

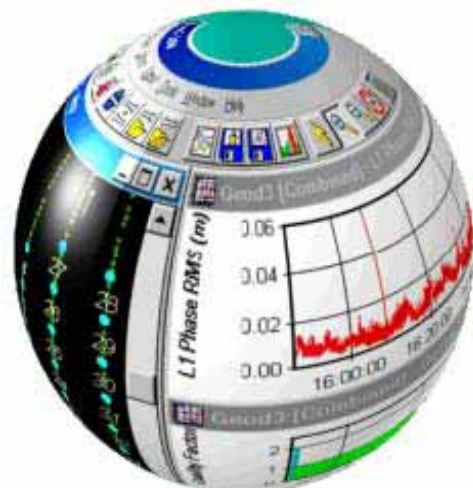
GrafNav/GrafNet

The following document is a detailed description of **Waypoint Consulting Inc.'s** GrafNav/GrafNet post-processing software package.

- [What is GrafNav/GrafNet?](#)
- [What is included with GrafNav/GrafNet?](#)
- [Waypoint Consulting's Philosophy](#)
- [Accuracy](#)
- [GPS Post-processing Kernel](#)
- [GrafNav User Interface](#)
- [GrafNet User Interface](#)
- [Quality Control](#)
- [Real-Time Data Logger](#)
- [Supported GPS Receivers](#)
- [Moving Baseline Processing and Heading Determination](#)
- [Upgrade and Support Policy](#)
- [Customization](#)
- [Applications](#)

What is GrafNav/GrafNet?

GrafNav/GrafNet is a Windows software package developed by Waypoint Consulting Inc. that corrects raw GPS data so that accuracies are significantly improved. Given the right GPS equipment and proper field procedures, accuracies of 1 cm or better can be achieved. Such processing requires data from two stations in order to perform the correction. One station is normally located on a point of known position and called the reference, base, or master station. The second receiver can either be stationary (static) or moving (kinematic) and is called the rover or remote. The combination of the two receivers' data is known as a baseline. GrafNav/GrafNet is unique in that it can also support applications where the base is moving via the Moving Baseline Upgrade, which is useful when the base cannot be located on a stationary location.

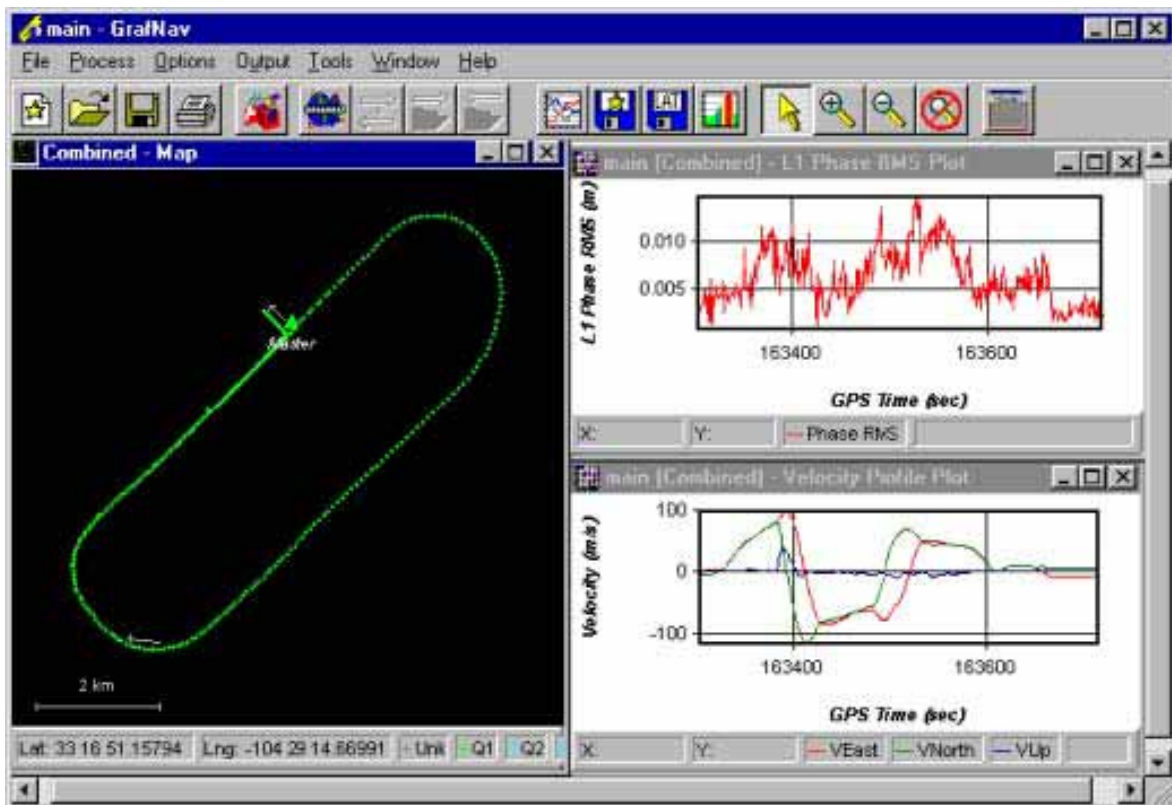


Waypoint supports binary data formats from most GPS manufacturers. However, for those users with an inexpensive GPS handheld receiver, you may not be able to use our software. GrafNav/GrafNet and its lower cost cousin GrafNav Lite can process data from OEM GPS receiver cores, costing as little as \$100, provided that they output raw measurement data. GPS receivers that generally work in an optimal fashion with GrafNav/GrafNet cost from \$750 to \$30,000. The more expensive receivers are generally used by surveyors and mapping companies and may support both L1 and L2 GPS frequencies. These units usually also come with data collection capabilities. OEM or less expensive units may require laptops, Windows CE palmtops, or DOS units to store GPS data using the data logging software that is provided with GrafNav/GrafNet.

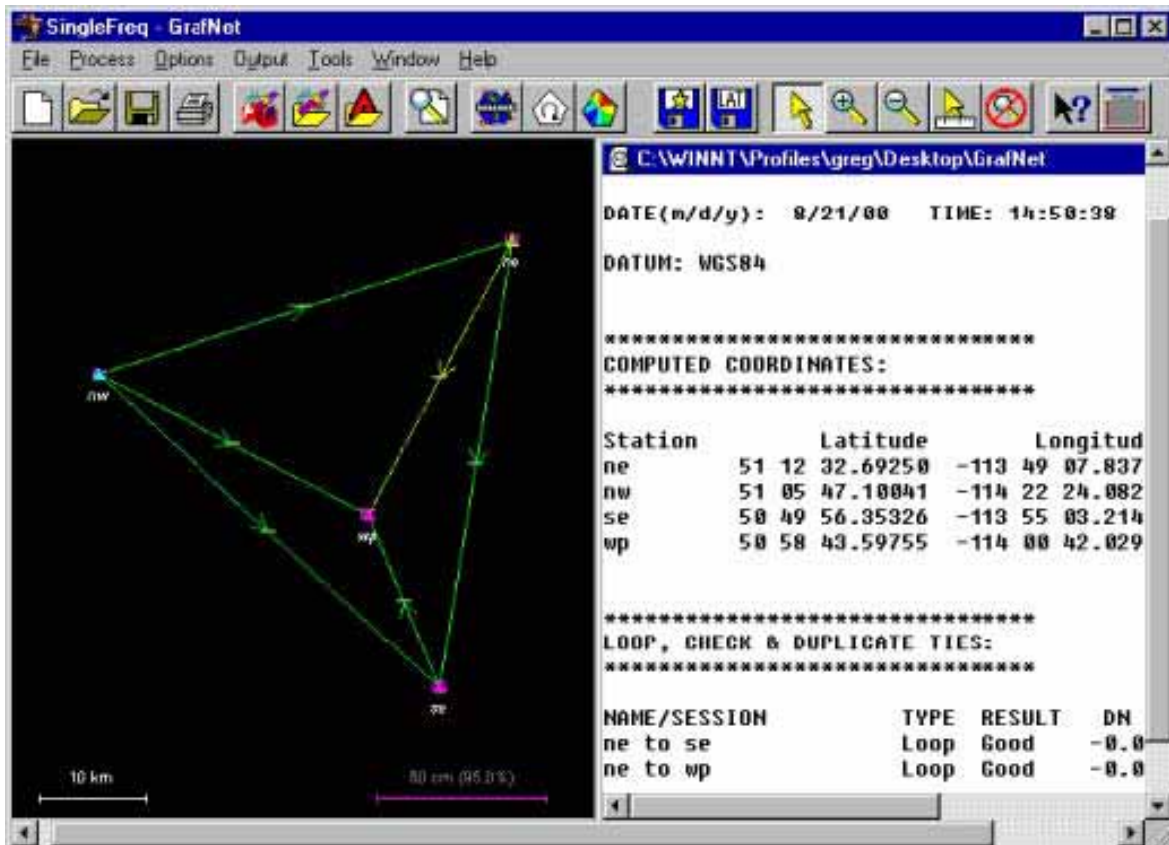
What is included with GrafNav/GrafNet?

GrafNav/GrafNet is a complete package, and with the exception of the Moving Baseline Upgrade, no additional modules need be purchased. The following major components are included with GrafNav/GrafNet:

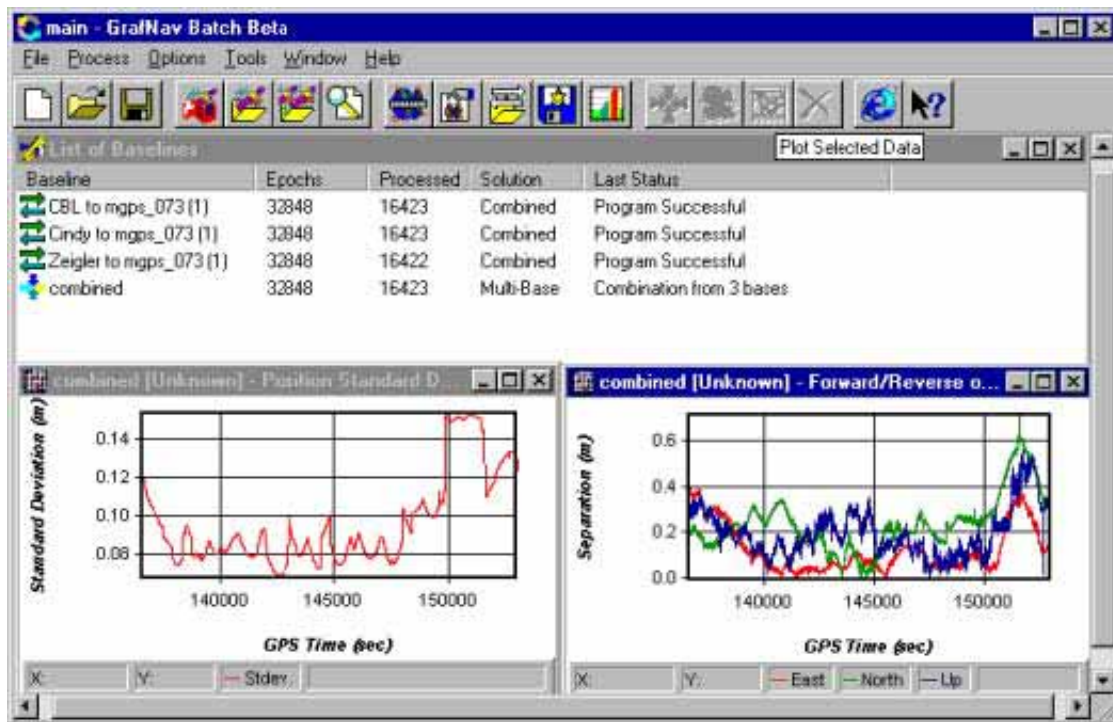
GrafNav processes data for one baseline (e.g. one base and one remote). GrafNav is normally used for kinematic data which it is extremely well suited for. It can also process single static baselines. Receiver types can be mixed and matched via the use of a common format.



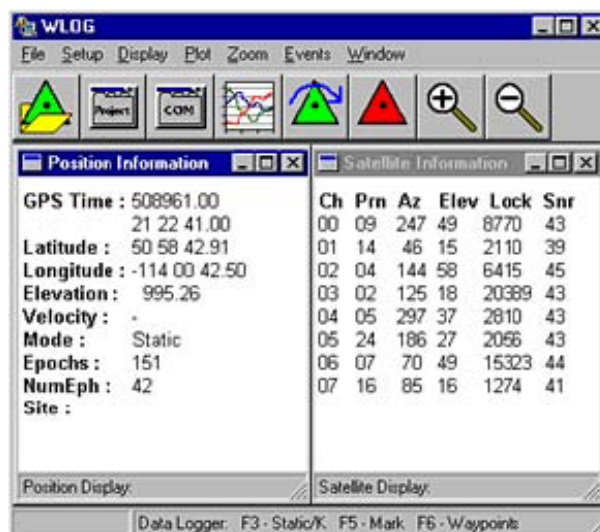
GrafNet automatically matches up common time periods from GPS observation files and forms a network of baselines that can be automatically processed. GrafNet can also perform a network adjustment for accurate computation of station coordinates and their standard deviations.



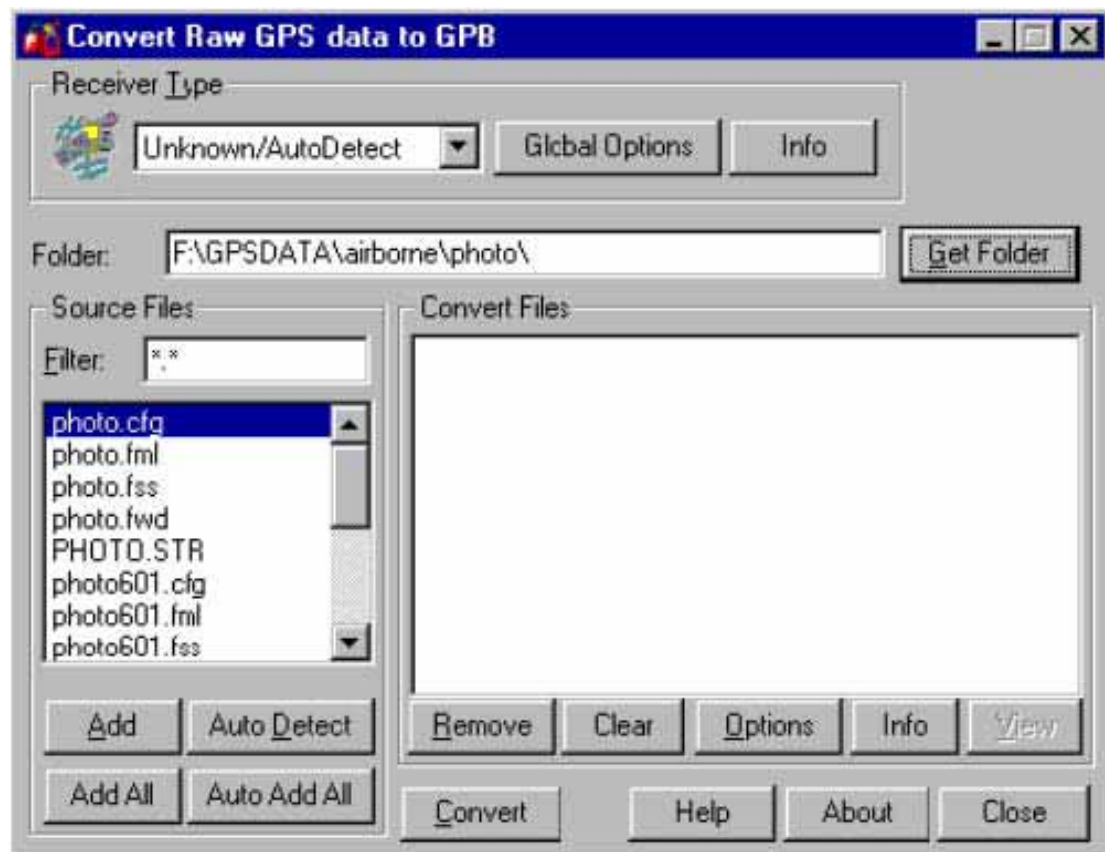
GrafNav Batch is used to "batch process" multiple kinematic or static GrafNav baselines. Most of the capabilities of GrafNav are contained in GrafNav Batch. With version 6.02, the ability to combine baselines computed for the same remote but from different base stations will be added for up to 128 bases.



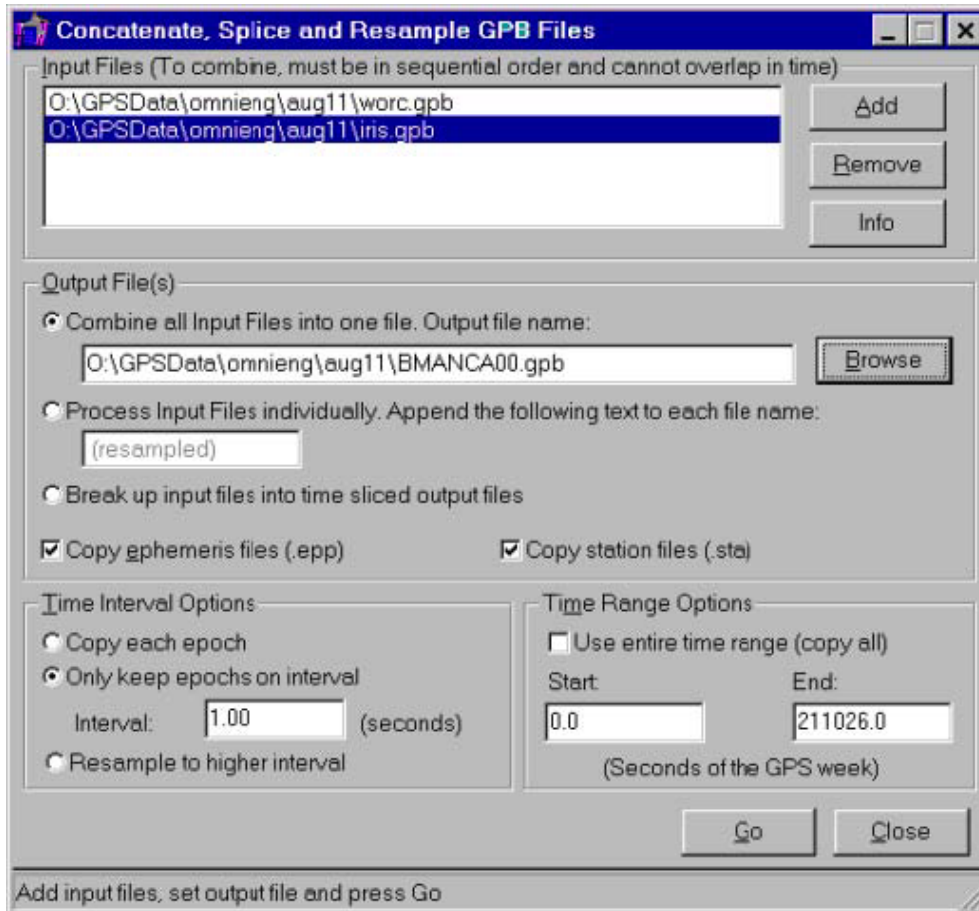
A **Data Logger** is included with GrafNav/GrafNet that collects GPS raw data from a number of GPS receivers (see below). Versions are available for DOS, Windows 95/98/NT, and WindowsCE.



The **Data Conversion** utility contained in GrafNav/GrafNet supports most raw GPS data formats (see below), and the file's GPS format will usually be automatically detected. Once the GPS data is converted to Waypoint's proprietary format, GrafNav/GrafNet can manipulate it. It can also be converted to RINEX.



Included with GrafNav/GrafNet are other **utilities** that can splice, resample, and combine raw data files, view raw data files, and resurrect corrupted files to name a few. GPS data can even be resampled to a higher data rate than collected.



Waypoint Consulting's Philosophy

The philosophy behind the GrafNav/GrafNet post-processing software can be summarized as follows:

Know Where You Stand - The most often asked question by a novice user is, "Have I achieved my accuracy?" With GrafNav/GrafNet's extensive quality control tools and plots, this question is easy to answer. For example, by processing the data both in the forward and reverse directions, the plotted difference between the two solutions is a very quick and easy check.

Free and Accessible Customer Support* - With Waypoint, there are no long telephone hold times nor do you need to get your credit card ready to ask a question. We pride ourselves on providing some of the best support in the industry. Due to the small size of our company, you will often be asking questions with one of the software developers.

Easy-to-Use but Powerful - A good graphical user interface is one that is easy to use for a first time user, while not limiting an advanced one. This medium is difficult to achieve, but with GrafNav/GrafNet we believe that this design objective has been met.

Receiver Independence - With GrafNav/GrafNet, users are not restricted to using GPS equipment from one manufacturer. In fact, we support the raw formats for most receivers on the market. For example, a user may wish to have GLONASS capable equipment for work in forested areas. However, another receiver manufacturer may be better suited for other types of work, and GrafNav/GrafNet can be used throughout the different projects.

No Black Box Magic - Since most of the processing files are ASCII, power users can view or tap into many of the intermediate stages of GrafNav or GrafNet. Therefore, if there is any kind of a problem, diagnosis or correction can be that much easier.

A Piece of the Pie - For most users, GPS post-processing is only a portion of the overall processing methodology. In many cases, real-time software will be storing time-tagged information from supplementary devices in addition to the GPS data. Further processing may be required, following the feature or trajectory coordinates determination in GrafNav. Our goal is for the GPS post-processing to be as fast and easy as possible. GPS postprocessing is important because its results govern positioning accuracies; however, it should not be slow or cumbersome!

We listen to our Customers - At Waypoint, most of our software improvements are made by customer requests. If you feel that something is missing with GrafNav/GrafNet, please let us know.

All Inclusive - For GrafNav/GrafNet, with the exception of the Moving Baseline Upgrade, additional modules do not have to be purchased. Even data logging and RINEX conversion are included at no extra charge.

* Customer Support is free for the first year after purchase and comes via telephone, email and fax assistance

Accuracy

Achievable accuracies are difficult to quote because they depend on the baseline length, receiver type, field procedure, data quality (i.e. cycle slips, ionospheric activity, and multipath), and occupation time (for static). However, there are some general guidelines available. If there is a discrepancy between the guidelines given by your receiver manufacturer and the ones given here, please contact Waypoint for clarification.

Accuracies are shown here as a two-part estimate. The minimum bias is given in cm, while a parts-per-million (PPM) values shows the effect of distance based errors. For instance, on a 40 km baseline, an error of 2 cm + 1 PPM translates into $(0.02 + 1.0 \cdot 10^{-6} \cdot 40,000 = 0.06 \text{ m or } 6 \text{ cm})$. For **static** occupations, the fact that accuracies improve with longer observation time makes it difficult to state just one accuracy estimate. However, using typical occupation times, the following chart is available. In general, dual frequency occupation times can be about $\frac{1}{2}$ of the single frequency time.

Baseline	Length	Observation time	Single Frequency accuracy	Dual Frequency accuracy
Short	0 - 10 km	10 - 30 min	1 cm + 1 PPM	1 cm + 1.0 PPM
Medium	10-100 km	30 min - 4 h	2 cm + 3PPM	2 cm +0.5 PPM
Long	100+ km	6 - 12 h	2 cm + 3 PPM	2 cm + 0.1 PPM

For **kinematic** positioning, occupation time is no longer an issue. However, loss-of-lock becomes a very important factor. In all cases, heavy loss-of-lock will severely degrade accuracies. Accuracy guidelines are given for kinematic mode as follows:

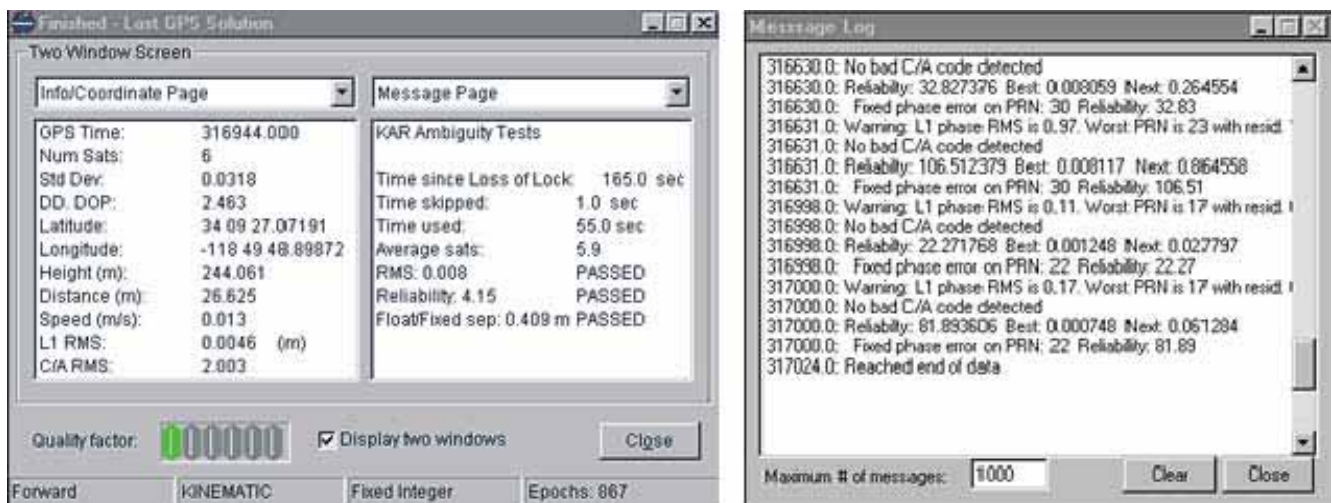
Baseline	Length	Single Frequency accuracy	Dual Frequency accuracy
Short	0 - 5 km	2 cm + 1 PPM*	2 cm + 1 PPM
Medium	5 - 35 km	5 cm + 4PPM	5 cm + 2 PPM
Long	35+ km	10 cm + 4 PPM	10 cm + 2 PPM

* No loss of lock

Please note: The accuracies shown here are only guidelines. They assume that proper field procedures have been used, the satellite geometry is good, multipath is not severe, and that no ionospheric storms occurring. Even then, anticipated accuracies may not be achieved if the receiver data quality is poor (eg. many cycle slips or losses-of-lock).

GPS Post-processing Kernel

GrafNav, GrafNet, and GrafNav Batch share the same processing engine that has been under continuous development since its original inception by Waypoint in 1992. The core of this robust engine is its carrier phase kinematic (CPK) Kalman filter. Some of the major advantages of Waypoint's kernel are:



Fast processing - The GrafNav kernel is one of the fastest on the market. It will process ~0.8 epochs per MHz per second on a Pentium II. For example, a 400 MHz machine will process about 320 epochs/second, which translates into 45 seconds of processing time for 4 hour data set collected at 1 Hz.

Robust Kalman filter - From experience with processing GPS data from fast jets and NASA sounding rockets, the processing kernel has become extremely robust. Efforts have been made to account for all of the various data error possibilities given the different types of GPS receivers that GrafNav/GrafNet can handle. With version 6.02 the bad data detection has been completely re-developed to handle as many cases as possible.

Reliable OTF - Waypoint's on-the-fly (OTF) algorithm, called Kinematic Ambiguity Resolution (KAR), has had years of development and stresses reliability. Variations are implemented for both single and dual frequencies, and numerous options are available to control this powerful feature. KAR now corrects for the ionosphere in version 6.02.

Accurate Static Processing - Three modes of static processing are implemented in the processing kernel. Fixed static is the most accurate and has immensely improved with version 6.00 and again with version 6.02. A quick static solution is also available as an alternative, while the float and iono-free float solution is useful for long baselines.

Dual Frequency - Full dual frequency support comes with GrafNav/GrafNet. For ambiguity resolution, this entails wide/narrow lane solutions for KAR, fixed static and quick static. Ionospheric processing is very important with the peak of the ionosphere's cycle occurring in 2000. The GrafNav kernel implements two ionospheric processing modes including the iono-free and relative models. The relative model is especially useful for airborne applications where initialization is near the base station, and this method is much less susceptible to L2 phase cycle slips.

Forward and Reverse - Processing can be performed in both the forward and reverse directions. Both GrafNav and GrafNet also have the ability to combine these two solutions to obtain a globally optimum one.

GPS + GLONASS - The GrafNav kernel has the ability to also process GPS+GLONASS data. This is especially advantageous for applications in forested areas, where the additional satellite coverage can greatly improve accuracies (see GLONASS reports: [Surveying with New NovAtel Millennium L1 GPS/GLONASS Receivers](#) and [Seismic Surveying under Tree Canopy Using Ashtec GG-24 GPS/Glonass Receivers and Waypoint's GrafNav Post-Processing Software](#) available on Waypoint's webpage at www.waypnt.com under tech reports).

Velocity Determination - Since the GrafNav kernel includes the L1 Doppler measurement in its Kalman filter, velocity determination is very accurate. In addition to this, a considerable amount of code has been added specifically for the detection and removal of Doppler errors.

High Dynamics -The GrafNav kernel can handle extremely high dynamics from missiles, rockets, dropped ordinances, and fast flying aircraft.

Long Baseline - Because precise ephemeris and dual frequency processing is supported, long baselines accuracies can be as good as 0.1 PPM. (See [Kazakh - Northern Block Single Frequency Long Baseline Adjustment](#) and [1000KM Baseline Determination in Static and Kinematic Mode](#) on Waypoint's webpage under tech reports).

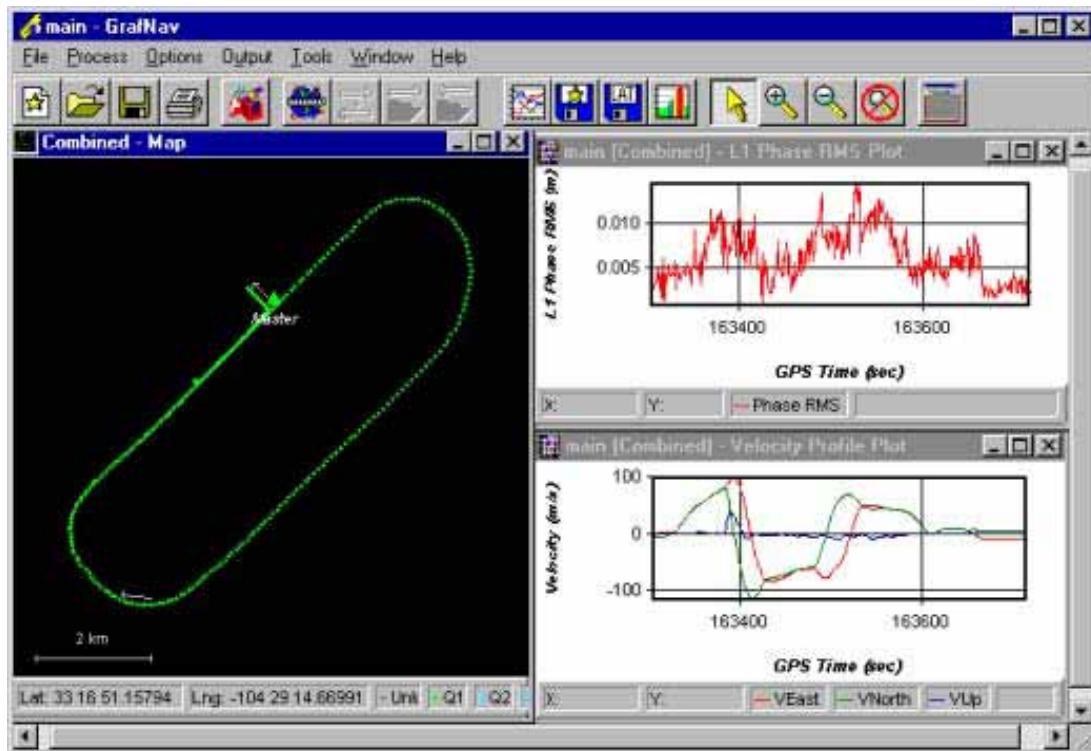
NMEA Correction - GrafNav even supports the ability to correct NMEA data using a position correction. This correction is not as accurate as the normal method, but it can still be better than 10 m given the right GPS receiver.

Developer's Kit - The processing dynamic link library (DLL) and the data conversion DLLs are available as a separate product. This allows users to add many of the capabilities of GrafNav into their own software.

RTK - These algorithms are available for real-time processing using our RtEngine/RtDLL product line.

GrafNav User Interface

GrafNav is primarily intended for kinematic processing, but it can also process single static baselines. GrafNav can also be called from GrafNet for further investigation of a problematic baseline. Some of GrafNav's major features are:



Easy to Use - The GrafNav interface is easy to use, while not limiting an advanced user from investigating their GPS data.

Extensive Plotting - Epochs, static occupations, and features (i.e. stations, GIS marks, and camera event marks) are all displayed to the mapping screen. Objects can be clicked on to view solutions. Epochs are even color coded depending on accuracy. In addition to a mapping screen, 26 data graphs can be viewed as well. All of this can be printed to your laser or color printer.

Datums and Projections - GrafNav supports many of the more common datums and the 'User Defined Datum' feature allows nearly any datum to be used for processing and output. The same can be said for map projection support. The common ones such as Geographic, UTM, Gauss Kruger, State Plane, Local Plane, Local Level, ECEF are all supported, while less common ones can be reproduced using the built-in user definable map projections.

Exporting Results -Once processing is complete, exporting results is an easy procedure. With the new Export Wizard, almost any ASCII file format can be reproduced,since the Export Wizard has access to over 110 variables. Even obscure variables such as checksums, sequence numbering by 10, and velocity covariance are supported.

Geoid Support - Geoids are used to convert GPS derived heights to mean sea level. GrafNav comes with Geoids for the World via EGM-96, continental US including via Geoid93, 96 & 99, Alaska via Geoid96 & 99, Mexico via Mexico97, and Australia via AusGeoid93 and 98. Canadian Geoids are also supported, but they must be purchased from NRCan.

Camera Events - Event marks from aerial cameras or other devices can be imported from most GPS receivers that support such a feature. A user defined event format is also available for importing unsupported variants. Position interpolation of the events from the GPS trajectory can be performed via either a linear interpolation or a second-order polynomial.

Station Editing - Stations names, description, remarks, and their antenna heights can edited using the Feature Editor within GrafNav.

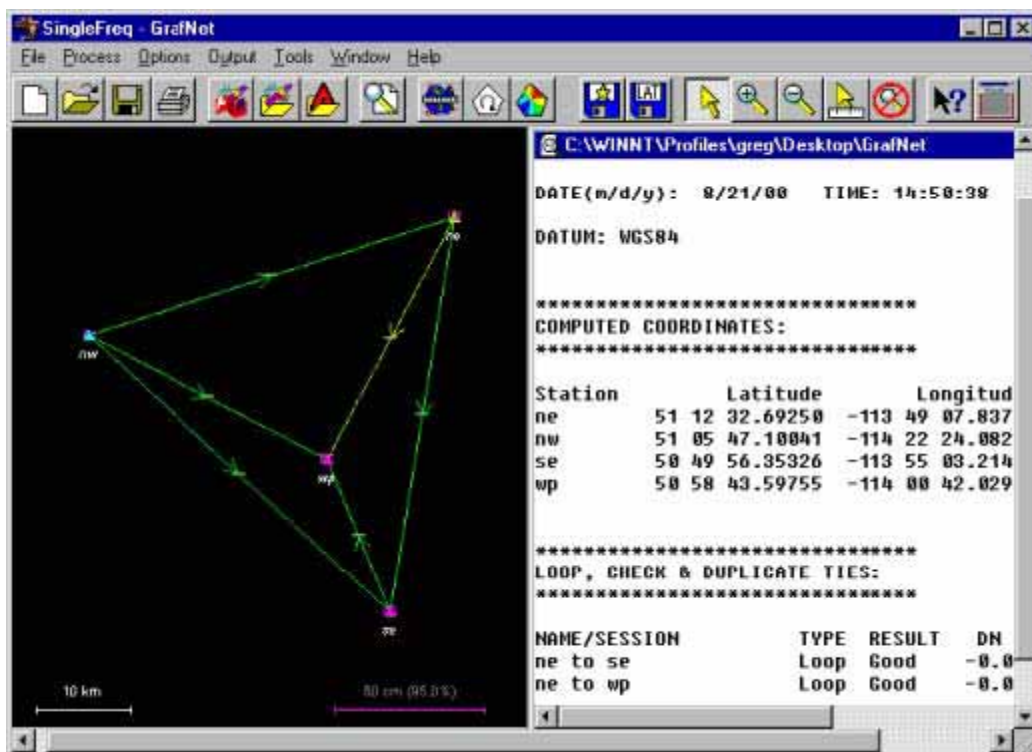
Mission Planning - With version 6.02, the ability to perform mission planning from within GrafNav will be available. Using almanac files downloaded from the Internet, users can predict the number of satellites and their geometry in the past, present or future. This includes selecting two stations for long baseline processing with common satellites.

RTK Data - The ability to view and export RTK data will also come with version 6.02. This is useful for quality control purposes.

Multi-Base Processing -With version 6.01, solutions from two base stations can be combined into a global optimum solution. However, with version 6.02, GrafNav Batch will be able to automatically process and combine solutions from up to 128 base stations.

GrafNet User Interface

GrafNet is a static network baseline processing tool used mainly by surveyors. However, any user that wishes to obtain a station's coordinates using RINEX files from a number of continuously operating sites (i.e. CORS or IGS) will find GrafNet very useful. GrafNet has most of the user interface features of GrafNav, like: Mapping Window, Export Wizard, Geoid support, same datums and projections and processing capabilities. The following features are additional:



Trivial Baseline Removal - GrafNet can automatically (or manually) remove trivial baselines in a GPS static network.

Network Adjustment - An easy-to-use network adjustment is included with GrafNet. For users requiring more advanced features that are not provided by the built-in network adjustment (e.g. the inclusion of conventional surveying observations), both GeoLab and StarNet can support GrafNet's export format.

Error Ellipse Plotting - GrafNet will display both absolute and relative error ellipses using a confidence level set by the user.

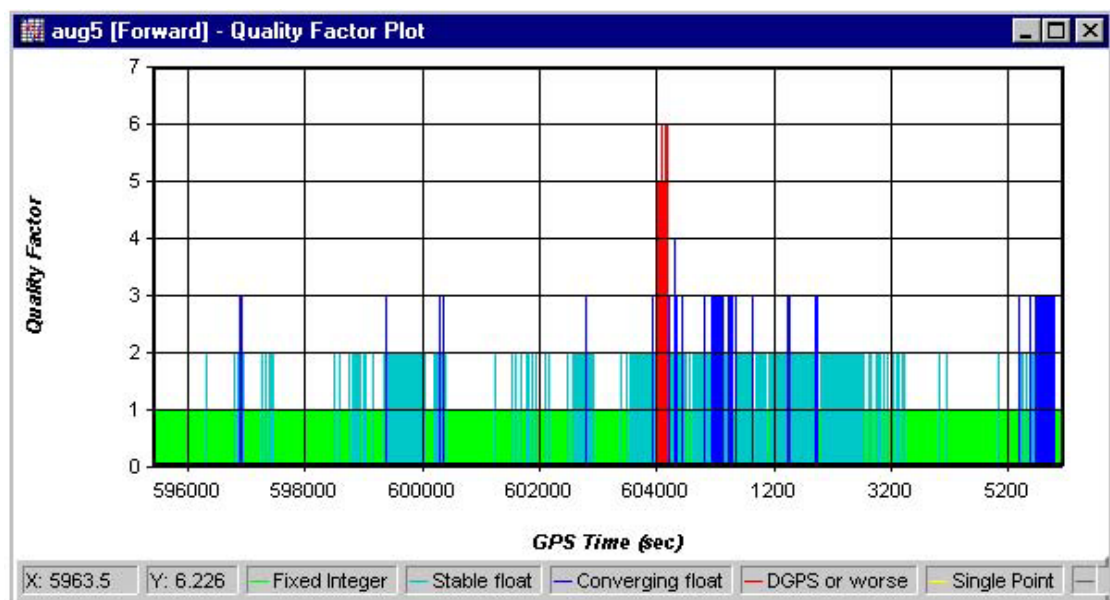
Automatic Loop Closures - Loop closures are automatically formed in the traverse computation feature of GrafNet. This allows for an easy isolation of problem baselines.

Color Coded Error Reporting - Baselines failing statistics are coded red allowing for easy visual inspection.

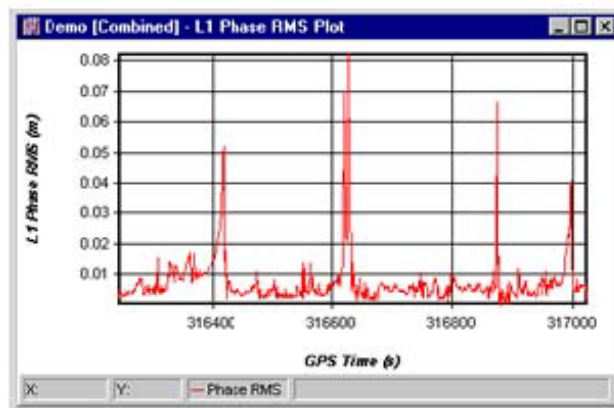
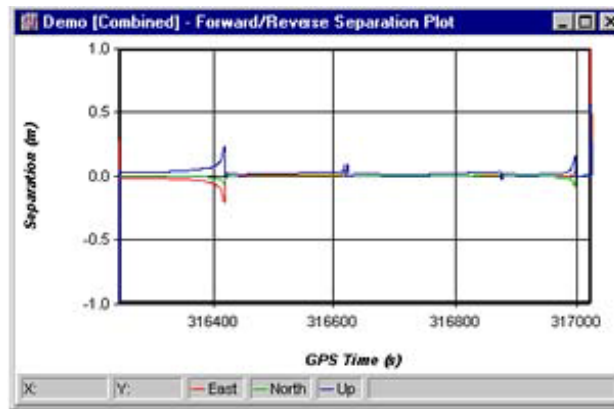
Quality Control

GrafNav/GrafNet is one of the best quality control (QC) tools available.

In GrafNav, the quality number is a central element. It ranges from one to six, and it is computed from 7 internal statistics. A quality value of one is best and required a fixed integer solution, while values of 5-6 generally indicate DGPS accuracies or worse (i.e. quality of 6). Each epoch is plotted with a certain color depending on its quality number.



Therefore, the user will see problem areas upon immediate inspection after processing. Additionally, the extensive plotting capabilities from 26 plots make QC possible on even the most troublesome GrafNav data sets. Some of the more common plots are the DOPs, L1 phase RMS, C/A code RMS, forward/reverse separation, quality number, and standard deviation. More obscure ones like L1 Doppler RMS, ambiguity drift (i.e. solution stability), and forward/reverse weighting are also available. Another useful graph is the LockPlot, which shows satellite elevation and loss of lock indication for each satellite being tracked. This can also make it easy to isolate problem areas. Since nearly every statistical value can also be exported, external graphical tools such as Excel, MatLab or Math CAD can also be implemented.



GrafNet also has a number of QC tools. Like GrafNav, color-coding is also used to identify problem areas. In this case, baseline vectors are plotted either green or red depending on whether they pass or fail statistics respectively. Also, parameters such as forward/reverse differences, reliability (RMS ratio), and carrier phase RMS can be examined by clicking on a baseline. If more detailed info is required, then GrafNav can be invoked on a particular baseline with the click of a button.

Real-Time Data Logger

GrafNav/GrafNet's built-in data logger can be used to store data directly from a GPS receiver connected to the serial port. The following three operating systems are supported:

Windows 95/98/NT - This datalogger, called WLOG, works on the Windows operating system. WLOG can either store the GPS data in the raw manufacturer's format or directly in Waypoint's custom format. A map screen is available for navigation purposes, and it shows the current location, loaded waypoints and a breadcrumb of previous positions. Stations can also be marked, and the station's name, time, description, remarks, and antenna height will be stored for post-processing. With Version 6.02 will come the ability to send RTCM Type 1,2 and 3 messages to an additional RS-232 port. This will give users DGPS capabilities in real-time without needing to purchase an expensive base station.

Windows CE -With version 6.02 of GrafNav/GrafNet, support for Windows CE will be available in BETA form. This increases the number of supported inexpensive datalogger platforms tremendously. Like WLOG, the Windows CE datalogger can mark stations and performs waypoint navigation.

DOS - The DOS data logger is called LOGGPS and will run under Windows 95/98/NT, as well as on many DOS laptops, palmtops, and hand-held CPUs. Embedded versions that log on DOS screenless and keyboardless CPUs are also available. Specialized versions are also available for specific data loggers such as the CMT PC5.

Supported GPS Receivers

This sections lists the GPS receivers and their formats supported by GrafNav/GrafNet. Support is categorized into the post-mission conversion, Windows 95/98/NT data logger, DOS data logger and the Windows CE data logger.

GPS Receiver Manufacturer	Receiver Model/Format	Post-processing Convert (offline)	Data Loggers		
			Win9x/ NT	DOS	WinCE
Allen Osborne	TurboRascal	△			
CMC	AllStar	✓	✓	✓	✓
CMC	SuperStar II	✓	✓	✓	✓
CSI	DGPS MAX	✓	✓		✓
Javad	All models	✓	✓		△
Leica/Magnavox	MX series	✓			
Leica	SR series	✓			
Leica	System 500	✓			
Leica	System 1200	✓			
Leica	MC1000/LB2	①			
Magellan	CAR/MOB	✓			
NavSymm/Parthus	XR5/XR6	✓	✓	✓	✓
NavSymm/Parthus	XR7	✓	✓		✓
NavSys	AGR	①			
NovAtel	OEM2	✓	✓	✓	✓
NovAtel	OEM3	✓	✓	✓	✓
NovAtel	OEM4	✓	✓		✓
Rinex	2.0 + 2.1	✓			
Rockwell	PLGR series	△		△	
Rockwell	NAVCOR	✓			
Septentrio	SBF	✓			
SIRF	Star II	✓			
Thales (Ashtech)	Real Time	✓	✓	✓	✓
Thales (Ashtech)	B-File	✓			
Thales (Ashtech)	DSNP	✓			
Trimble	4x00/DAT	✓			
Trimble	4x00/RT1	✓	✓		✓
Trimble	5x00/DAT	✓			
Trimble	5x00/RT1	✓	✓		✓
Trimble	6x00/DAT	✓			
Trimble	6x00/RT1	✓	✓		✓
Trimble	CMR	①			



GPS Receiver Manufacturer	Receiver Model/Format	Post-processing Convert (offline)	Data Loggers		
			Win9x/ NT	DOS	WinCE
Trimble	TSIP	✓			
Trimble	Force5/TIPY	✓			
U-BLOX	Antaris	✓			
UKOOA		①			

✓ Implemented

① Data logger available from Waypoint or as separate utility on CD

△ Implemented but decoder only available from receiver manufacturer.

Moving Baseline Processing and Heading Determination

The moving baseline module allows for GPS post-processing between two moving platforms. By processing directly between two moving kinematic objects, the accuracy of the relative trajectory can be improved significantly over that of a stationary base. This is especially true if the base station distance is much larger than the relative distance. If the two antennae are fix mounted, then heading can also be computed. The Moving Baseline module (called GrafMov) is purchased as an upgrade to GrafNav/GrafNet, and some of its additional features are:

Relative Processing - All of the advanced features of GrafNav including KAR, reliable Kalman Filter, forward/reverse/combined processing, dual and single frequency, and fast processing speed are all supported.

Relative Vector Output - GrafMov can export a number of relative vectors including local level, ECEF, and range and bearing.

Relative Velocity - Not only is the relative position available, the instantaneous differential velocity vector is also computed.

Heading Determination - For applications that require heading, GrafMov's fast integer ambiguity resolution algorithm (i.e. KAR) can make use of the antenna separation to further the speeding up of initialization times. Pitch can be computed from the relative vector output.

Upgrade and Support Policy

Software upgrades are free for one year after the date of purchase. Support by phone, fax, or email is also free for one year after the date of purchase. Data processing support is limited and charges may apply.

Customization

If the GrafNav/GrafNet does not completely meet your requirements, Waypoint does entertain user requests for changes to GrafNav, GrafNet, GrafMov, GrafNav Batch or the post-processing engine. Each request is evaluated on a case by case basis.

Applications

Although there are many uses of GrafNav/GrafNet, a few such applications have been isolated below.

Airborne Flight Testing - A number of aircraft manufacturers such as Boeing, Dornier, Lear Corp., Cessna, as well as, many service companies use GrafNav as a tool for aircraft trajectory reconstruction. With its many plotting tools, detailed analysis can be performed within GrafNav before exporting the trajectory. Velocity determination features can also be very useful.

Airborne Geophysical - This application requires precise velocity determination for subtraction of aircraft motion from gravimeter data. Position may also be required, but accuracies are usually less stringent. For magnetometer surveys, trajectory determination is also required. A number of airborne geophysical operators use GrafNav for their GPS post-processing needs.

Airborne Photogrammetry - This industry has been using GPS for kinematic positioning of aerial photography for almost 10 years. In some cases, accuracies of 10 cm or better are required for large scale photography. High accuracy requirements combine with long baseline separations make this application very difficult, and many users are switching to GrafNav from their GPS manufacturer's package to make the difficult task of obtaining these accuracies easier. GrafNav's reliable accuracy, fast processing speed and extensive quality control combined with geoid and camera event mark, support make GrafNav extremely well suited for this application.

Forestry - Most GPS forestry users usually use GIS post-processing packages. However, packages usually have very few QC tools. In situations where accuracy is important, GrafNav or GrafNav Lite is advantageous. Moreover, with GrafNav's GPS+GLONASS processing capabilities, it can also deliver superior accuracies to GPS only under the forest canopy.

GPS/INS Integration - Accurate position and velocity trajectory determination combined with full covariance output capabilities make GrafNav very well suited for the post-mission integration of GPS and INS data. In fact, Applanix Corp. (maker of the POS) uses GrafNav for GPS position determination in their GPS/INS processing. With version 6.02's process DLL, will come much tighter coupling capabilities with the integration with INS Kalman filters.

High Dynamic Trajectory Tracking - Missiles, rockets, and ordinances can travel at extremely high velocities and accelerations. Due to these high dynamics, the GPS data collected under these conditions has many cycle slips and data errors. However, with GrafNav's built-in robustness impressive accuracies are still obtained. GrafMov, the moving baseline variant of GrafNav, can be used to position the object trajectory with respect to the moving launch craft. Many DoD and NASA agencies use GrafNav for such purposes.

Land Surveying - GrafNet is a full-featured static baseline processing tool. With support for most GPS receivers on the market, users can easily mix and match their equipment. Moreover, surveyors need to only learn one package making it easier to manage shops with multiple receiver types. GrafNav's powerful kinematic processing capabilities make kinematic surveying much more reliable. Both GrafNav and GrafNet can output most projections (including State Plane) and support 2-D and 3-D local coordinates.

Laser Profiling - In this application, accurate aircraft or helicopter height determination is necessary in order to precisely obtain a ground height profile or digital elevation model (DEM). Again, GrafNav's superior airborne processing capabilities make it ideal.

Marine Buoy Tracking - GrafNav or specifically GrafMov is an excellent tool for determining the position of a buoy or other marine object with respect to ship or shore. (See [Dynamic Baseline Survey of Marine Buoys with respect to a Moving Vessel Using Ashtech G-12 Receivers and Waypoint's High Precision GrafMov Software](#) on Waypoint's webpage www.waypnt.com under tech reports).

Remote Sensing - Airborne remote sensing accuracies are normally not as stringent as that of aerial photogrammetry. However, data volumes can be higher and it is important that accuracy specifications be met with minimal operator effort.

Seismic Surveying - GPS is not new to the seismic surveying industry. Although there has been a general trend towards real-time, post-processing is still very important. GrafNav can be used to improve accuracies over real-time, process problem areas, or it can be used to double check RTK accuracies. Also, GrafNav's GPS+GLONASS processing capabilities make it possible to meet accuracies specifications in treed areas (See and [Seismic Surveying under Tree Canopy Using Ashtech GG-24 GPS/Glonass Receivers and Waypoint's GrafNav Post-Processing Software](#) available on Waypoint's webpage at www.waypnt.com under tech reports).