR and MX
Leica raw GPS measurement data can come in two types of formats. The MX series data files are produced by the MX 4200 and 9200 receivers while the SR series data formats are produced by the SR-299, 399, 9400, 9500 sensors. The SR files usually start with DS. The decoder automatically detects if the files are from the SR or MX series.

The *Table 20* describes the files supported for the SR series and *Table 21* describes the records and files supported for the MX series.

Make all epochs kinematic
Entire file will be set to kinematic mode. Applies to MX format only.

Reject measurements that Leica declares bad
Leica's rejection flags are very sensitive, and better results can often be obtained by ignoring them. If bad measurements are a problem, this option should be enabled. Applies to SR series.

Breakup chains into separate files:
For SR files that contain more that one static session (chain) per file, this option splits the chains up into separate GPB files. You will be prompted for IDEX file. See the note in the shaded box.

Leica System 500

This decoder handles data from the System 500 or SR530 receivers.

Table 22 describes the supported records.

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 23 describes the supported records.

Re-compute position and receiver clock offset
Enable this option if the clock shift data is corrupt, or if positions records are not present.

Make all epochs kinematic
Entire file will be set to kinematic mode.

Use new GPB format
Converts data into the new GPB format.

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 information output
Alerts you of additional warnings and errors that have occurred.

Table 22: 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

Table 23: Records Supported for Leica 1200

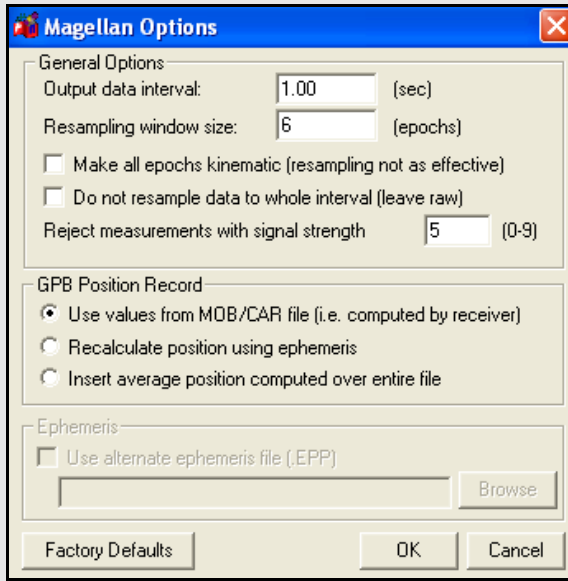| Record	Type	Comment
120	Measurements	Required
115	Ephemeris	Required
110	Position	Recommended for GrafNet users
109	Antenna Height	Written to STA file
113	Event Mark	Written to STA file

Table 24: 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

Magellan ProMark

General Options

> *Output data interval*
> Resample data to specified interval.

> *Resampling window size*
> Number of epochs used for resampling operation. Not recommended for use with kinematic data.

> *Make all epochs kinematic*
> Sets file to kinematic mode.

> *Do not resample data to whole interval*
> If data is kinematic, use the *Concatenate, Splice and Resample* utility to resample the data using the base station interval. See *Section 8.6* on *Page 223* for help.

> *Reject measurements with signal strength*
> Reject very poor measurements. Users should consult receiver documentation.

GPB Position Record
The following options are available:

> *Use values from MOB/CAR file*
> Utilize position computed by receiver.

> *Recalculate position using ephemeris*
> Recompute position by decoder.

> *Insert average position computed over entire file*
> Use average of values compiled by receiver.

Ephemeris
If ephemerides are missing or incomplete in the raw data, enable the *Use alternate ephemeris file (.EPP)* option to specify an outside source.

NavCom
Table 24 describes the supported records.

Make all epochs kinematic
Entire file will be set to kinematic mode.

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**.**

Use new GPB format
Converts data into the new GPB format.

NovAtel CMC

This decoder handles data from the NovAtel CMC AllStar and SuperStar receivers. *Table 25* describes the supported records.

Make all epochs Kinematic
Sets file to kinematic mode.

Verbose messaging mode
Displays additional warning messages.

Reject satellites with low CNO
Satellites with low CNO will not be decoded.

Write new GPB format
Converts data into the new GPB format.

Table 25: Records Supported for NovAtel CMC

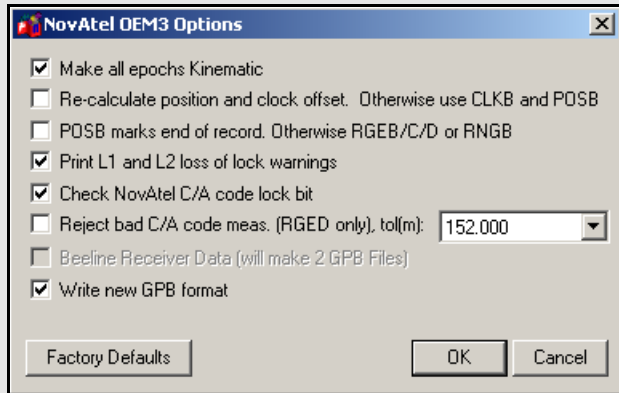| Record	Type	Comment
ID #23	Measurements	One of these records is required, but ID #23 is strongly recommended over the others
ID #13	Measurements (old style)	
ID #14	Measurements (old style)	
ID #15	Measurements (old style)	
ID #16	Measurements (old style)	
ID #20	Position	Recommended for GrafNet users; should be requested last
ID #22	Ephemeris	Required

Table 26: Records and Files Supported for NovAtel OEM2, OEM3 and SoftSurv

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**
*.orb	Ephemeris	Required for SoftSurv

⊠ 1. If using receivers with standard correlators, you should either request the CLKB record, or else re-calculate the position and clock information. See description of the decoder options below. The clock correction (offset) is needed for processing. This record is also suggested for users logging data right from power-up. The CLKB record should be requested 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.

NovAtel OEM2, OEM3 and SoftSurv

This decoder handles data from the NovAtel OEM2/Softsurv and the NovAtel OEM3 receivers. *Table 26* describes the supported records and files.

Make all epochs Kinematic
Sets the entire file to kinematic mode.

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. See Section 7.1.3.2 *Section 8.5.2* on *Page 222* 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. Consult NovAtel documentation for further information.

Beeline Receiver Data
Splits Beeline data into two files for primary and secondary antennas.

Write new GPB format
Converts data into the new GPB format

NovAtel OEM4 / OEMV

Table 27 describes supported files.

⊠ Contact Waypoint to obtain the OEM4 on-board program. See *Page 15* for information.

⊠ Almanac data can be used in *Mission Planner*. See *Section 2.8.11* on *Page 133* for help.

Make all epochs Kinematic
Entire file will be set to kinematic mode.

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.

Report L2 cycle slips
Alerts you of L2 phase lock problems.

Verbose messaging mode
Displays additional warning messages.

Ignore measurement validity check
Utilizes more measurements by ignoring NovAtel data validity checks.

Write new GPB format
Converts data into the new GPB format.

Extract inertial SPAN data:
This option is only for users of NovAtel's SPAN Technology, and is only available in Inertial Explorer. As such, users should refer to *Inertial Explorer Version 7.70 Manual* for details.

Time tolerance for synchronizing BESTPOS and RANGE records
Assigns position to GPB record if time difference between measurement and position records is less than tolerance.
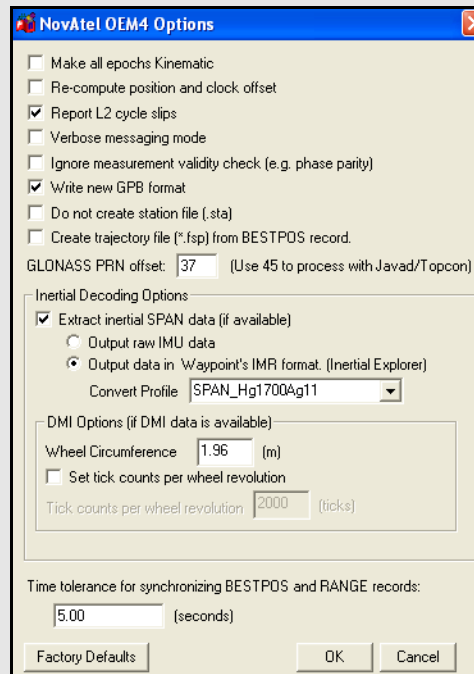
Table 27: Records Supported fro NovAtel OEM4

Record	Type	Comment
RANGEB (ID #43)	Measurements (expanded)	One of these records is required
RANGECMPB (ID #140)	Measurements (compressed)	
UCRANGE (ID #64000)	Measurements (Waypoint Ultra Compressed)	See **Note 1**
RAWEPHEMB (ID #41)	Ephemeris	Required
ALMANACB (ID# 73)	Decoded Almanac	Written to EPP file; see **Note 2**
RAWALMB (ID #74)	Raw Almanac	
BESTPOSB (ID #42)	Position	Recommended for GrafNet users
MARKTIMEB (ID #231)	Event Mark Time	Written to STA file
PRPCLKMODELB (ID #71)	Propagated Clock Model	
TIMEB (ID #101)	Receiver Time Information	
IONUTCB (ID #8)	Ionospheric Parameters	
RAWIMUSB (ID #325)	IMU Measurements	SPAN Technology users only
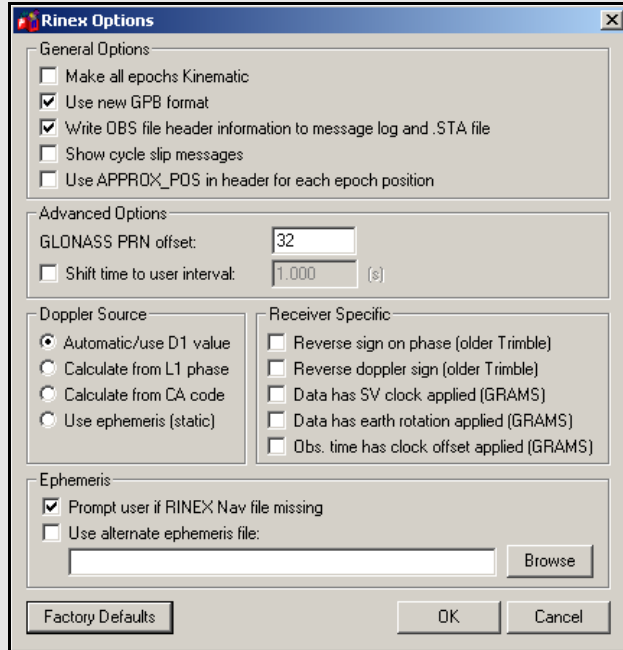
Table 28: Files Supported for RINEX

File	Type	Comment
*.yy*o, *.obs, *.rxo	Measurements	One of these files is required
*.yy*d	Measurements (compressed)	
*.yy*n, *.nav, *.rxn	Ephemeris	Required

✉   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.

RINEX

Receiver Independent Exchange (RINEX) data consists of two ASCII files. The first is referred to as the observation file and contains the measurement data. The second file is the navigation file and contains ephemeris data.

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.

Table 28 describes the supported files.

The following describes the options available for this converter:

General Options
Make all epochs Kinematic
Entire file will be set to kinematic mode.

Use new GPB format
Converts data into the new GPB format.

Write OBS file header information to message log and .STA file
Saves header information from observation file to message log and station file. Can be useful for determining receiver and antenna type.

Show cycle slip messages
Prints L1 and L2 cycle slip messages.

Use APPROX_POS in header for each epoch position
Uses approximate position from header in observation file for each epoch's position.

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.

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.

Receiver Specific
The following settings are available:

Reverse sign on phase (Trimble)
Some older versions of the Trimble software created RINEX files with incorrect signs on the phase measurements.

Reverse Doppler sign (Trimble)
Some older versions of the Trimble software created RINEX files with incorrect signs on the Doppler measurements.

Data has SV clock applied (GRAMS)
Data has earth rotation applied (GRAMS)
*Obs. time has clock offset applied (GRAMS)*
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.
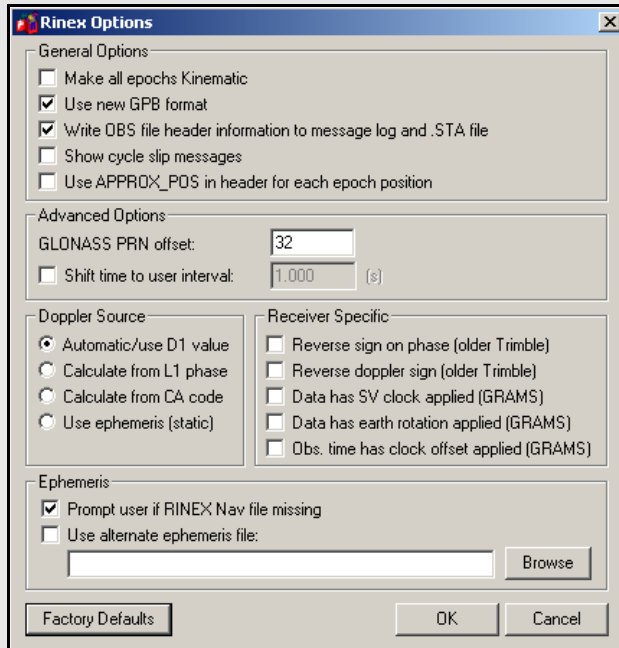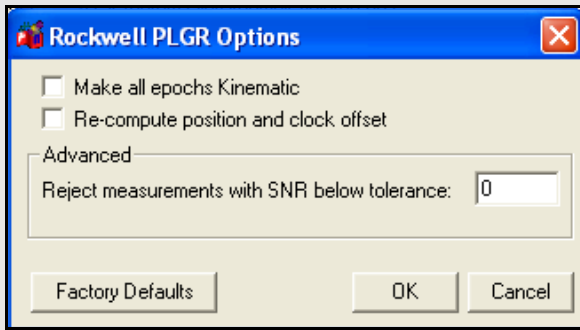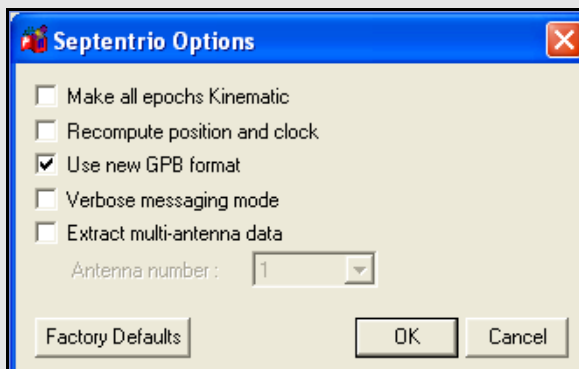
Table 29: Records Supported for Rockwell PLGR/MPE12

Record	Type	Comment
1102	Measurements & Ephemeris	Required. See **Notes**
1000	Position & Clock Offset	Recommended

⊠   In order to extract the ephemeris from record #1102, it must be logged at 1Hz.

Table 30: 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

Rockwell PLGR/MPE12

⊠This converter is available only in the Rockwell version of the software.

Table 29 describes the supported records.

Make all epochs Kinematic
Entire file will be set to kinematic mode.

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.

Advanced
   Reject measurements with SNR below tolerance
   Satellites with low CNO will not be decoded.

   ⊠Older versions of Rockwell Jupiter firmware did not make measurements on the even second. In order to make the data usable, the measurements need to be skewed to the even second by using Doppler measurements. Newer versions of the firmware have corrected this issue.

Septentrio SBF
Table 30 describes the records supported.

Make all epochs Kinematic
Entire file will be set to kinematic mode.

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.

Use new GPB format
Converts data into NEW GPB format.

Verbose messaging mode
Allows you to see additional warning messages.

Extract multi-antenna data
For multi-antenna applications only.

SiRF Binary

Table 31 describes the records supported.

General Options

Make epochs Kinematic
Entire file will be set to kinematic mode.

Verbose messaging mode
Allows you to see additional warning messages.

Reject satellite measurements with low C/No
Satellites with low C/No will not be decoded.

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 8.6.1* on *Page 223* 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.

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 8.6.1* on *Page 223* for help.

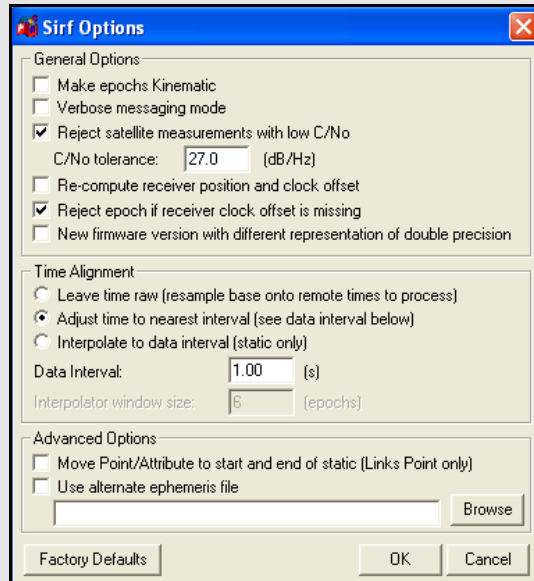**Table 31: Records Supported for SiRF Binary.**

Record	Type	Comment
28	Measurements	Required
15	Ephemeris	Required
7	Clock Offset	Recommended
2	Position	Recommended for GrafNet users

Table 32: 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.

Thales B-File

This decoder handles Thales data that has been downloaded using the Thales utility. Log this data into internal receiver memory. *Table 32* describes the supported files.

Thales (Achtech) Receiver Type
Selects the receiver used to collect the data. If auto-detect does not work, then select the receiver manually.

General Options

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.

Make epochs Kinematic
Entire file will be set to kinematic mode.

Ignore questionable L2 phase
Allows for processing of highest quality L2 data only. Should be enabled if KAR is having difficulties.

Verbose messaging mode
Allows you to see additional warning messages.

Write new GPB format
Converts data into the new GPB format.

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.

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.

Thales Real-Time

This decoder converts Thales Real-Time (DG16, G12, or Super C/A) data. The real-time data is formed when data is logged externally from the receiver using a utility like as WLOG or another custom data logger. *Table 33* describes the supported records.

General Options

Make all epochs Kinematic
Entire file will be set to kinematic mode.

Recompute position and time
Enable this option if the clock shift data is corrupt, or if positions records are not present.

Write new GPB format
Converts data into the new GPB format.

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 (e.g. Sensor II) output locktimes with a different resolution. Enable this option to output the locktime value.

Parthus MACM Settings
The following settings are available for users 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, this option should be enabled.

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 8.6.1* on *Page 223* 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 (e.g. Parthus, GSU-2) to specify an outside EPP file.

Table 33: 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 (i.e. 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.

Table 34: 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 35: Files Supported for Trimble DAT

File	Type	Comment
*.dat	Measurements, Ephemeris and Event Marks	Required

Table 36: Records Supported for Trimble Real-Time

Record	Type	Comment
0x0	Measurement	Required
0x1	Position	Recommended for GrafNet users
0x2	Ephemeris	Required

Thales DNSP

Table 34 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.

Make all epochs Kinematic
Entire file will be set to kinematic mode.

Write new GPB format
Converts data into the new GPB format.

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 35* describes the supported files.

Make all epochs Kinematic
Entire file will be set to kinematic mode.

Write new GPB format
Converts data into the new GPB format.

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.

Trimble Real-Time

Data captured directly from a Trimble 4000-5800 receiver can also be converted to GPB using this decoder.

The *Table 36* describes the records supported.

Make all epochs Kinematic
Entire file will be set to kinematic mode.

Verbose messaging mode
Allows you to see additional warning messages.

Write new GPB format
Converts data into the new GPB format.

Trimble TSIP

Data in Trimble's TSIP format is converted with this decoder. Receivers that support this format include Ag20, MS-750 and MD-950. *Table 37* describes the supported records.

Make all epochs Kinematic
Entire file will be set to kinematic mode.

Verbose messaging mode
Allows you to see additional warning messages.

Reverse sign on receiver clock bias
Opposite sign will be applied to receiver clock bias.

Trimble TIPY

This decoder converts data from Trimble's Force 5 receiver. Carrier phase measurements may not be usable. *Table 38* describes the supported records.

Make all epochs Kinematic
Entire file will be set to kinematic mode.

Skew measurements to top of second
Shifts times to whole second to make differential possible. However, you may also wish to consider leaving the times raw and interpolating the master file onto the remote. See *Section 8.6.1* on *Page 223* for help.

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.

Input alternate ephemeris
If ephemeris missing or incomplete, enable this setting to specify an outside EPP file.

Shift (corrected) measurement time
Apply time correction to measurements. This is used to correct a bug in older versions of the Trimble firmware.

U-Blox

Table 39 describes the supported records.

Make all epochs kinematic
Entire file will be set to kinematic mode.

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.

Use new GPB Format
Converts data into new GPB format.

Verbose messaging mode
Allows you to see additional warning messages.

Table 37: Records Supported for Trimble TSIP

Record	Type	Comment
0x9A	Measurements	One of these records is required, but 0x9A is recommended.
0x6t	Measurements	
0x5A	Measurements	
0x58	Ephemeris	Required
0x4A	Position	Single Precision
0x8A	Position	Double Precision

Table 38: Records Supported for Trimble TIPY

Record	Type	Comment
0xAE	Measurements	Required
0x84	Position	Recommended for GrafNet users
0x99	Ephemeris	Required
0x44	Dilution of Precision	Not used in post-processing

Table 39: 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

8.8   GPS Data Logger Overview

All of Waypoint's software packages include *WLOG*, a WIN95/98/2000/XP/NT 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 29* for more information on supported receivers.

WLOG configures the GPS 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.
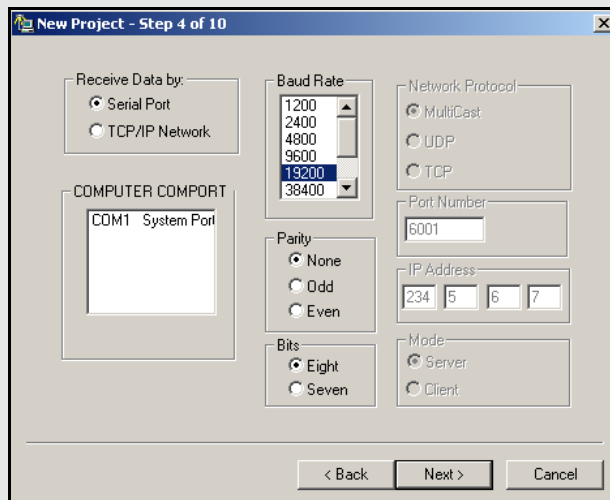
How to log data with WLOG

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**.

8.9   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 con't

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 (i.e. size of data records, data logging rate, etc.). 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*.
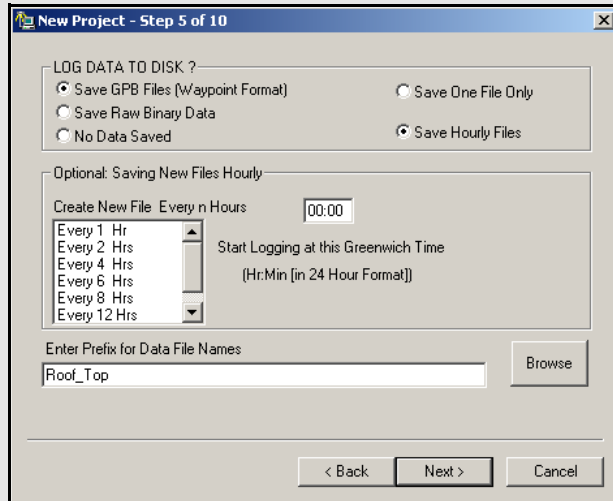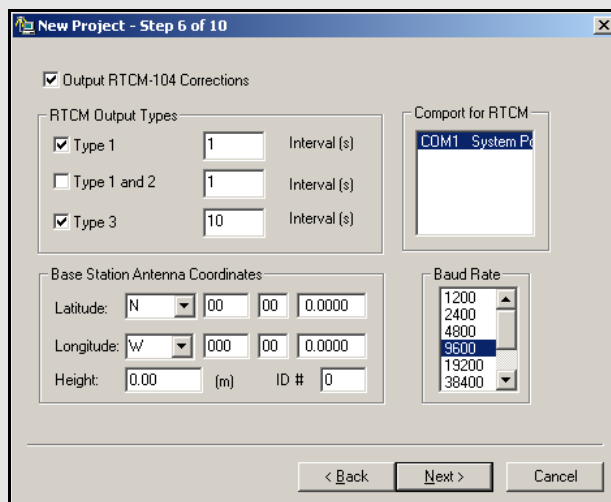
How to log data with WLOG con't

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 con't

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.

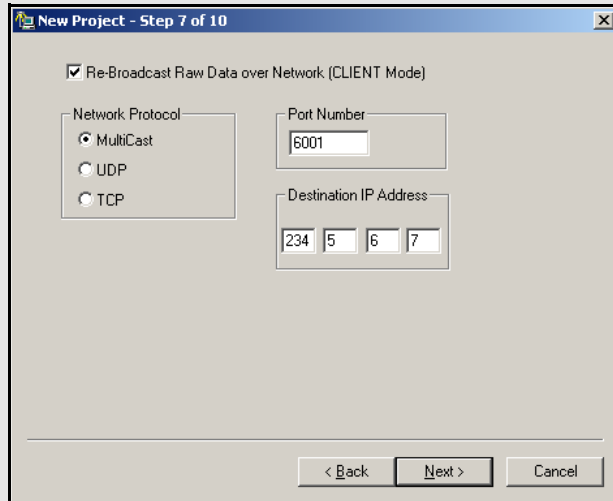19. Select the desired type of RTCM output and the interval for each:

> **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 con't

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*.
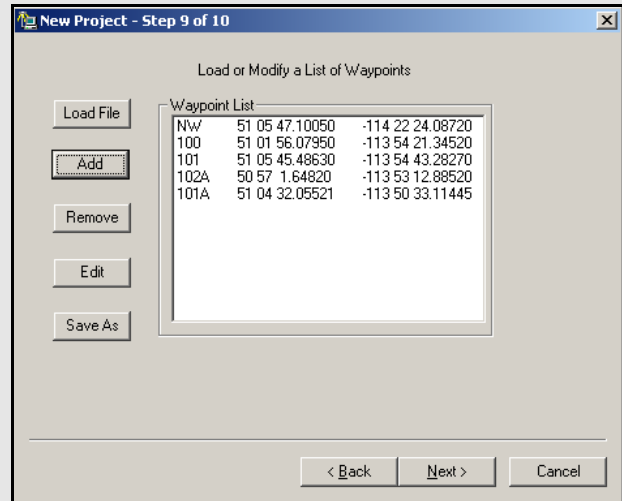
How to log data with WLOG con't

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 ways:

    • 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.

    • Alternately, waypoints can be added by click the *Add* button. These waypoints can be edited, removed, or saved to a file of their own for later use.

26. Click *Next*.
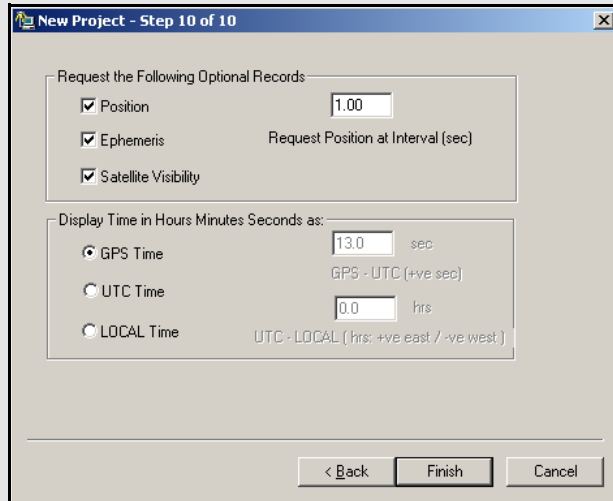
How to log data with WLOG con't

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*.
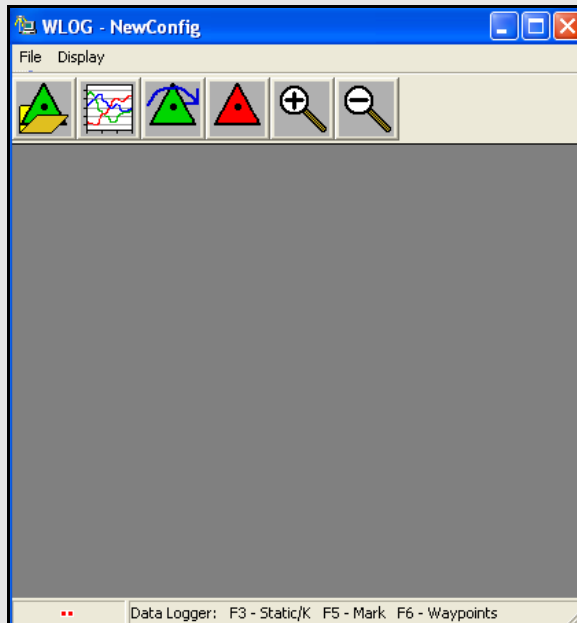
If these steps have been followed successfully, *WLOG* will start logging data. If the screen is blank, and the program appears to be inactive, initialization was not successful.

8.10 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.

8.11 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.

8.12 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 are represented on this plot by triangles.

8.13 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.

8.14 Events Menu

Static/Kinematic *(Shortcut key = F3)*

This feature toggles the mode between static and kinematic. By default, the mode will be set to static once logging commences, so needs to be changed 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.

Any stations that are occupied during the survey should be marked with this feature. Stations can be marked while the receiver is static or kinematic mode. Any station marks added will be time-tagged according to the GPS time at which the feature was invoked, and they will be written to the STA file.

3. 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.
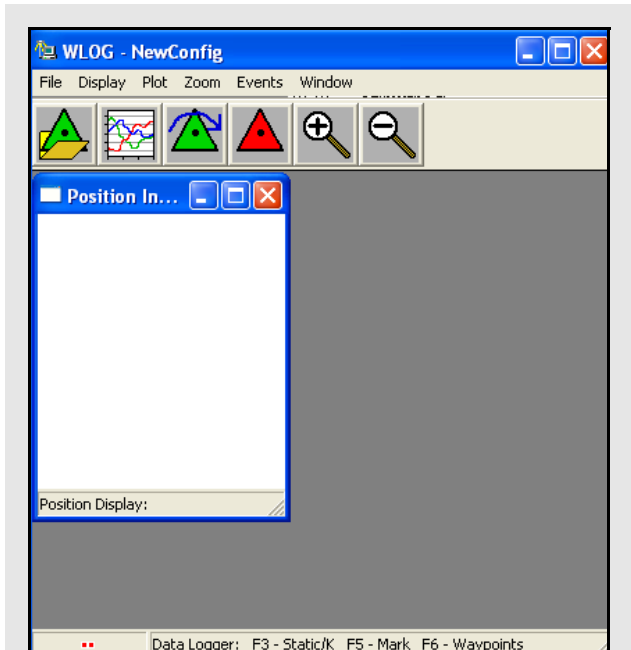
8.15 WinCE Data Logger Overview

How to install CELOG

1. Copy three files to the root directory of their CE device using Active Sync or whatever generic file transfer service is provided by the CE manufacturer.

   The three files required are the following:

   > *CELOG.EXE,*
   >
   > *SIOGPS.DLL*
   >
   > *VARDISP.WPD*

   ⊠ To display State Plane coordinates, *STPLN83.BIN* will also be required in the root directory.

How to start logging data with CELOG

1. Following installation, click on *CELOG.EXE*.

2. Select *File | New Project* and give the project a name. The file will be stored given a IN extension. If a project already exists, use *File | Open Project* to open it.

3. Select *File | New Project* to launch a series of windows to guide you step-by-step through the process of creating a project. All of these windows are made accessible for existing projects as well, in case you wishes to make modifications.

4. Under the *Rcvr* tab, choose the appropriate receiver type. Make sure to enter the data interval to log at.

5. Select the port on the GPS receiver from which the data is sent.

6. NovAtel and Ashtech receivers support ASCII commands. Any extra commands which *CELOG* does not send the receiver may be entered under the *Rcmd* tab. *CELOG* will send its normal configuration for that command set and then transmit any extra commands typed here.

   ⊠ This step may be skipped for any receiver type that does not support an ASCII command set.

7. Set up the serial or network communication parameters for logging data from the GPS unit under the *Com* tab.

   ⊠ In most cases, data transfer will be via serial cable. Defaults of 8 bits and no parity are assumed. Baud rates up to 115200 are supported. Note that TCP network protocol is also supported in the event that GPS data is input via a standard network connection.

All of Waypoint's software packages include *CELOG*, a data logger that supports various receivers from NovAtel, Ashtech/Thales, Trimble, CMC, Rockwell Jupiter, Javad/Topcon, Parthus, CSI, Navcom, and Ublox. See to the *Table 2* on *Page 29* for more information on the specific supported receivers.

There are 3 components to the WinCE data logger:

CELOG.EXE
The graphics interface.

SIOGPS.DLL
Performs serial/network communications and data decoding.

VARDISP.WPD
A script file that can be built or modified with a text editor to build or change your text display windows.

CE data logging devices come in a variety of flavours. They have different CPUs and form factors. This makes a generic data logger very difficult to write. *CELOG* has been developed on the TDS Ranger - a CE unit which has a 320x200 screen pixel size and an ARM processor *CELOG* and *SIOGPS* can be compiled for other CPUs. The *VARDISP* script file allows you to define text display windows with an ordinary text editor. This lets you custom build text screen output windows to fit your display size. The *VARDISP* file and script format are described in Section 9.2.3 which focuses on getting started with the features of the CE data logging software.

8.16 Installing CELOG

To install the CE data logging software, follow the steps in the shaded box.

8.17 Getting Started with CELOG

This section examines all the steps required to begin logging data through *CELOG* by analyzing each screen encountered when creating a new project.

Log

The *Log* tab provides information concerning the format in which the data is to be saved to disk. *CELOG* will send the necessary configuration commands in order to force any of the given receivers to send measurement and position data out of the chosen port. This binary data will either be decoded by *CELOG* into Waypoint's GPB format, or else it will be stored byte-by-byte to disk in a binary file. This file can be decoded into Waypoint's format later on. You can also enter a name to be assigned to the saved file.

Grid

The *Grid* tab allows for the output of positions in different coordinate grids. Geographic coordinates are always available from the GPS receiver. However, depending on the grid chosen, geographic coordinates can be converted in real-time to UTM, TM or the State Plane coordinate systems. Specify whether they are in the northern or southern hemisphere prior to reading in a waypoint file.

If a coordinate frame is defined as anything other than simple geographic, that grid must be defined with relevant parameters. This is accomplished under the *Units* tab, and the *UTM*, *TM*, or *STP* tab, depending on the selection made in **Step 7**.

WP

Waypoints can be entered manually under the *WP* tab, or they can read in from a user-defined ASCII file. Any waypoints can be removed or edited here as well, and the modified list can be saved to disk.

Mode

Finally, the *Mode* tab allows you to define a static occupation period. This feature is typically used for a tree cover survey where some static occupations are present among the kinematic data. The static occupation feature will display a window during data logging which counts down until the session is finished.

Continuous static/kinematic is the normal mode of operation where the surveyor would perform a static occupation to start and then go to kinematic status for the remainder of the mission. Any marked points are marked while in kinematic mode and typically occupied for only a few seconds. Occupation mode allows you to set up at a station for some given length of time. At the end of the static period, *CELOG* prompts you to quit the static session and go directly back to kinematic mode.

How to start logging data with CELOG con't

8. Use the *Log* tab to provide information on the saved format and enter the name of the new file.

9. Choose a grid to output positions.

   ⊠ If a waypoint file is being loaded, *CELOG* will assume that the coordinates in the file will correspond to the chosen grid.

   ⊠ The *VARDISP.WPD* file allows display of a *North* and *East* variable. These values will be associated with the grid coordinate frame chosen under this tab.

10. With the *WP* tab, manually enter waypoints. You can also remove, edit, and save a modified list.

    ⊠ In order for a list of waypoints to be loaded, they must be contained within a properly-formatted ASCII file. That is to say, the file must space-delimited, and, if geographic coordinates are being used, must contain the station ID, as well as the latitude and longitude, in degrees minutes seconds or decimal degrees. Any grid coordinates, whether UTM, TM, or State Plane, must contain the station ID, followed by the northing and easting, in meters, feet, or US survey feet. Again, all fields must be space-delimited.

11. Define a static occupation period with the *Mode* tab

8.18 Variable Display File

VARDISP Variables

Gpstime GPS seconds of the week

Latitude Latitude in degrees, minutes, seconds

Longitude Longitude in degrees, minutes, seconds

Height Elevation as output by the GPS receiver

Epochs Number of measurement epochs since data collection started

Diskspace Number of free megabytes remaining on the device

Elev Elevation of the satellite in degrees above the local horizon

Prn PRN number of the given satellite

Az Azimuth of the satellite in degrees with respect to local north

Locktime Number of seconds of valid phase lock for a particular PRN – resets to 0 on loss of lock

East Easting as given by the defined grid. Grids can be UTM, TM or State Plane

North Northing as given by the chosen grid

Tosta If waypoints have been entered or read in from a file, this is the chosen waypoint ID to which you are navigating

Fromsta If a waypoint list is present, this is the waypoint that is being navigated from. The line between the **Tosta** and the **Fromsta** defines an along track/across track reference frame

Acrosstrack The distance left or right of a line joining the current **Tosta** and **Fromsta** waypoints

Alongtrack The distance along a line given by the **Tosta** and **Fromsta**

Todist The distance from the current position to the chosen **Tosta** waypoint

Toaz The azimuth from the current position to the chosen **Tosta** waypoint

Surveymode Static or kinematic. Define this from the *CELOG* menu or toolbar if you are performing kinematic surveys

Station If marking a point for static or kinematic occupation, this will be the name that is given to that marked point

Static_epoch If using Occupation Mode for marking a station, this is the number of measurement epochs that you have occupied that station

There are three components to the WinCE data logger:

1. *CELOG.EXE*: the graphics interface

2. *SIOGPS.DLL*: performs serial/network communications and data decoding

3. *VARDISP.WPD*: a script file which can be built or modified to enable you to build or change their own text display windows.

The reason to build or modify display windows is that a number of different screen sizes are used by various manufacturers of CE products. Hand-held CE units tend to be 320x200 pixels or 200x320 pixels. Palm-top CE devices are usually in the order of 640x200 pixels. Other variations might exist.

The *VARDISP* script file not only defines the text display for *CELOG*, but can be modified to display a given list of variables in any position on any defined window. *CELOG* only displays one window at a time. The window size is the default window size given by the CE device being used. For instance, those owning CE units with 200x320 displays may wish to output variables which are ordered in long columns and short rows. Alternately, users with 320x200 displays may want to build windows which display items as long rows with relatively short columns. You can modify *VARDISP.WPD* with a text editor to accomplish this.

Variables Given in the VARDISP File

The list of variables that you are allowed to display is set at the bottom of the *VARDISP* file. These variables are listed in the shaded box can be requested by you for use in any defined text window.

- ✉ The variables below are not case sensitive in the context of *CELOG*.

- ✉ It is important that the variable list in the *VARDISP.WPD* file is not edited

Modifying the VARDISP Script File

CELOG presents one text window at a time to the viewer. The text windows are defined completely by the window elements in the *VARDISP.WPD* script. If the file is not present or corrupted, you will not get a display. These text windows can be changed during operation of *CELOG* by pressing the side arrow keys on the keyboard or the toolbar.

The content of the windows is defined by you through the script file both in terms of which variables are displayed and where those variables are placed within the window region. All of the following rules must be followed exactly if you wishes to build or modify their *VARDISP* file with a text editor. Modifying the *VARDISP* file is useful or even necessary depending on the screen size of the Win CE device being used.

Defining a New Window

Up to 12 text windows can be created in *VARDISP.WPD*. Each new window is built by using the form in the shaded box.

These are text windows only. They are designed to display the variables listed above in any particular format as designed by the writer.

Defining a Window Title

Each window may have some theme as given in the title. To add a title to a new window use the form in the shaded box.

Defining a Line of Text

Where the $ indicates text to follow. The text must be enclosed in double quotation marks. The $" " format allows the use of spaces within the text. Spaces may be interpreted as delimiters by some basic C programming functions.

Embedding a Variable in a Line of Text

Where the & sign must be followed by one of the variable names listed in *Section 8.21* on *Page 229*.

Separating Variables or Text by Spaces

Spaces can be defined as text strings by using a line of text as $" " or spaces can be given by type in #s#s#s, where each "#s" represents one space. In the example in the shaded box, the text word "Position:" will be displayed in the "My Position Information Window" window followed by the current latitude, longitude and height.

Separating Variables or Text by Tabs

Using spaces as delimiters is not as exact as using tabs. Single tabs can be used in the *VARDISP* script by simply inserting a tab of four spaces using a "%t" format as displayed in the shaded box.

Defining a new window

    DISPWINDOW {
    }

Defining a window title

    DISPWINDOW {
    Title: "My Position Information Window"
    }

Defining a line of text

    DISPWINDOW {
    Title: "My Position Information Window"
    Line: $"Latitude:"
    }

⊠   In this case, the spaces are part of the text string to be displayed.

Embedding a variable in a line of text

    DISPWINDOW {
    Title: "My Position Information Window"
    Line: $"Latitude:" &latitude
    }

Separating Variables or text by spaces

    DISPWINDOW {
    Title: "My Position Information Window"
    Line: $"Position:" &latitude $"   " &longitude #s#s#s#s#s &height
    }

Separating Variables or Text by Tabs

    DISPWINDOW {
    Title: "My Position Information Window"
    Line: $"Position:" &latitude %t&longitude %t &height
    }

Separating Variables or Text by Percent Screen Sizes

```
DISPWINDOW {
Title: "My Position Information Window"
Line:
Line: $"Latitude:" &latitude  %50t &prn[0] %t &locktime[0]
Line: $"Longitude:" &longitude  %50t &prn[1] %t &locktime[1]
Line: $"Height:" &height  %50t &prn[2] %t &locktime[2]
Line: $"" %50t &prn[3] %t &locktime[3]
Line: $"" %50t &prn[4] %t &locktime[4]
Line: $"" %50t &prn[5] %t &locktime[5]
Line: $"" %50t &prn[6] %t &locktime[6]
}
```

⊠ The second column (i.e. %50t) must be preceded by any value including a space in the first column.

Adding another window in the VARDISP file

```
DISPWINDOW {
Title: "My Channel Information Window"
Line: $"Prn    Azimuth    Elev    Locktime "
Line: &prn %t &az %t &elev %t &locktime
}
```

Script for defining each element of the channel array with a zero based index

```
DISPWINDOW {
Title: "My Position Information Window"
Line:
Line: $"Latitude:" &latitude  %50t &prn[0] %t &locktime[0]
Line: $"Longitude:" &longitude  %50t &prn[1] %t &locktime[1]
Line: $"Height:" &height  %50t &prn[2] %t &locktime[2]
Line: $"" %50t &prn[3] %t &locktime[3]
Line: $"" %50t &prn[4] %t &locktime[4]
Line: $"" %50t &prn[5] %t &locktime[5]
Line: $"" %50t &prn[6] %t &locktime[6]
}
```

Separating Variables or Text by Percent Screen Sizes

One of the most exact ways of delimiting text is to organize text and associated variables in columns which start at certain percent values ACROSS the screen. For example, you may wish to start displaying a certain column of variables exactly half-way across the current window. An example is in the shaded box.

In the example, the first column of values are single variables such as longitude and height. These variables are displayed in the first column of the window. The PRN numbers are output half way across the window in a column and their corresponding locktime values, one tab from the PRN numbers.

Displaying Array (Channel) Variables Versus Single Item Variables

Variable such as latitude, longitude and height are defined here as single item variables. On the other hand, values given to PRN numbers, locktimes, azimuth and elevation and so on are per channel variables. These are given in arrays – up to 12 values corresponding to each channel of a 12 channel GPS receiver.

Array or channel variables can be output in two ways. The first method is to simply define the channel variable by its name with no index. For example, add another window to the *VARDISP* file. A sample of this is in the shaded box.

This window displays all *n* channels at each epoch. *CELOG* recognizes the variable prn, az, elev and locktime as array variable requiring *n* channel rows to be displayed.

⊠You cannot put %t in the sub-title string, but must space this header manually.

The second method of outputting per channel variables to a text window is to define each element of the channel array variable explicitly with a zero-based index. An example of this is seen in one of the previous Position Information windows.

Of a possible 12 channels, only 7 (0 – 6 inclusive) are explicitly output to the text screen. If you have a CE screen wider than longer, you may wish to display array variables as shown in the shaded box.

This displays *n* channel values across the page with one tab delimiting each variable. Each line is prefaced in the first column with a text string indicating the nature of the variable. See the shaded box for the script.

⊠　Lines in the window can be commented out and ignored by prefacing them with a semi-colon.

Script for displaying *n* channel values across the page with one tab delimiting each variable

```
DISPWINDOW {
Title:  "My Channel Information Window"
Line:  $"Prn" &prn[0] %t &prn[1] %t &prn[2]
…… %t &prn[n]"
Line:  $"Locktime" &locktime[0] %t &lock-
time[1] %t &locktime[2]   %t  &locktime[n]"
}
DISPWINDOW {
Title: "Position Info "
Line: $"GpsTime   :" %35t &GpsTime
%70t $"Prn"  %t $"Lock"
Line: $"Latitude    :" %35t &latitude  %70t
&prn[0] %t &Locktime[0]
Line: $"Longitude :" %35t &longitude   %70t
&prn[1] %t &Locktime[1]
Line: $"Height      :" %35t &height   %70t
&prn[2] %t &Locktime[2]
Line: $"Grid North :" %35t &north       %70t
&prn[3] %t &Locktime[3]
Line: $"Grid East   :" %35t &east       %70t
&prn[4] %t &Locktime[4]
Line: $"SurveyMode :" %35t &surveymode
%70t &prn[5] %t &Locktime[5]
Line: $"DiskSpace  :" %35t &diskspace
%70t &prn[6] %t &Locktime[6]
Line: $"" %70t &prn[7] %t &Locktime[7]
Line: $"" %70t &prn[8] %t &Locktime[8]
Line: $"" %70t &prn[9] %t &Locktime[9]
}
```

Chapter 9   FAQ and Tips

9.1   Overview of FAQ and Tips

This is a valuable section to pass on some of Waypoint's processing knowledge to you along with a few tips that can vastly improve certain data sets. Many of the answers to the FAQ and the tips listed for GrafNav can also be applied to baselines in GrafNet.

9.2   General FAQ and Tips

9.2.1   How can I store Master Station Coordinates?

Every time a new project is created, you are prompted for the coordinates at the master station. If certain base stations are being used repeatedly, it is easier to store the station coordinates by using *Add To Favourites* in the *Enter Master Position* window, and loading the master station coordinates using *Select from Favourites* when needed. This method is faster and removes the possibility of typing errors.

Stations from network or traverse solutions can also be added to the stations list in *Favourites Manager* using GrafNet. Once a network solution has been processed, and you right-click on the station in the *Map Window*, a menu appears with the *Add point to Favourites* option. Stations added from GrafNet will also be available for use in GrafNav.

> ⊠   If no network solution is loaded, you are prompted to see if a traverse solution should be used or not. A list of coordinates can also be loaded from the *Favourites Manager.*

It is worth noting here that CORS, IGS, AUSLIG, IGN, and GSI control points are pre-loaded into the *Favourites Manager.* It is important to note that these coordinates should only be used as guidelines, as they are subject to change. Additionally, be careful to note the datum of the coordinates found in the *Favourites Manager.* For instance, IGS coordinates are given in WGS84. If high accuracies are desired, the exact coordinates should be found via the Internet. See *Table 11* on *Page 141* for website addresses.

By selecting the datum prior to clicking on the *Select from Favourites* button, coordinates in this datum are favoured. This has application for stations that are part of two networks, such as CORS and IGS. While CORS coordinates are in NAD83, those from IGS are in ITRF/WGS84.

9.2.2   How can I customize output formats?

The *Export Wizard* is available to allow you more control over output format. Export profiles can now be customized and saved for future usage. Along with more access to different variables for output, the *Export Wizard* can also vary in format with user-defined header and footer files, strings, error/warning messages, and a processing summary. See *Section 2.7.4* on *Page 107* for a complete description of this feature.

9.2.3   How can I download base station data?

GrafNav supports single point processing which is generally accurate on the level of 1 to 3 meters at best, assuming the presence of precise ephemerides, dual frequency data and good quality code measurements on both frequencies.

Generally, a more accurate solution can be obtained by using the *Download Service Data* utility, which is launched from all of Waypoint's software via *Tools | Download Service Data.* Currently, there are over 3000 stations worldwide loaded into the software. The *Download Service Data* utility will do the following:

- Download the RINEX data for the selected stations from the Internet
- Decompress the file in which the data is packed
- Convert the data from RINEX to GPB

- Concatenate files together if data from multiple days was downloaded

- Resample the data to a higher data interval, at your request

See *Section 2.8.12* on *Page 136* for more information.

9.3   Kinematic Processing FAQ and Tips

9.3.1   Why would I use pre-configured options profiles?

Waypoint's software comes with pre-loaded configuration profiles, available in GrafNav via *Settings | Load Settings From*. You can also add your own. Using these makes the configuration of processing options much easier. Selecting either these or *Factory Defaults* is especially important for processing projects created in previous versions.

Before processing kinematic data, consider selecting an options profile, such as *Airborne, Low Cost Receiver.* Do this when using the *File | Auto-Start* feature or after a project is created or loaded by selecting *Settings | Load Settings From*.

9.3.2   Should I combine forward and reverse solutions?

For carrier phase processing, accurate ambiguity determination is the most important goal. The *forward/reverse* combination is a fast and easy check on this determination. Select *Process | Combine Solutions | Forward and Reverse* after both directions have been processed allows for this. The *Combined Separation* plot shows the difference, and gives an indication of the reliability of the solution. This difference does not necessarily represent the errors. The weighting of these two solutions can be plotted as well.

⊠   Problem periods such as incorrect integers determined in either the forward or reverse direction can be blocked. See *Process | Combine Solutions | Combine Settings*.

9.3.3   How can I use static / kinematic flags?

GrafNav keeps track of static and kinematic processing, and achievable accuracies are better in static than kinematic. If you have a period of static longer than five minutes, then it is beneficial to flag that data as being static. It is even more important to set portions of the data where the antenna is moving to kinematic. Even if the movement is a few centimeters, that data should be set to kinematic. This is performed via *GPBView* or the *Insert Static/Kinematic Markers* utility. See *Section 8.2* on *Page 219*.

To make use of this flag, properly identify which data is static and which is kinematic. An easy way to separate the static from the kinematic is as follows:

1. Flag entire remote data file as being kinematic using either *GPBView* or *File | GPB Utilities | Insert Static/Kinematic Markers*.

2. Process data using a float solution. Disable the usage of KAR and fixed solutions.

3. View the *Velocity Profile* plot via *Output | Plot GPS Data*. Data is normally considered to be static wherever the velocity is very near zero (i.e. less than 0.02 m/s). Always be cautious about slow movements, which can be shrouded in the measurement noise.

4. Use the *GPB Viewer* to switch these periods from kinematic to static. It is generally a good idea to mark the static 10 to 20 seconds after movement stops, and to stop the static 10 to 20 seconds before movement begins. Again, the *Insert Static/Kinematic Markers* feature can also be used.

⊠   GPS receivers that make an accurate Doppler measurement facilitate static/kinematic identification.

9.3.4   How do I eliminate problem satellites?

Sometimes a single problem satellite will introduce considerable error in the solution. Two techniques to identify and eliminate problem satellites are briefly discussed here.

1. To examine the message logs after processing and look for repeated warnings concerning specific satellites. If one satellite has many warning, you may wish to eliminate this satellite for either the entire data set or for specific time periods, as indicated in the message logs.

2. Identify problem satellites by processing in the forward direction only, with the *Write MB binary values/satellite residuals* option enabled, which is located under *Settings | Individual | Advanced*. Enabling this setting allows you to plot the C/A code and the L1 phase satellite residuals via the *Individual Satellite Statistics* plots under *Output | Plot GPS Data*. Problem satellites will usually have large spikes or generally stand out from the other SV plots, and omitting these satellites will generally improve results.

If large spikes appear in every SV plot, determining which satellites are the worst offenders (look for the largest satellite phase residuals) just prior to the filter reset, and omitting them until just after the total loss of lock will often serve to avoid a filter reset and improve results considerably.

9.3.5   How do I set the measurement standard deviations?

The standard deviation on the C/A code is set to 4 meters by default. This is to satisfy the requirement of all GPS receivers. However, many receivers produce more accurate C/A code measurements by using narrow correlation or smoothing technologies, while other low-cost units have much poorer C/A code accommodations. Setting proper measurement standard deviation values will improve float accuracies and also increase KAR reliability.

To determine a new C/A code standard deviation, process once in float mode, meaning that the usage of fixed solutions or KAR is disabled. After processing, plot the *C/A Code RMS* from the *Plot GPS Data* feature from the *Output* menu.

⊠   The current standard deviation value should be plotted in green.

Pick a value that nicely represents a good overall RMS for the C/A code. Pessimistic values are better than optimistic ones. Set the C/A code standard deviation to this new value under *Settings | Individual | Measurement*, and re-process the data. Although the C/A code RMS can also be obtained via *View| Processing Summary*, the value provided is often too optimistic, and the methodology discussed previously is better.

A similar methodology can be used for the carrier phase. However, instead of lowering the value, it is often raised to account for increased error.

⊠   The carrier phase standard deviation value may be higher than the entered value due to the *Adjust for Iono* option being enabled.

Setting proper standard deviation values is especially important for float-only processing, and can do more to help than most any other action. The L1 phase standard deviation may need to be raised (i.e. 0.05 to 0.10 m). This is performed under *Settings | Individual | Measurement*. Setting proper standard deviations is also helpful for integer processing (i.e. KAR) because it helps to attach more meaningful accuracy estimates to float solutions.

9.3.6   How do I control bad data?

When GrafNav sees very high residuals for code or carrier RMS, it tries to correct the problem by removing a measurement (i.e. Doppler or P2 code), baseline (MB processing only), or satellite. In some cases, if it cannot correct the problem, it will issue a cycle slip to all satellites. This is known as a filter reset and can be observed by a sharp increase in estimated position accuracy (in forward or reverse direction), and a *$$$* message will be printed to the message log.

You can control how GrafNav handles bad data in the *Outlier Detection/Rejection* section under *Settings | Individual | Measurement*. Specifically, a looser carrier phase level will prevent fewer resets from happening, while a stricter carrier phase level will be more energetic in finding errors, but at the risk of issuing more resets.

9.3.7   How do I avoid missing epochs?

After processing with GrafNav, epochs can be missing for a number of reasons. One main reason is that either the base or remote GPB files are missing one or more epochs. Use *GPBView* and check the epochs in question. If epochs are missing on the remote, then there is nothing that can be done here but gaps in the master data can be filled in by selecting *View | GPS Observations | Master | Resample/Fill Gaps, using*. See *Section 2.4.1* on *Page 52* for more information.

GrafNav ignores the first four seconds of data after a satellite rises. This is to avoid any possible half-cycle problems in determining the carrier phase that are more likely during the first few seconds of lock. The tolerance is known as the locktime cut-off, and can be altered *Settings | Individual | Advanced*. If missing epochs are a problem, try lowering this number.

If an epoch has been determined to be "bad", data is not written to the FWD or REV files and, thereby, not received by GrafNav. This is to protect you from receiving very bad data. However, if data quantity is more important than quality, then these epochs can be written by setting the *Write epochs containing bad data* option from *Settings | Individual | Advanced*.

There may also be less than 4 satellites in common between base and remote. If there are no obstructions, then check for messages regarding missing ephemerides in the FML/RML file. If there are not enough ephemerides, then broadcast ephemeris files can be downloaded from NGS/CORS or obtained from a service provider. Convert the RINEX ephemeris to EPP using the provided *Raw GPS data to GPB* conversion utility.

Otherwise, coordinate interpolation is the only other option. GrafNav can interpolate missing epochs from within the *Export Wizard* or the *Write Coordinates* features, which can both be accessed via the *Output* menu. Interpolation is permitted in the *Export Wizard* from the screen titled *Select Epoch Sampling Mode*. Likewise, interpolation is permitted in the *Write Coordinates* feature by selecting *Time Format*. At the bottom of this window, enable the missing epoch interpolation, and select the desired data interval.

9.3.8   Should I avoid using RINEX for kinematic data?

Most GPS receivers attempt to detect cycle slips at a data rate much higher than the recording rate, and their native formats indicate such slips. Although RINEX has a loss of lock character, RINEX converters do not always use it. Therefore, use the receiver specific converter if possible.

9.3.9   How do I process kinematic data logged during an ionospheric storm?

Ionospheric activity peaked in 1999-2000, and baselines over even 10-15 km can sometimes be hard to process if ionospheric activity is high. Since the effect of the ionosphere on electromagnetic signals is frequency dependent, dual frequency data can be used to combat ionospheric problems very effectively. By default, GrafNav does not use L2 phase data to correct for the ionosphere because noise can be added to shorter baselines. In order for ionospheric processing to be enabled, a dual frequency receiver is required at both ends of the baseline.

In GrafNav, ionospheric processing is enabled from *Settings | Individual | L2/Ionosphere*. Make sure the *Use L2 carrier for dual frequency ionospheric processing* option is enabled. There are two modes of ionospheric processing. The first, which employs the relative model, assumes that the remote starts very near to the base and that the initial ionospheric error is zero. As the remote travels, it transfers the ionospheric correction.

The second mode, which uses the iono-free model, forms a phase measurement, which is a combination of L1 and L2 and free of ionospheric error. This method is more effective for static positioning or if the remote starts far from the base. One of the disadvantages of the iono-free model is that a cycle slip on L2 will induce a cycle slip for that satellite. This is not the case for the relative model. Regardless, for many kinematic data sets, both should be tried. For the relative model, it may be advantageous to lower the *Engage distance for relative ionosphere* during high ionospheric activity.

9.3.10   How do I process long kinematic baselines?

For dual frequency processing on long baselines, it is important to enable L2 ionospheric processing. This option is set under *Settings | Individual | L2/Ionosphere*. Once L2 ionospheric processing is enabled, there are two ionospheric processing methods:

- The *Ionospheric Free model* works well when the remote initializes far from the base. This method creates a carrier signal that is free of ionospheric error. However, a cycle slip on L2 will induce a total loss of lock for that satellite. In some cases, this method may do better than the relative method even if initialization is close.

- The *Relative ionospheric model* works by only applying an ionospheric correction to the L1 signal. If initialization is close, then an initial correction of zero is assumed. The error then accumulates as the remote vehicle travels away from the base. The relative model tends to have a higher L1 phase error than the iono-free, primarily due to the fact that the model is only an approximation. However, cycle slips on L2 do not reset the ambiguity like the iono-free solution. Hence, accuracies may be better if L2 cycle slips are present in large quantities. For days with high ionospheric activity, the *Engage distance for relative ionosphere* may need to be lowered. If a static initialization is performed close to the base, which is always suggested, then it may be beneficial to make this distance tolerance longer than the distance at which the initialization was performed. Raising the rejection tolerance and/or the PPM value of the standard deviations under the *Measurement* tab will stop GrafNav from mixing up large ionospheric corrections with carrier phase errors. See *Section 2.5* on *Page 61* for more information.

Although KAR can be used with both ionospheric methods, a KAR fix will have some ionospheric error if the *Ionospheric correction* model is not used, under *Settings | Individual | KAR* . It may also have difficulties on longer baselines. Therefore, setting the maximum distance for engaging KAR is important. Normally, values between 20 and 60 km are realistic.

On very long baselines, the C/A code can be corrected if P2 code is available. In many cases, this will simply add more noise, but the noise is very white, and overall improvements can be observed. This is enabled from *Settings | Individual | L2/Ionosphere*.

For single frequency, it is important that the standard deviations be set properly on the C/A code and L1 carrier phase signals. The L1 phase standard deviation may need to be raised (i.e. 0.05m to 0.10 m), and a stricter phase rejection tolerance may need to be used as well. Setting proper standard deviations is also helpful for dual frequency processing. for additional information. In addition, users should download an IONEX ionospheric correction file via the *Options* tab under *Tools | Download Service Data*. You should then add the file to the project via *File | Alternate Precise/Ephemeris Files*, and then enable the *Correct single frequency using IONEX or broadcast model* option under *Settings | Individual | L2/Ionosphere*.

9.4   KAR Tips

9.4.1   How can I detect and fix incorrect integer fixes?

Incorrect intersections (fixes) are caused when KAR picks the wrong solution. This error exhibits a near constant offset in the combined forward/reverse separation.

Confirm that the large forward/reverse separation is due to a bad KAR fix

1. Open the *Combined Separation plot*, which will show the times when the forward/reverse separation is poor.

2. Open the *Float/Fixed Ambiguity Status* plot. This shows when there is zero, one or two fixes available for an epoch. Incorrect KAR intersections are most apparent when there are two fixes (i.e. for both forward and reverse). These areas show up as green. This does not mean that an incorrect fix cannot occur when there is just one fix. In this situation, you are comparing a float solution to a fixed. The large bias is usually due to the float solution, but this is not always the

case. In such a situation, plotting the standard deviation of the float solution can be very helpful.

Determine processing direction of bad solution

It is always a good idea to determine which processing direction is the cause since only that direction needs to be reprocessed. This is significant because in the following step, many options will be changed. It is important to only make these trials on the bad direction as you would not want to corrupt the good direction.

1. Load each direction because it is the fastest way to determine which direction is bad.

2. Plot the *L1 Phase RMS*. The incorrect fix normally exhibits a linear growth to the carrier phase RMS. There may be jumps as the software is trying to correct the problem by removing satellites. After some time, it may stay low if a filter reset has been issued.

Another way to determine the likelihood of a bad KAR fix is to view the *Static/KAR Summary* file (FSS/RSS). There will be records for each KAR fix. Look for fixes with poor RMS (less than 0.05 cycles), low reliabilities (less than 2 or 3) or large float-fixed separations (greater than 1 m).

Correcting the Problem

A bad KAR fix is normally a very easy problem to correct. It just requires one or more of the following settings to be changed, listed in order of likelihood to help:

- Enable the *Stricter RMS tolerance* and/or the *Stricter reliability tolerance* options

- Lengthen the minimum KAR time. As KAR uses more time, it usually does a better job of identifying and rejecting bad fixes.

- Try disabling *Refine L1/L2 KAR search*.

- If the auto-reduce KAR search area is used for dual frequency, try increasing the scale factor, or switch to the fixed search region size

- Consider re-engaging KAR manually after the bad fix. Be sure the checkbox *Reset Kalman Filter* is enabled on the *Manual KAR Engage* record.

- Use the **KAR_SEP_TOL** command to force KAR to only accept intersections that are close to the float solution. For instance, use a value of 1 m.

- Lower the maximum engaging distance for KAR.

- If poor geometry is a concern, try lowering the *Maximum DD_DOP* value

- If all else fails, disable this time period during combination. See *Section 2.5* on *Page 61* for help.

Unless otherwise specified, all of the options discussed above can be found under *Settings | Individual | KAR*. See *Section 2.5* on *Page 61* for additional information.

9.4.2   How can I use KAR with interpolated data?

If the *Download Service Data* utility was used to download CORS or IGS data, you have the option of interpolating to a higher interval. For data originally logged at 30 seconds, the epochs that do not fall on the original interval have added errors of about 1-2 cm. For data logged at intervals of 5 seconds or less, the interpolation error is negligible. Examine the RINEX header saved to the STA file to determine the original interval via *View | GPS Observations | Master | View Station File*. If KAR uses the 30 second resampled data, it may fail. Therefore, under *Settings | Individual | KAR*, set the *Search on interval* value to the original data interval of the data (i.e. 5, 10 or 30 seconds). In addition, enable the *Only search on exact interval* option. This will cause KAR to only use the data on the original interval, which does not suffer from interpolation error. Note that the minimum KAR time may need to be increased to compensate for less data being used by KAR.

9.4.3   How can I help KAR find a solution?

Resolving the problem of KAR not being able to find a solution tends to be more difficult than resolving the problem of picking a wrong solution. This is because the inability to pick a solution is most often related to noisy carrier data on L1 and/or L2. Usually, playing with the KAR time and search region size is all that can be done. Consider disabling the *Stricter reliability tolerance* and/or *Refine L1/L2 KAR search* options as well. For dual frequency, switching to other noise models can help if there is a problem with L1 or L2. With single frequency KAR, the L1 phase needs to be very clean, and there has to be a period of at least 10 minutes without a loss of lock. These conditions are not always possible in many environments.

For dual frequency data on short baselines (less than 8 km), try enabling **Use fast KAR** under *Settings | Individual | KAR*. Enabling the **Use Fast KAR even for 5 SVs** option is not suggested.

For dual frequency GPS data with good C/A code, the following tricks can be used:

- Under *Settings | Individual | Measurement*, set the C/A standard deviation to 2 to 3 meters.
- Under *Settings | Individual | KAR*, change the size of the KAR dual frequency search region to 1.5 meters.
- Under *Settings | Individual | KAR*, raise the KAR minimum time for dual frequency to 3 minutes or more.
- Under *Settings | Individual | User Defined*, enter the **KAR_SEP_TOL=0.75** command.

Using this procedure will help KAR to find a solution, but may increase the chance of a false intersection as well. Therefore, it is important to check that the forward and reverse solutions agree.

9.4.4   How can I use KAR on long baselines?

⊠   Most of these tips are available primarily to dual frequency users due to the ionospheric modeling.

The *Ionospheric correction* model removes ionospheric error to improve reliabilities and also seed the ionospheric correction, when engaged. The *Automatic* option chooses between the **High noise** and **Ionospheric correction** models based upon the distance when the search is performed. The distance tolerance for choosing between the two noise models can be specified under *Settings | Individual | KAR*. In most cases, the *Automatic* setting works best. However, manually selecting either of the model has its advantages. For example, the **High noise** model is less dependent on L2, which can make it more reliable if L2 is noisy. The **Ionospheric correction** model seeds the **Ionospheric free** and **Relative ionospheric** models, which can produce a more accurate final solution.

KAR can also be engaged in static mode under *Settings | Individual | KAR*. This means using the fixed static solutions can be avoided, which simplifies processing. Normally though, the fixed static solution is more reliable, and fixed solution can be solved for each of the static periods in the data.

Using the option *Maximize long baseline data usage*, under *Settings | Individual | KAR*, has a great effect on airborne long distance data where the aircraft is continuously flying within and outside KAR distance tolerances. Enabling this option is generally beneficial, as more data is used. However, sometimes this can result in the incorrect integer being chosen if a carrier slip is missed while the aircraft was far away.

9.4.5   How can I use KAR to improve poorly combined separations?

Even for long baseline airborne processing, 5-10 cm accuracies are sometimes needed (i.e. large photogrammetric scales or LIDAR). However, after initial processing, the forward/reverse separation may only show 20-30 cm. The forward/reverse separation is not an absolute indicator of accuracy, but a very tight separation provides for a very nice level of comfort. This section describes how 20-30 cm separations can be improved.   If it took a great deal of effort just to achieve 20-30 cm, then improving upon this may be bleak. Regardless, here are some tips:

- Make sure that a fixed integer (ambiguity) solution is obtained for as much of the mission as possible because fixed integers solutions (i.e. KAR or the fixed static solution) are usually necessary to achieve 5-10 cm accuracies. This can be observed by plotting the *Float/Fixed Ambiguity Status* plot for both the

forward and reverse directions. If there is a larger separation and only one of the solutions (i.e. forward or reverse) has the fixed ambiguity solution, then this is not a significant problem if you are sure that the fixed integer solution (i.e. KAR/fixed static) is correct.

- Manually engage KAR at times where base or remote distance is small but forward/reverse separation is outside tolerance.

- Enable the *Engage on even of poor DD_DOP* option under the *Settings | Individual | KAR*. This will be helpful if large DOPs are observed. View the *DD_DOP* plot for values over 15-25, which can cause instabilities. You may also need to check the *Message Log* file (FML/RML), as epochs with extremely poor DOPs are skipped and not visible on the data plots.

- In MB processing especially, try engaging KAR when close to a base station. Use the *Engage if distance < tolerance1, reset if > tolerance2* option under *Settings | Individual | KAR*.

- Increasing either the KAR time or the KAR distance-dependent time (min/10 km) can help as well, since KAR can sometimes pick the wrong L1 or L2 lane resulting in a 10-20 cm error.

- Try enabling the *Stricter RMS tolerance* option. KAR will be less likely to accept a bad fix.

- Try forcing the use of the *Ionospheric Correction* model under *L2 Noise Model* (or lower the *Automatic* distance tolerance). The ionospheric corrections will be more properly estimated.

- Try using a stricter carrier phase level in the *Outlier Detection/Rejection* section under *Settings | Individual | Measurement*.

- If static data is available, using the fixed static solution can be helpful.

Try both the *Ionospheric Free* and *Relative ionospheric* models, and combinations thereof, for forward and reverse processing.

9.5   Static Processing FAQ and Tips

If there is a problem with a static baseline in GrafNet, it is a good idea to export it into GrafNav by right-clicking on it and selecting *GrafNav*. This allows for control over many more processing options, and gives access to additional plots for a more detailed analysis. Once inside GrafNav, many of the previously mentioned techniques are equally applicable.

9.5.1   Can I use GrafNet for static batch processing?

If you have numerous static baselines with a single base, using GrafNet is much faster to setup and process. If problems develop with the receiver at the base station, try downloading the nearest CORS/IGS station, or even the nearest few CORS/IGS stations, and use the GrafNav Batch processor to get a combined solution from multiple base stations. See *Chapter 4* on *Page 177* for more information.

9.5.2   Can I use kinematic processing on static baselines?

If data has static sessions defined, and there is even a small amount of movement, the L1 carrier will suffer. This may cause a fixed solution to fail or a float/quick to deliver poor results. To compensate for the small movement, you may want to process the data in kinematic mode, which gives better results if there was movement in the antenna. Changing the entire remote file to kinematic can be accomplished within the *GPB Viewer*. Alternatively, you can process the data in static mode, but select the *Engage KAR while in STATIC mode* option. KAR is very reliable for dual frequency data but can only be engaged in kinematic mode.

9.5.3   How can I optimizing the fixed static solution?

Like in KAR, an ionospheric L2 noise model is available. This can greatly increase the range of fixed integer solutions, especially with longer observations. With such long occupations, enabling the iono-free solutions in GrafNav can further improve accuracies. In GrafNet, this is performed by default for the iono noise model.

For both GrafNav and GrafNet, the automatic noise model works very well. However, on days with heavy ionosphere, switching to the iono L2 noise model can be helpful. Having longer static occupation times can be extremely helpful under these conditions.

On longer baselines, fixed solutions usually fail as a result of RMS rejections. Conversely, poor reliabilities are usually the cause of failure on short baselines. In either situation, engaging the *Reduce as float solution accuracy improves* option is helpful. This is possible for both GrafNav and GrafNet under the *Fixed Static* tab of the processing options. If the float or iono-free float is fairly accurate (i.e. +/- 10 cm), then using a user-defined search area size is helpful as well. Values as small as 20 cm can be used.

9.5.4   How can I refine L1/L2 integer solutions?

The *Refine L1/L2 integer solutions* option can be beneficial for obtaining the proper static fix. However, sometimes it can actually result in the one or more satellite resolving the incorrect integer. Try processing with and without this option enabled.

9.5.5   Can I use a larger interval for static processing?

You may have collected data at a high rate such as 1 Hz. Such high data rates, while necessary for kinematic positioning, are detrimental to static processing, for two reasons. The first reason is that carrier phase measurements are correlated over time periods of 10 seconds or more. Since each epoch is considered an independent set of measurements in the static computation, time correlation is not modeled. This results in statistics being overly optimistic when processing using the higher data rate. Although ten independent measurements are more accurate than one, if they all have a systematic bias that is much larger than the random error (i.e. epoch-to-epoch white noise), which is possible on GPS signals over short periods, one measurement is essentially as good as ten. The second reason, which is a result of the first, is that the floating solution will converge too quickly, making it very sensitive to erroneous measurements at the start.

The solution to this problem is to simply process at an interval of 15 or 30 seconds. This will produce essentially the same coordinate values as with a higher data interval, but with a much more accurate estimated standard deviations. In GrafNet, the network adjustment's variance factor will be much closer to unity. Both GrafNav and GrafNet have options for setting the processing data interval.

9.5.6   How do I process static data logged during ionospheric storms?

Ionospheric activity peaks in 1999-2000, and data over even 10-15 km can sometimes be hard to process if ionospheric activity peaked in 1999-2000, and baselines over even 10-15 km can sometimes be hard to process if ionospheric activity is high. Since the effect of the ionosphere on electromagnetic signals is frequency dependent, dual frequency data can be used to combat ionospheric problems very effectively. By default, GrafNet does not use L2 phase data to correct for the ionosphere because noise can be added to shorter baselines. In order for ionospheric processing to be enabled, a dual frequency receiver is required at both ends of the baseline.

In GrafNet, only the iono-free model can be used. It is enabled from the *General* tab of the processing options by selecting *Iono-free solution* under *Static Solution Type*. This is a float solution, meaning that non-integer ambiguities are solved. As a result, observation times of at least 30 minutes should be used. On longer baselines, several hours are suggested. It is also suggested that if short and long baselines are combined in a GrafNet network, the use of a fixed solution can give better results on the shorter baselines.

To detect if there is bad ionospheric data, process with a float static solution and use single frequency. If processing in GrafNav, ensure that KAR is disabled. Once the data is processed, view the *L1 Phase RMS* plot. If the data is littered with peaks over 0.05 meters, then there may be ionospheric problems. The ionosphere should not show up on baselines less than 5 km.

9.5.7   How do I process long static baselines?

Fixed solutions may be susceptible to ionospheric errors that are produced on long baseline lengths. This may result in a failed solution (e.g. high RMS value and/or low reliability) or an incorrect fix. In such cases, the iono-free solution or float solution should be used for dual and single frequencies respectively.

The maximum distance for fixed solutions varies from data set to data set. For dual frequency, maximum fixed solution distances are usually 30-50 km, but may be less during ionospheric storms. For single frequency, this distance is closer to 10-15 km. In both cases, longer fixed solution distances can be achieved but with varying degrees of success.

For single frequency, the float solution is the only alternative. It should be used if the fixed fails in both forward and reverse directions. If not, then the solution must be manually re-processed by right-clicking on the baseline in the *Sessions* window of the *Data Manager*. The float solution is more accurate if the fixed solution has determined an incorrect integer ambiguity solution.

For dual frequency, the iono-free solution is normally superior to the float. The only time that this is not the case on long baselines is if the L2 signal from the GPS receiver has either many slips or data errors. In such a case, the float solution is better. For long observation periods on very long baselines, the iono-free may in fact be more accurate than the passed L1/L2 fixed solution. This is because the ionospheric error has been removed. On short baselines, the iono-free solution should not be used.

For either frequency, the inclusion of the precise ephemeris is also important. This can be downloaded at no charge from IGS using the *Download Service Data* utility. See *Section 2.8.12* on *Page 136* for help. The SP3 file can be imported into GrafNet via *File | Alternate Ephemeris/Correction Files*. Normal precise ephemeris files, which are the most accurate, take approximately one week to become available. However, slightly less accurate rapid orbits are also available within one or two days.

The different modes of processing are selected under the *General* tab of the processing options. If long and short baselines are mixed, then it may be necessary to process the short baselines using *Fixed solution* and the long ones with the *Iono-free solution* or *Float solution*.

9.5.8   How do I multi-base process?

Many GPS post-processing applications utilize multiple base stations, and processing can be handled in two ways:

- Sequential manner, where baselines are processed separately and combined afterwards. This requires the use of GrafNav Batch. Despite the introduction of a multi-base processor, this capability is still supported.
- Process all bases simultaneously in a combined multi-base Kalman filter (MB-KF). Processing in this manner is possible through both GrafNav and GrafNav Batch.

9.5.9   How should I choose a processing mode

Generally, you have several options:

- Use the older sequential method exclusively
- Use the MB-KF method exclusively
- Use both of the above methods, which is possible via GrafNav Batch
- Use the combined MB-KF first, and follow up with the sequential method if needed

Generally, this last option is preferable for the following reasons:

- The sequential method, although requiring less CPU effort to compute a solution, does require more operator intervention, especially in terms of analysis and the number of user iterations required to reach an optimal solution.

- Since the MB-KF uses all of the bases at once, KAR can be much more effective if lock is lost in the project area.

- Cycle slips on base receivers, although not common, are much better handled by the MB-KF as well. For these reasons, the older sequential method should only be used if necessary.

9.5.10   How important are base station coordinates?

⊠   The use of incorrect base station coordinates is the most common error in MB processing. <u>The averaged coordinate values that are loaded by default are not acceptable for processing.</u>

Latitude, longitude and height errors, especially for MB-KF processing, must not be larger than 5 cm, and accuracies should be much better than this. In addition to correct coordinates, the correct antenna height must also be entered. All values should be double-checked. The best approach is to utilize GrafNet to quickly run a network adjustment using the all the base station data. Use the iono-free float if baseline separations are longer than 20 km. Process at a longer interval (15 or 30 s) and check each of the coordinates given. Be sure that the antenna heights in GrafNet match those in GrafNav.

The effect of incorrect coordinates depends on the method and is as follows:

For the sequential method, one of two phenomena will occur:

1. Smaller errors will show up as a bias in the separation plot for the combined baseline.

2. If the error is larger, the outlier rejection algorithm will reject one baseline, but not necessarily the same one throughout the trajectory, for each epoch. For this reason, it is important to check the number of outlier rejections after combining multiple baselines in GrafNav Batch. See *Section 4.3.7* on *Page 183* for help.

For the MB-KF, the effect is much more obscure, and it is most apparent in the *MB Phase RMS and SD* plot. A very obvious ramping or "saw-tooth" effect is visible. See *Figure 6* for an example. For this reason, it is very important to always view this plot in addition to the separation.
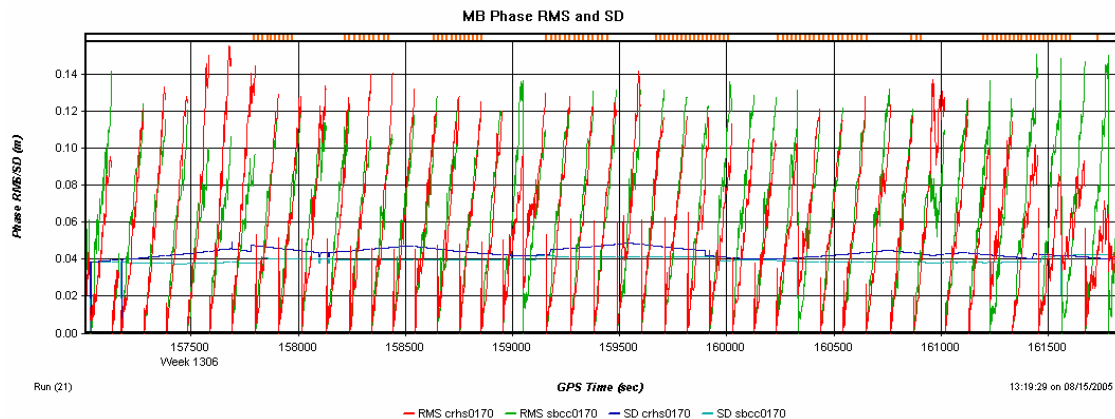
Figure 6: The Effect of Bad Base Station Coordinates in MB Processing

9.5.11   Can I use the MB Plots?

When using the MB-KF methodology, a number of new plots are available. These utilize the FBV/RBV files that are produced in addition to the regular ASCII outputs. *Binary Value* (FBV/RBV) files contain separate statistics for each baseline and satellite. The *Output | Plot Multi-Base* feature shows the baseline values. Here are some of the more common plots, list in order of usefulness:

Carrier Phase RMS/SD

Shows carrier residuals for each baseline along with measurement standard deviations. This plot indicates how well the carrier phase fits with the overall solution. It also shows errors in base position, and it can be used to determine if one baseline is worse than another.

Number of Baselines

Shows how many baselines are used for processing. This is important to check as it will indicate if any baselines are ignored or rejected during data line-up.

Distance Separation

Shows distances from remote to each of the base stations.

Effective Weighting

This number is computed after the fact as is an approximate indicator of how much weight each baseline has. This value is not used to compute the solution, but it can be very helpful in indicating which baseline has the most weight. It is most affected by proximity, but the number of satellites can have an effect as well.

Carrier Separation

Shows the difference between combined KF solution and individual baseline solutions using code+carrier. It is not really a measure of accuracy, but it does indicate how well multiple baselines fit to each other.

Number of Satellites/DOP

You can plot the number of satellites and/or DOP values. This shows if one base is tracking fewer satellite than another. For very large areas, it also shows the effect of different satellites being above the elevation mask.

9.5.12 How do I select a data interval?

In theory, all base stations do not need to be logged at the same data interval but, in reality, they should be. The MB-KF methodology can handle data with varying data rates, but the constant dropping in and out of base data will result in closer bases possibly not being used when they should. In addition, it may destabilize the filter. In the sequential method, processing is not affected, but a bumpy trajectory can be produced after combining.

For these reasons, both GrafNav and GrafNav Batch can resample data right within the interface. See *View | GPS Observations | Master | Resample/Fill Gaps, using | Processing Interval*, and be sure to set the processing interval to the remote data interval before performing this operation. You can also select *View | GPS Observations | Master | Resample/Fill Gaps using | Remote File Times*, which resamples to each exact epoch in the remote file. If only one remote file is processed, this is works well. If many remotes are present for the same time, then data gaps in the remote used for resampling causes drop-outs at the resampled master.

9.5.13 How do I handle data drop-outs at the master station?

Isolated data gaps are not as severe as differences in the interval. However, depending on the frequency, side effects can be present as well. For this reason, GrafNav will prompt you to resample the master data if small gaps are detected while creating a new project. This process will fill in these gaps. Resampling can always be performed in the manner described in *Section 9.5.12* on *Page 268*. This operation is suggested if a significant number of drop-outs are present. To determine how many data gaps there are, select *View | GPS Observations | Master | Show Time Gaps*.

9.5.14 How should I decide which base stations to use?

In general, only base stations that are within the project area should be included. This is because stations farther away will hinder, rather than help, results as they only serve to add increased errors due to tropospheric and ionospheric effects. As a general rule of thumb, if a base station never becomes the closest station, it should not be included. In addition, using two stations very close together adds nothing in comparison to just using one. In such a case, if different, pick the base that tracks the most satellites.

9.5.15 How do I deal with problematic baselines?

Poor baselines can be defined with the following criteria:

1. One baseline continuously tracking fewer satellites than the others. See *Number of satellites* under *Tools | Plot Multi-Base*.

2. KAR regularly resolving incorrectly, or not at all, on one baseline but not the others.

3. Numerous cycle slips in the *Message Log* files stemming only from one base.

4. *Print cycle slips to message log* must be enabled under the *Advanced 1* tab.

5. Numerous bad data messages (those starting with *$$$*) are present in *Message Log* files (FML/RML) and seem to stem only from one base station.

6. Having larger carrier phase or C/A code RMS residuals. See *C/A Code* and *Carrier Phase Measurement Residual RMS* plots under *Tools | Plot Multi-Base*.

For the first three cases, eliminating the baseline only from KAR should be sufficient. This is performed from *Settings | Individual | General*, by clicking the *Omit…* button. Reject *all satellites*, on the *selected baseline* for the *entire data set*, but *from KAR/Fixed-Static only*.

For the fifth case, there are two approaches. The easiest is to disable it, which works best in most cases. Disabling can be performed a number of ways, but the easiest is to right-click on the base in the *Map Window*, and click *Edit*. Once the *Disabled* option is selected, the base station symbol should have a red X on it. The other alternative is to de-weight it, which is done from *Settings | Individual | Measurement*. From the *Values are for* list under the *Measurement Standard Deviations* box, select the problematic baseline. Disable the *Use main settings* option. Enter code and carrier phase standard deviations that are more representative of the data for this baseline. You may also wish to disable this baseline from KAR as well, which is explained in the paragraph above.

For the fourth case, disabling the base station is the best approach. See the paragraph above for help.

9.5.16   Can I use KAR with MB-KF processing?

In general, very little is different. By default, KAR uses the closest baseline for resolving KAR, or all those under 8 km. After the KAR fix, the other baselines will be fixed to the same location as well. The following two KAR settings relate to MB processing:

• The *Search only closest base* option under the *KAR 2* tab, when enabled, causes KAR to only use the base station that is nearest, or to use all base stations that are within 8 km. In general, you should leave this enabled. If a base station is causing bad fixes, it is better to disable the base station. See *Section 9.5.15* for more information.

• A useful setting (for corridor work especially) is the *Engage if distance < tolerance1, reset if > tolerance2* option. It will engage KAR on the first occurrence the proximity to each base is less than *tolerance1*. KAR engagement will be reset if distance is greater than *tolerance2*. The values *tolerance1* and *tolerance2* may need to be refined for a particular data set.

This latter feature is a useful means of taking advantage of periods where the remote is close to base stations in order to improved fixed integer accuracies. The only disadvantage of using this method is that KAR may engage in the middle of the flight line, possibly causing a position shift, which is not necessarily desirable during image, laser or SAR data capture. The only alternative is to manually fix KAR during the turns, although this approach is more time consuming.

9.5.17   How can I use the fixed static solution?

KAR is the most common way to resolve fixed integer ambiguities, but the fixed solution works well too and can often be more accurate. It obviously needs a static period of a few minutes for dual frequency, while longer times are needed for longer baselines. For MB-KF processing, this process becomes more complex because GrafNav attempts to compute a fixed solution to all baselines. It will disable those where the distance or time is too long or short, respectively. See *Settings | Individual | Advanced*.

For each static period, only one fixed solution will be utilized for "fixing". A number of criteria are used to pick the best one, including distance, RMS, reliability and estimated standard deviation. The fixed solution used, will be signaled as **BEST** in the GrafNav interface. To view the solutions, right-click on the static sessions, or select *View | Objects | KAR/Static*. Click the *View* button for the desired static session. All of the static sessions will be shown. For combined solutions, both forward and reverse will be shown. In addition, a *Combined* static solution may also be computed. This is signaled as **PRIMARY**, and these solutions are only used for exporting and do not affect processing. In summary, each static session has one **BEST** solution for each direction, which is used to fix the kinematic trajectory. Each session will then have one **PRIMARY** solution used for exporting. In some cases, both solutions will be the same.

If the **BEST** fixed solution used is deemed in incorrect from the forward/reverse separation or other means, then it can be disabled from the fixed solution. To do this, first note the start/end times of the static session by clicking *Edit* from the *Object Menu*. From the *Settings | Individual | General*, click the *Omit…* button. After clicking *Add*, disable all satellites from the erroneous baseline for the noted time period. Be sure to select *KAR/Fixed-Static only* and to reprocess.

9.5.18   How can I speed up processing?

MB-KF processing can be much slower due to the increased numbers of states and observations. For example, 12 satellites on 4 bases will result in 50 states and 132 observations on every epoch. Therefore, here are some tips to cut down processing time without buying a faster computer:

- Disable any bases that are far outside of the project area, as they will add very little to final accuracies and may even hinder them.

- Consider disabling the Doppler measurement from processing. This is performed from *Settings | Individual | Advanced*. Under *Velocity/Doppler*, disable *Doppler measurement usage for phase processing*. If accurate velocity is needed, enable it again in the final stage.

- Reduce the data interval for preliminary analysis to something like 2 seconds. One of the problems is that 1 or 2 Hz data can result in different effects and problems. This can be helped by forcing KAR to use the same data, which is accomplished under Settings | Individual | KAR. The processing value should be entered in the Search on data interval field. Be sure also to enable Only search on exact interval. This will help to make 2 second and high data rate data produce similar results, although it is best not to continue on this low data rate too long.

- Utilize only the closest base for fixed solutions. Consider lowering the maximum distance for fixed static usage under *Settings | Individual | Advanced*.

- Ensure that simultaneous forward and reverse processing is enabled for Xeon and dual CPU machines. See the *Solution* tab under *Settings | Preferences*.

9.6   Common Inquiries

This section contains general information and instructions on how to perform some of the tasks that were not covered in previous sections.

9.6.1   How can I determine the quality of a final solution?

The best method to check the quality of the final solution is to analyze the plots. These can found under the *Output* menu. The following are some plots that might be useful:

Combined Separation Plot
This should be the one of the first plots to look at. It shows the difference between the forward and reverse solution. An ideal solution should have separation of zero as this indicates that the carrier phase ambiguities have been determined to be exactly the same value in both directions. This plot gives you a general idea of what kind of accuracy you are achieving. For a combined baseline in GrafNav Batch, this plot will always be positive as it shows maximum minus minimum value, and you may wish to also view the *Combined RMS* plot.

Float/Fixed Ambiguity Status Plot
This plot shows if the solution is float or fixed. Fixed integer ambiguities generally have better accuracies (i.e. usually less than 20 cm). Ideally, the plot should show two fixes (green), as this indicates a fix in both directions. Furthermore, the separation plot is the most meaningful. A fix in just one direction (cyan) is generally okay too, but it cannot be verified via the combined separation plot as well. Sometimes, a trajectory will lose its fixed status because the DD_DOP became too poor. In such a case, the separation may not be as badly affected as a loss of lock.

Quality Factor Plot
This plot shows the quality of the solution. There are five different quality factors. Increasing quality factors indicate a worse solution. This is not a perfect indication, but it can be useful to isolate problem areas. See *Table 4* on *Page 103* for a description.

9.6.2   How do I copy user files?

User files such as *Export Wizard* profiles, *Favourites* stations and coordinates, and antenna, datum and grid definitions can be copied or backed-up. There are two ways to do this:

1. Click the *Start* button in Windows and navigating to *Programs | Waypoint GPS | Utilities | Copy User Files*. This utility runs automatically during installation of the software. You are prompted for the source directory.

2. Manually copy the files listed below. These files are copied by the *Copy User Files* utility, and represent those that should be copied if you choose to do so manually.

    ⊠ Not all the files are available.

    User.prf – *Export Wizard* profiles

    User.fvt – From *Favourites Manager*

    User.dtm – Datum definitions

    User.grd – Grid definitions

    Local.fav – Local Coordinate *Favourites*

    Missplan.mpf – Cities defined in *Mission Planner*

    User.dn1 – *Download Service Data* user-defined file

    User.adf – Antenna definitions

    *.DefOpt – User-defined project/option settings

9.6.3   How do I update manufacturer files?

The pre-loaded datums, station coordinates (*Favourites*), download stations, grid definitions and IMU definitions will change from time-to-time. Waypoint periodically updates these values on its FTP site. Download these via *Help | About* in all of Waypoint's software. Be sure to re-start the program so that any changes will take effect.

⊠   New manufacturer files may not be updated for older versions of the software that are now outside of the support period. This feature is only supported by newer versions.

9.6.4   How do I produce local coordinates?

The three possibilities for producing local coordinates are the following:

1. **Local Cartesian:** Creates an orthogonal coordinate system, meaning the X, Y and Z axes are at right angles to each other, that can be used for further computations. This creates a coordinate system where the Z axis and the ellipsoidal height axis are parallel at a central point (or origin). As the observer moves from the origin, a point with the same ellipsoidal height as the origin will have a negative local Cartesian Z value. The advantage of this system is that it is easy to reproduce and is well suited for 3-D applications requiring further transformations. In the case of photogrammetry, such a system would not need an earth curvature correction applied to the image data. However, this is not a "mapping system" and would require an ultimate transformation to UTM, State Plane, etc.

2. **Local Coordinate Grid:** In many cases, users wish to reproduce a localized system based on a number of points where coordinates are known in grid or geographic and the local system. The procedure solves for a geometric transformation between grid and local. The following transformations are possible:

    •   1-parameter vertical height shift

    •   2-parameter X and Y shift

    •   3-parameter X, Y and Z shift

    •   4-parameter similarity (or Helmert) transformation (affects only horizontal axes). This solves for scale, rotation and X/Y translation.

    •   6-parameter affine transformation, which solves for scale in X, scale in Y, rotation, shear (or skew) and X/Y translation. Like the similarity, this only affects the horizontal axes

    •   7-parameter similarity transformation, which solves for scale, rotation about X, Y and Z axes, and X, Y and Z translation.

    Such a system is highly dependent on the grid system that the transformation coordinates are based upon. This is because scale and convergence angle (difference between true and grid north) vary differently for each system. Therefore, it is important to match this intermediate grid system if possible. The default system used for internal computations is a Transverse Mercator system with a central meridian scale factor of 1.0 and central meridian and parallel passing roughly through the centre of the project (determined by averaging all of the points' longitudes).

    In the process of creating a local coordinate definition, an LDF file is generated, which can be copied to other computers or shared with other GrafNav users.

3. **Scaling, Rotation and/or Translation of Existing Grid System:** In some cases, you may just wish to slightly alter an existing grid system. One common technique used by surveyors is to divide the coordinates by the combined scale factor. This removes the map scale factor and applies the height scale factor, which creates true horizontal surface coordinates that will match an electronic distance measurement (EDM) device. Other applications include applying rotations in mine sites and translations to create coordinates that have one axis lined up with a certain linear feature.

9.6.5   *How do I define a local cartesian coordinate system?*

Simply defined, a local Cartesian grid is a plane that is tangent to Earth at a user-defined origin. The orientation of the plane is also entirely dependent on your preference. See *Figure 7* below.

Figure 7: Local Cartesian Plane

A grid can be created in any of Waypoint's programs by performing the following steps:

Create a New Grid Definition
Select *Tools | Grid/Map Projection | Define*. The *Define Grids* window should appear, displaying a list of already existing grid definitions. Click the **New** button and give the grid an appropriate name. Select *Local Cartesian* as the grid type. Click the *Next* button.

Define the Origin of the Grid
In the *Origin in Geographic Coordinates* box, enter the known coordinates of the point where the plane is to be tangent. If the height is unknown, an approximate value can be used, although it should be noted that a value of zero is used in many applications.

The local Cartesian coordinates of the origin also need to be defined in the *Origin in Local Cartesian Coordinates* box. While these coordinates are generally left at zero for most applications, you are free to change them.

Define the Orientation of the Grid
If the Y-axis is to be parallel to north at the origin, the rotation angle can generally be left at zero. Otherwise, click on the *Compute* button to calculate the rotation angle. In order to do so, coordinates must be known for a second point, which must lie along either of the horizontal axes. Enter these coordinates in the new window that opens under the *Geographic Coordinates of a Second Point* box. You must then specify on which axis the point lies, keeping in mind whether it is in the positive or negative direction.

Once the information has been entered, click the *OK* button. The program displays the calculated rotation angle of the grid, as well as the azimuth and distance between the two points. Click *OK*.

Define the Scale Factor
In the *Local Cartesian Settings* window, the computed rotation angle should now appear. The scale factor can be left at unity, or else it can be corrected such that spatial distances will agree with horizontal distance measurements. In such a case, the correction, *s,* can be calculated with the following equation:

$$s = \frac{R+h}{R}$$

In the above formula, *R* represents the radius of curvature of the Earth (~6371 km), while *h* is the height of the second point, also in kilometers.

Once you click the *Finish* button, the grid is defined and appears in the list of grids in the *Define Grids* window. This grid is now available for use in the *Export Wizard* so long as you select a profile containing the *Selectable Grid* variables. See *Section 2.7.4* on *Page 107* for more information.

9.6.6   *How do I define a local coordinate grid?*

Localized systems can often be best reproduced in Waypoint's software through the creation of a Local Definition File (LDF). These can be defined in advance via *Tools | Grid/Map Projection | Define*, or through the *Export Wizard* at the time of output by using any profile that contains the *Local Plane* variables. The following procedure assumes you have chosen to create the LDF file in advance.

Create a New Grid Definition
Select *Tools | Grid/Map Projection | Define*. The *Define Grids* window appears and displays a list of already existing grid definitions. Click the *New* button and give the grid an appropriate name. Select *Local Coordinate Definition* as the grid type. Click the *Next* button.

Select Transformation Parameters
From the *Type* drop-down menu in the *Definition* box, select the transformation that is required.

⊠   An error will occur during the computation if insufficient observations have been supplied for the selected transformation.

Next, specify the datum in which the geographic input coordinates will be supplied, as well as the units in which the grid coordinates are measured. Finally, select a grid upon which the program will base its computations. The default is a *Transver Mercator* projection where the central meridian and parallel represent the approximate center of the survey, which the software computes by averaging all points.

Enter Observations
To define the grid, add observations by clicking the *Add* button under the *List of Stations* box. The *Add/Edit Local Station* window appears.

If a station with known coordinates is already loaded in the project, you can enter its name in the *Name of station* field and click the *Find Point* button to load its coordinates. If the name of the point is unknown, you find it via the drop-down menu available under the *Select from list of points in project* option. Listed points include station or camera marks loaded from the STA file, or any known points that were loaded with user-provided latitude and longitude. You are also free to specify points from your *Favourites*. If the point does not already exist in the project or in the *Favourites*, define it here by providing a name and manually entering its coordinates.

Next, enter the coordinates of the point in the local grid system. If a coordinate for the point is unknown, be sure to disable the *Valid* option.

Compute the Transformation Parameters
Once all the observations have been entered, click the Compute button to allow the software to calculate the values of the unknown transformation parameters. An RMS fit of the transformation points will be computed. At this point, the transformation required to obtain positions in the local system will be completely defined. Click *OK* to save an LDF file to the installation directory. The *Update* button will replace existing station geographic coordinates with those currently loaded in the project.

With the transformation now defined, you can output your solution in the local system by running *Export Wizard* and selecting either the *Local Coordinates* profile, or any user-defined profile which contains the *Local Plane* variables. See *Section 2.7.4* on *Page 107* for additional information.

9.6.7 How do I process an aerial survey with camera event marks?

Load Camera Event Marks
After adding the master and the remote, ensure that the camera event marks are loaded. For user logging position records, the camera event marks should be visible in the *Mapping Window*. If position records are not being logged at the remote, it is possible that these marks will not show up until after processing has been performed. However, if the marks fail to show after processing, they will have to be loaded manually via *File | Load | Camera Event Marks*. For instance, Ashtech (Thales) events must be loaded in this manner. See *Section 2.3.10* on *Page 41* for details.

Configure Processing Settings

Select *Settings | Load Settings From | Airborne* to utilize a parameter set that is well-suited for airborne data. While these options may not be perfect, they are an ideal place to start. If the base station data is interpolated, make sure the *Only search on exact interval* option is enabled and enter the original interval in the *Search on data interval* field. See *Page 98* for information.

Process and Analyze Data

After processing has completed, view the *Combined Separation* plot under *Output | Plot GPS Data*. The plot should, ideally, show a separation near zero. See *Section 9.6.1* on *Page 271* for further help analyzing the results.

Output Final Coordinates

When processing is done and the results are to your satisfaction, the final step is to output the solutions. To do this, use the *Export Wizard*, under the *Output* menu.

To obtain the coordinates for the camera marks, select the *Features/Stations* as the *Source*, and select an appropriate profile. See *Section 2.7.4* on *Page 107* for help creating a profile.

You will then be asked to enter the camera-to-antenna offset. This lever arm is used by *Export Wizard* to transfer the computed coordinates from the Kalman filter at the remote antenna to the camera.

> ⊠   The offset is defined in the local body system of the aircraft, and not the camera. The right-handed coordinate system is defined as follows:
>
>   **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

9.7   Digital Elevation Models (DEM) FAQ and Tips

This section goes over the implementation of DEMs into GrafNav and how to obtain some DEM data for the United States over the Internet.

⊠   DEMs are optional when processing GPS data.

A Digital Elevation Model (DEM) is a representation of the height of the ground. There are two ways they can be stored:

1. Regular grid with constant density (i.e. spacing). The DEM is stored as an array to minimize memory usage. Access is very fast, but flat areas require an unnecessarily high number of points.

2. Irregular point distribution where density generally increases with increased relief. This type is represented by a Triangulated Irregular Network (TIN).

While it can theoretically handle both types, GrafNav uses the latter type. The first one will be handled much less efficiently.

DEMs, after loading, are expressed in ellipsoidal height. Therefore, if the DEM is mean-sea-level, which is usually the case, the geoid undulation must be subtracted from the elevation values. This is performed automatically during the import process but it requires that a geoid (WPG) be available.

9.7.1   Why would I use a DEM?

There are two main reasons for using GrafNav's DEM capabilities:

1. The vehicle is traveling over a surface (e.g. road, runway, etc…) and the ground height is to be used for quality control purposes. GrafNav has the following plotting tools that help:

    • The Height Profile plot shows the height of the ground as well as remote station height. If the GPS antenna is a constant vertical offset above the ground, it should be entered as the remote antenna height.

    • The Height Above Ground plot shows the difference between kinematic GPS and ground heights. The ground surface height at each GPS position can be exported as well. DEM precision and accuracy is very important here.

2. In aerial photogrammetry, mapping is often performed on the map projection. This leads to an incompatible scale used for horizontal and vertical axes. The vertical scale factor (VSF) correction compensates for this, but usually only accepts a constant ground height. A more accurate compensation can be employed by using the height of the DEM under each image frame. In high relief areas, the DEM can improve this correction significantly. The amount of improvement depends on the size and variation of the scale factor in the project area and variation of the ground height. DEM accuracy is not as important, given that a 25 m DEM error will result in a very small final error in VSF height for UTM and an insignificant error for most State Planes.

9.7.2   What are the DEM sources?

There are many sources, but for VSF correction purposes, 1:250 000 (1-degree) DEMs are sufficient. In the USA, these can be obtained free of charge from the Internet, via the following steps:

1. Go to http://edc.usgs.gov/geodata/ and click on the **1:250K** along the top. Select **State**.

2. Select the state in which the project area lies. Then, select the area.

3. Download the map sheets from USGS site. For each file, use the utility *DEM2XYZN.exe*, available from http://data.geocomm.com/dem/dem2xyzn/, to convert these files to a listing of geographic points. The output will be *Longitude Latitude Height* where the latitudes and longitudes are in arc-seconds and the height is in metres.

4. If needed, concatenate files of together to create one file that will cover the entire project area. From the command prompt, use the **Copy** command and the following convention:

- copy file1.xyz + file2.xyz + file3.xyz combined_file.xyz

See *Section 2.6.5* on *Page 97* for help importing the DEM file into the software.

9.7.3   What DEM formats are supported by GrafNav?

GrafNav only supports DEMs stored in ASCII, where each elevation point is a separate record in the file. The full position must be made available for each point. This means that many grid files must be expanded before importing. The following formats are supported:

[ID]	Grid-East(m)	Grid-North(m)	Height(m)
[ID]	Grid-North(m)	Grid-East(m)	Height(m)
[ID]	Grid-East(usft)	Grid-North(usft)	Height(usft)
[ID]	Grid-North(usft)	Grid-East(usft)	Height(usft)
[ID]	Lat(deg min sec)	Lon(deg min sec)	Height(m)
[ID]	Lat(deg min)	Lon(deg min)	Height(m)
[ID]	Lat(decimal-deg)	Lon(decimal-deg)	Height(m)
[ID]	Lon(arc-sec)	Lat(arc-sec)	Height(m)

The *[ID]* term is an optional identifier that may be present. The last format listed is the one used in those files created by the *DEM2XYZN* utility.

9.7.4   How do I handle large DEMs?

DEMs can become very large. GrafNav's ability to handle them is very functional but is not designed for extremely dense data sets. DEMs consisting of over 500 000 points will become very slow within the software. They will also require a significant amount of memory. Such a DEM will utilize an additional 157 MB in GrafNav, not including contours. This means that a fast computer with at least 512 MB of memory is required. For VSF applications, DEM accuracy is not paramount, so DEM thinning is highly suggested.

Some helpful hints to speed up GrafNav with large DEMs:

- Enabled the *Reduce DEM density using error tolerance* option during the importing of the DEM procedure. This will cause the TIN formation to take longer, but GrafNav will operate much quicker afterwards. This is especially important for regular grids.

- Before importing, create a GPS trajectory composed of just the project area. Use the start/end processing times to achieve this. Ensure that the *Reject points outside DEM area* option is enabled.

- Disable contouring under *Settings | DEM Plotting*, or else select a very coarse contour interval. See *Section 2.6.5* on *Page 97* for more information.

- Disable ground height plotting on the *Height Profile* plot under *Settings | DEM Plotting*. See *Section 2.6.5* on *Page 97* for more information.

- In GrafNav Batch, only load the DEM into one baseline because an instance of the DEM will be created for each baseline.

9.8   Datum FAQ and Tips

A datum defines where the absolute coordinate values are referenced. For instance, WGS84, NAD83 and ED50 are datums. A datum is composed of an ellipsoid and a reference frame. The ellipsoid is a geometrical approximation of the earth's sea level surface, and it is needed to compute geographic or map projection coordinates. A semi-major

axis, *a*, and a semi-minor axis, *b*, define the size of the ellipsoid. A flattening value, *f*, may also be used in conjunction with the semi-major parameter for this definition as well. The relationship between these three variables is given by the following equation:

$$f = \frac{(a-b)}{a}$$

The reference frame defines the location and orientation of the geocentric coordinate axes (i.e. the origin). The absolute location of the reference frame for a given datum is not accurately known. However, differences between datum reference frames are often known precisely. These datum conversions can be represented as follows:

- **3-parameter (Molodensky)** – Includes shifts in the ECEF X, Y and Z axes.

- **7-parameter (similarity)** – Includes 3 shifts, 3 rotations and one scale.

- **14-parameter (7-parameter + temporal values)** – Includes 3 shifts, 3 rotations, one scale, 3 velocity and 3 rotational rates, and a scale rate. Temporal values are referenced to a certain year. This is useful for datums that move with respect to each other.

- **Horizontal grid based method (e.g. NADCON)** - This methodology does not try to use an analytical formula. Rather, it uses a grid of localized corrections to latitude and longitude to transform one horizontal datum to another. Normally, it does not include corrections to the ellipsoidal height.

9.8.1   *What are the available features of datums?*

The following capabilities are available:

- Built-in support for most of the world's datums using the NIMA (DMA) shift values.

- You may select between multiple conversions between the same datum.

- Better support for 7-parameter transformations.

- Support for 14-parameter transformations. This is useful for datums that are shifting with respect to each other due to tectonic movement.

- Support for the NADCON grid transformation (i.e. NAD27/NAD83 conversion)

- Ability to combine two conversions (i.e. ITRF97 ◊ NAD83 = ITRF97 ◊ WGS84 + WGS84 ◊ NAD83)

- Much-improved ability for users to add their own transformations. For instance, users can now add their own 7-parameter transformations.

- Coordinate transformation tool.

- Very powerful datum conversion computation tool (3- and 7- and 14-parameter conversion)

9.8.2   *How are datums handled within the software?*

WGS84 is the datum that GPS satellite orbits are referenced to. GLONASS is in PZ-90, but the software takes care of the difference. WGS84 has undergone a number of changes over the last 10 years, and it is now referenced to ITRF96…ITRF2004. ITRF datums are global datums, meaning that they are moving with respect to most of the world's datums due to plate tectonics. Such movements can be as large as several centimeters per year. For this reason, WGS84 is not a suitable datum for publishing coordinates in.

Waypoint's software supports two methods for handling other datums:

1. **Transform satellite coordinates into local datum:** This is a very seamless methodology for supporting local datums. It enables the datum transformation to be applied only once, which minimizes the danger of mixing up conversions. Users need only to select the correct datum during processing and enter the base station coordinates in the local datum. For this reason, this method is highly suggested.

2. **Process in WGS84:** Input coordinates are transformed into WGS84, which is the same datum that processing is performed in. This methodology allows you to use very localized or grid based datum conversions. It is not possible to transform the very distant satellite coordinates, like the previous method does, using such localized conversions. Normally, final coordinates are also desired in the input datum. Therefore, care must be taken to convert the coordinates from WGS84 to the local datum using the same transformation.

9.8.3   How do I making additional datums available?

Waypoint's software has over 100 built-in datums. Most of the transformations from these datums to WGS84 are from the NIMA document: http://164.214.2.59/GandG/pubs.html. See also http://www.nima.mil/. Only a few of these datums are initially displayed in the processing options and other datum-selection tools. To enable the datums that are going to be used frequently and disable the rest, use the *Datum Manager* under the *Tools* menu. From the *Datums* tab, the entire list of datums is displayed. Select the datum from the list and click the *Enable* or *Disable* button; the status will be toggled.

9.8.4   How do I enter a 7-parameter transformation?

Add new transformation under the *Tools | Datum Manager.* To do this, select the *Datum Conversion* tab. Once you specify the two datums between which the transformation will apply, click on *Add* to bring up the *Add/Edit Conversion* window.

When using 7-parameter transformations, be careful of the rotation angles, as there is no standard definition for the sign. The sign convention used by Waypoint's software is as follows:

$$
\begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{To} = \left(1 + scale\right) \begin{bmatrix} 1 & -\theta_Z & \theta_Y \\ \theta_Z & 1 & -\theta_X \\ -\theta_Y & \theta_X & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{From} + \begin{bmatrix} \Delta X \\ \Delta Y \\ \Delta Z \end{bmatrix}
$$

Recent analysis shows the opposite sign tends to be more frequent. If your transformation uses the opposite signage (i.e. θ_x, θ_y, θ_z have the opposite sign in front of them) then enable the *Use reverse sign for rotations* option. The best way to determine which sign should be used is to inquire with the agency producing the transformation. You can also match the overall transformation to an existing datum conversion but use extreme caution when doing this.

To ensure the availability of the datums between which the conversion will be applicable, see *Section 9.8.3*.

To add a datum conversion, follow these steps:

1. Go to *Tools | Datum Manager* and select the *Datum Conversions* tab.

2. Select the *From* and *To* datums for the conversion. It does not matter which is selected where, but it is easier to assign the datums in a manner corresponding to the transformation for which the values are available.

3. Click the *Add* button

4. Type a name in the *Info string* field. Only alphanumeric characters, as well as hyphens and underscores, are allowed. You may also wish to enable the *Set as default transformation* option to ensure that these parameters are used for transforming between these two datums.

5. Select the *7 parameter (similarity/Helmert)* in the *Type* box,

6. Enter the shift values in meters.

7. Enter rotations in arc-seconds (not milli-arc-seconds, as they are sometimes expressed in). If the opposite sign formula is used, enable the *Use reverse sign for rotations* option. Ensure that the proper sign definition is used. See the equation above.

8. Enter scale in parts-per-million (i.e. PPM_value x 10^{-6}).

9. Check the transformation under the *Transform Coordinates* tab. At this stage, you can also compare the overall transformation to that of another datum conversion.

9.8.5 How do I enter a 14-parameter transformation?

Again, be careful of the signage when using 14-parameter transformations. The sign convention used by Waypoint's software is as follows:

$$
\begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{To} = \begin{bmatrix} \Delta X \\ \Delta Y \\ \Delta Z \end{bmatrix} + \left(\begin{bmatrix} sf' & -\theta_Z & \theta_Y \\ \theta_Z & sf' & -\theta_X \\ -\theta_Y & \theta_X & sf' \end{bmatrix} + \begin{bmatrix} 0 & -VR_Z & VR_Y \\ VR_Z & 0 & -VR_X \\ -VR_Y & VR_X & 0 \end{bmatrix} \times \Delta Year \right) \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{From} + \begin{bmatrix} V_X \\ V_Y \\ V_Z \end{bmatrix} \times \Delta Year
$$

Where:

$$ sf' = (1.0 + ppm + ppm\_vel \times \Delta Year) $$

In terms of adding such a transformation, follow the same steps described previously in *Section 9.8.4* and *Section 9.8.5*. Certain modifications to these steps will have to be made, such as selecting *7 parameter + time dependency in Step 4*. This gives you access to the additional fields required to complete the 14-parameter transformation.

9.8.6 How do I use NADCON conversion files?

NADCON are the datum conversion files produced by the National Geodetic Survey (NGS) in the United States. This conversion is expressed as a grid of corrections to latitude and longitude. For the most part, this correction is used for NAD27/NAD83. However, some other countries have also adopted this format. In addition, the NGS has corrections between NAD83 and NAD83(HARNS). The NGS files can be obtained from http://www.ngs.noaa.gov/TOOLS/Nadcon/Nadcon.html. The latitude correction is located in the LAS file, while the LOS file contains the longitude correction.

To add a NADCON datum conversion, follow the first three steps of the procedure defined in *Section 9.8.4* above. After that:

1. Select *Nadcon (NGS)* in the *Type* box,.

2. Select the LAS file for the region. The LOS file need not be defined, as it is loaded automatically.

3. Choose how the height is to be treated. *Leave 'As Is'* means that there will be no transformation to height. Care must be taken when importing/exporting coordinates. In *Export Wizard*, enable the *Do not convert elevation (leave in processing datum)* option when prompted. In addition, make sure to combine the datum transformation with a geoid height correction since only the orthometric height may be valid in this datum. Using another 3- or 7-parameter transformation for height can be a safer alternative, but it can be more difficult to incorporate a geoid model as there may not be one for the datum**.**

4. Check the transformation under the *Transform Coordinates* tab.

5. Under *Settings | Datum*, make sure that the **C**onvert input coordinates to processing datum (for Nadcon and localized datums)* option is enabled. This can also be done by clicking the *More Datum Options…* button under *Settings | Individual | General*. In addition, ensure that WGS84 or NAD83 is selected as the processing datum.

9.8.7 How do I prevent corruption from conversion errors?

In many cases, datum transformations can have errors of several meters or more. Be cautious about using any transformation in an absolute sense. Transformations should only be used for relative corrections. Care should also be taken that the same correction be used throughout. Here are several tips on minimizing these effects:

- Process in the local datum (e.g. NAD83, ED50, etc…) as much as possible. This methodology effectively uses a relative datum correction and minimizes the possibility of using multiple datum conversions. Processing in the local datum is performed by selecting the processing datum under *Settings | Individual | General*. Click on the *More Datum Options…* button to ensure that the *Use processing datum by setting processing datum to local datum* option is enabled.

- For localized datums (i.e. datums with large rotations, scale or shifts) or for NADCON corrections, processing should use a more global datum (e.g. WGS84 or NAD83). It is very important that the same conversion be used in the coordinate input and for the *Export Wizard*. This entails checking the conversion being used. In addition, avoid using the *Write Coordinates* feature to export coordinates, as it does not support input datums different from the processing datum.

- If using a newer version of GrafNav or GrafNet, or if examining an old project, be sure that the default conversion has not changed.

- If using an external program to transform coordinates to the processing datum (e.g. WGS84), then use the same program to convert the final coordinates back to the local datum.

- Be cautious with geoids. Geoids designed for one datum may not be compatible with another.

9.9   Projections FAQ and Tips

A map projection is the representation of the earth's spherical surface on a flat surface. Map projections are also sometimes referred to as grids. UTM is one of the most common map projections. Waypoint's software currently support three types of map projections:

Transverse Mercator
This employs a cylinder placed horizontally around the earth. Transverse Mercator (TM) has little distortion in the north-south direction, but the scale factor deviation from unity grows along with the convergence with distance from the central meridian. UTM starts a new zone every 6 degrees to circumvent this.

Lambert Conformal
This utilizes a cone placed over the north (or south) poles. Distortion is minimal in the east-west direction, while the limitations are in the north-south direction.

Oblique Mercator
This is similar to the TM in the sense that it employs a cylindrical projection. The difference is that the cylinder is oblique, running along the great circle arc between any two points. The result is a projection with little distortion in the direction of the chosen arc.

Local Cartesian
See *Section 9.6.5* for information.

Local Coordinate Grid
See *Section 9.6.6* for information.

US State Plane
New Zealand Mapping Grid (NZMG)
Earth-Centred Earth-Fixed (ECEF)

9.9.1 What features are available with map projections?

Waypoint's software supports two manners of map projections:

1. Direct selection (e.g. UTM, TM, Gauss Kruger, State Plane, Lambert, etc…).

2. Pre-defined and user-defined grid definitions using the *Grid Manager.*

For coordinate output, both methods can be used in the *Export Wizard* by using the *Selectable Grid-East* and *Selectable Grid-North* variables. See *Section 2.7.4* on *Page 107* for more information. For *Write Coordinates*, only direct selection is possible.

For coordinate input (i.e. base stations in GrafNav and control points in GrafNet), only grid definitions can be used. Another advantage with using grid definitions is that users can manage multiple user definitions more easily (i.e. for each country or region).

9.10 Geoid FAQ and Tips

The geoid is the level of the sea surface (equipotential surface under land masses). For instance, a spirit level, or surveyor's level, would follow the geoid. Because of this, vertical datums are based upon the geoid. Maps are also based on the geoid to prevent any contour lines from forming on level surfaces such as lakes.

GPS can only make measurements on the ellipsoid, and, therefore, elevations must be corrected to reference the geoid. The height above the geoid is known as an orthometric, or mean-sea-level (MSL), height. The difference between the geoid and the ellipsoid is called the geoid height or undulation value, and it changes across the earth by 100 meters. Luckily, many government agencies put out geoid undulation grid files that can be used to convert ellipsoidal to orthometric heights.

The relationship between the orthometric height, H, the ellipsoidal height, h, and the geoid height, U, is given by:

* $h = H + U$

9.10.1 What are the available features of geoids?

Waypoint's software supports geoids in three different formats including the U.S. National Geodetic Survey's GEO format, the Geodetic Survey of Canada's BIN/SLV format, and Waypoint's own WPG format.

When correcting ellipsoidal heights to produce orthometric heights, it is very important that the geoid and processing datums match. For example, if EGM-96 is used, then the base station coordinates should be in WGS84, and this datum should also be used for processing. Be careful to use the same geoid model as used on the control sheets. This lessens the likelihood of differential errors developing.

Table 40 provides a list of the geoids included on Waypoint's installation CD. The datum upon which each is based is also provided, as well as websites for more information.

Table 40: Geoids and Service Provider Website Addresses

Geoid	Datum	Web Address
AusGeoid93-1M	GDA94	http://www.ga.gov.au/geodesy/ausgeoid/ag93.jsp
AusGeoid98	GDA94	http://www.ga.gov.au/geodesy/ausgeoid/
EGM96-World	WGS84	http://earth-info.nga.mil/GandG/wgs84/gravitymod/index.htm
France-RAF98	WGS84	http://www.esgt.cnam.fr/fr/default.htm
Geoid03-ContUS	NAD83	http://www.ngs.noaa.gov/GEOID/GEOID03/
Geoid96-Alaska Geoid96-ContUS	NAD83	http://www.ngs.noaa.gov/GEOID/GEOID96/
Geoid99-Alaska Geoid99-ContUS Geoid99-Hawaii Geoid99-PuertoRico	NAD83	http://www.ngs.noaa.gov/GEOID/GEOID99/
GPS-H-Canada	NAD83	http://www.geod.nrcan.gc.ca/index_e/products_e/products_e.html
GSD95	NAD83	http://www.geod.nrcan.gc.ca/index_e/products_e/products_e.html

In some cases, you may wish to process in a datum different than the one the geoid uses. For this case, accurate results can still be obtained by using 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 may result in a few centimeters of orthometric height error. The same can be said for other datums with large shifts (e.g. 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 will be 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 will 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.

Appendix

Output Variables

Table 41: 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
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 (i.e. true-north).
ECEF Covariance Matrix	Estimated ECEF position covariance matrix; needs extended output in GrafNav

Table 41: List of Output Variables

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
Latitude	North/South geographic coordinate

Table 41: List of Output Variables

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. Useful to separate multiple baselines in GrafNav Batch.
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
Slope Distance	Free air distance between stations

Table 41: List of Output Variables

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 (e.g. 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.

Antenna Measurements Diagram
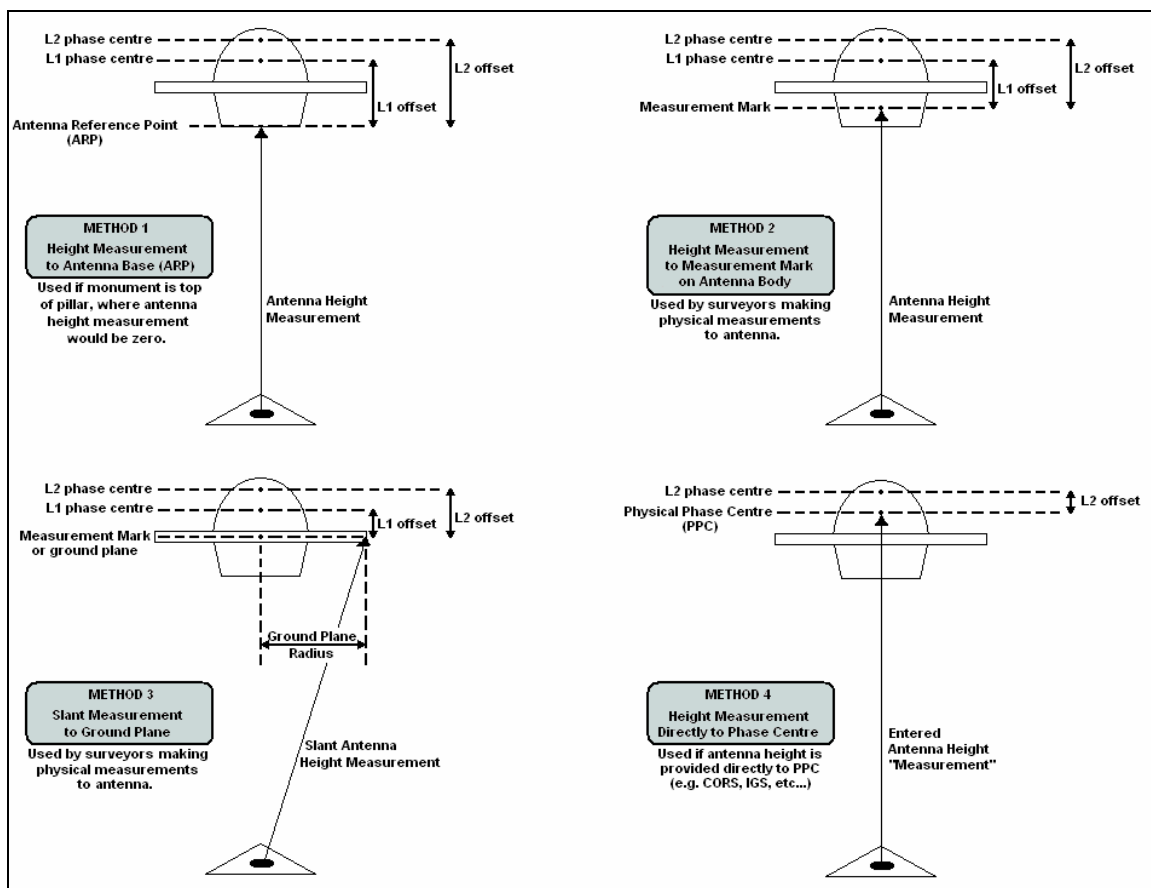
Figure 8: Antenna Measuremnents

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, etc, 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 GrafNav 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 deamed 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 cor-

rections 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 multi-path 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 ime 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 (e.g. 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).

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 intials 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 Hemisphere (e.g. 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 (i.e. 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.

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 troposheric 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 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/OFFON 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 1.3 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**.

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