Appendix C

Manufacturer Brochures for Survey and Processing Equipment

MAGELLAN®
PROFESSIONAL

Z-Max®.Net
NETWORK GENERATION



Get Free From Operational Constraints



Get Free From Operational Constraints

Z-Max.Net:

Liberate Yourself!

Z-Max.Net is the next-generation survey solution from Magellan. The .Net generation offers NTRIP, GPRS and RTCM V3.0 network communication. Z-Max.Net delivers high accuracy and enhanced performance for all your survey needs.

Z-Max.Net is the most flexible GNSS surveying system available, offering multiple operating modes, configurations and communication protocols:

- Survey in NTRIP, VRS or FKP networks.
- Select your communication mode: GSM/GPRS, UHF, unique combined UHF+GSM/GPRS module or external source.
- Switch seamlessly from post-processing to RTK.
- Use Z-Max.Net as a base or rover.

You can perform any GPS survey with Z-Max.Net.



Survey with Added Freedom

The innovative design offers comfort and ease-of-use. Detachable modules make configuration changes and system upgrades simple.

You can use the intuitive keyboard or Bluetooth® wireless field terminal to perform any survey with added freedom. Configure your Z-Max.Net "all-on-the-pole" or in the comfortable backpack for long-duration missions.

Z-Max.Net fits your needs and frees your mind from technology concerns. Simply select the operating mode and you're ready to go!

Get the Max Out of Your GPS

Z-Max.Net delivers the strongest RTK on the market. A combination of unique technologies enables you to optimize your time and maximize your profit. Z-Max.Net offers two-second initialization, extended operation up to 50 km (30 miles) and cuts static data collection time by up to 50%.[1]

Powered by state of the art technologies, Z-Max.Net ensures exceptional RTK coverage and data confidence even in difficult environments.



All-In-One Surveying Solution

Z-Max.Net enhances your surveying capabilities, improves your data quality and upgrades your deliverables with a comprehensive suite of software tools. FAST Survey™ field software simplifies data collection and real-time operation. GNSS Solutions™ office software provides powerful support to a wide range of applications, handling both real-time and post-processing data within the same project.

Z-Max.Net delivers survey-grade positioning on demand, boosts your productivity and sets you free from operational constraints.



Key Features and User Benefits

Survey Your Way

The ultra-flexible Z-Max.Net survey system lets you control your survey your way. It operates in a wide range of data formats including ultimate standards such as NTRIP and RTCM V3.0.

Z-Max.Net features GSM/GPRS modem and offers a unique combined UHF-GSM/GPRS module supporting all operational configurations. Z-Max.Net is available with the Pacific Crest UHF data link, or the unique Magellan Professional UHF for high-performance and superior results when surveying on long baselines.

Z-Max.Net is so flexible that data can even be communicated using an external radio modem like CDMA or EDGE when necessary.

Whichever configuration you chose, Z-Max.Net adapts to your survey environment and delivers the best performance

Strongest RTK on the Market

- Patented **Z-Tracking™** and advanced multipath mitigation technologies ensure the strongest centimeter-level position even in weak signal conditions.
- **Instant-RTK®** technology enhances survey productivity by offering two-second initialization: The fastest on the market.
- Magellan Professional unique **LRK®**, long range kinematic technology, combines fast, real-time centimeter-level positioning up to 50 km (30 miles).
- State-of-the-art **Prism®** technology cuts data collection time by as much as 50% for post-processed surveys.[1]

Plus, Z-Max.Net is ready for tomorrow's RTK networks with features that include **GPRS, NTRIP, RTCM V3.0, VRS and FKP.**

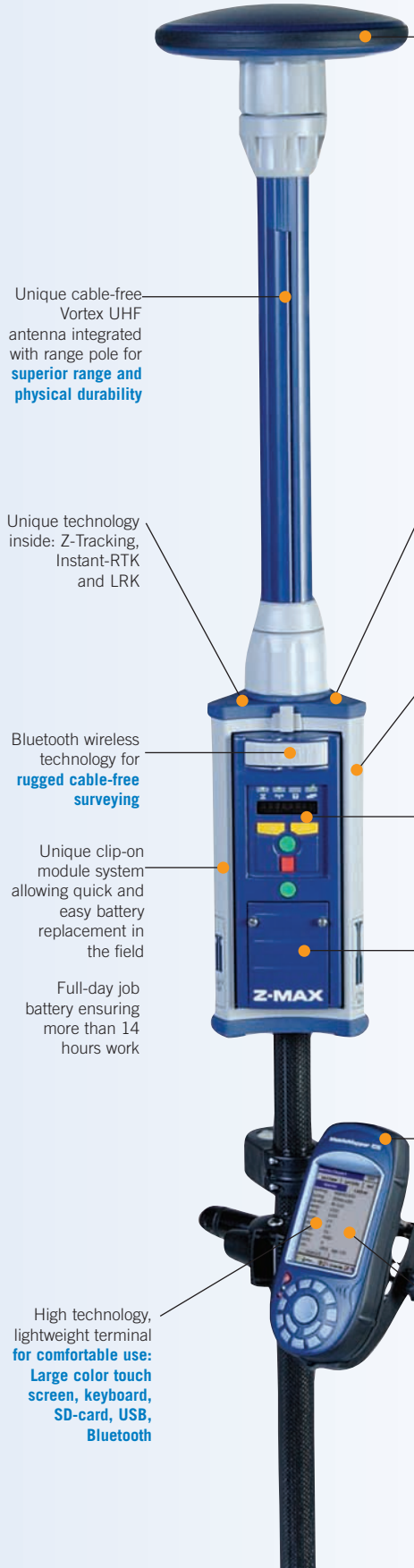
Increased Productivity

Z-Max.Net is designed to increase your productivity with fast initialization, easy modular configuration, superior long-range capability and reliable accuracy. Surveys are faster than ever in both RTK and post-processed mode.

The modular design and flexibility makes upgrades easy and cost-efficient, protecting your investment and ensuring a high return.

Maximum Simplicity

Every aspect of the Z-Max.Net survey system is designed to simplify the job of the surveyor



Complete Solution in the Field and at the Office

State of the Art Field Terminals

Z-Max.Net offers two high-quality field terminals: the MobileMapper™ CE from Magellan and the classic Allegro CX™ from Juniper Systems Inc.®

Features such as color touch screen, SD-card, USB and Bluetooth wireless technology, are included to ensure a robust, easy-to-use, cable-free RTK rover.

Combined with MobileMapper CE, Z-Max.Net becomes the only survey system on the market to include an additional handheld GPS for multiple application needs (GIS, navigation, and more). Only Z-Max.Net can offer that kind of advantage.

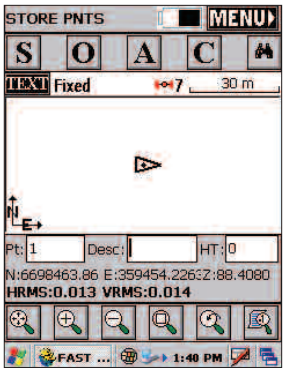


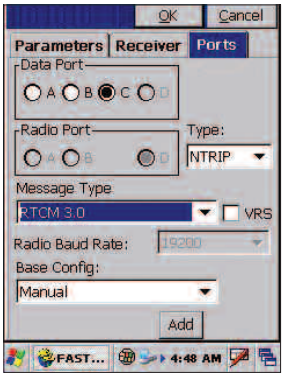
FAST Survey - Field Software

FAST Survey is a graphical field software for topography and construction, designed to optimize the functionality and performance of the Z-Max.Net GNSS system. The ability to collect single coordinate shots, full RTK vectors, raw GNSS data and all data types concurrently, provides a flexible solution for your changing needs.

Power in the Palm of Your Hand

FAST Survey is both powerful and easy to use. Scaleable map-view screen displays points and lines as they are surveyed, offering large-print controls for rapid, reliable data collection. Rich attributing, full editing in the field and export to industry-standard data formats provides true field-to-finish capability, saving time and effort.







GNSS Solutions - Office Software

GNSS Solutions is a comprehensive software package with all of the tools required to successfully process GPS, GLONASS and SBAS survey data. Focusing on simplicity, the software guides you through mission preparation planning, processing, quality control, reporting and data exporting.

Intuitive Handling of Graphical Data



The innovative approach to presenting survey data in graphical and tabular form makes post-processing with GNSS Solutions a simple and enjoyable experience.

Any collection of data can be viewed in different forms through simple drag and drop operations. Importing raster or vector map formats enables you to open background projects and combine them with land survey projects.

Accuracy and Reliability

GNSS Solutions can handle both real-time and post-processing data within the same project. The software includes advanced blunder detection and quality analysis tools to ensure extremely accurate and reliable results. Loop closures, automatic repeat, observation analysis, automatic control analysis, and least-squares adjustments are integral components of GNSS Solutions.

Applications

As a Z-Max.Net surveyor you are prepared for any job condition and ready to meet your customers' needs. Quality, productivity, ease-of-use, cost-efficiency and profitability: **Z-Max.Net delivers it all.**

Network Generation

New communication protocols, such as NTRIP and GPRS, provide higher performance and lower cost access to differential data for RTK surveying. The number of correction service providers is rising and base station networks will expand over the coming years, transforming rover/base surveying to rover only. Z-Max.Net offers the advantage of the latest data communication standards so you are ready to adapt to tomorrow's survey world.

Combined with a MobileMapper CE field terminal, Z-Max.Net is the only survey system on the market to include an additional handheld GPS for multiple application needs (GIS, navigation and more).



Base / Rover Configuration

Z-Max.Net is the most flexible survey system on the market. Thanks to its wide data format compatibility (RTCM V.2.x, CMR/CMR+, DBEN, RTCM V3.0 and other standards). Z-Max.Net easily combines with your equipment and ensures seamless operation within any network.

As a base, Z-Max.Net broadcasts simultaneously through UHF and GSM, providing 100% field coverage for the rover.



Post-Processed Surveys

Z-Max.Net performs all types of post-processed surveys - static, stop-&-go and kinematic - reaching unprecedented accuracy levels.

Base data can come from a CORS station or any GPS receiver. Raw data from Z-Max.Net can also be used with the OPUS processing system. Whatever the source, unique Prism technology cuts survey data collection time by up to 50%[1].



Z-Max.Net Technical Specifications

GNSS Characteristics

- 24 parallel channels all-in-view
- L1 C/A code and carrier
- L1/L2 P-code, full wavelength carrier
- Z-Tracking
- Multipath mitigation
- Integrated real-time WAAS/EGNOS
- Update rate: 10 Hz
- Protocol: NMEA0183

Accuracy Specifications[1,2]

Static Rapid Static

- Horizontal 0.005 m + 0.5 ppm (0.016 ft + 0.5 ppm)
- Vertical 0.010 m + 0.5 ppm (0.033 ft + 0.5 ppm)

Post-Processed Kinematic

- Horizontal 0.010 m + 1.0 ppm (0.033 ft +1.0 ppm)
- Vertical 0.020 m + 1.0 ppm (0.065 ft +1.0 ppm)

Real-Time Performance[1,2]

SBAS (WAAS/EGNOS) (rms)

- Horizontal: <3 m (10 ft)

Real-Time DGPS position

- < 0.8 m (2.62 ft)

Real-Time Kinematic Position (fine mode)

- Horizontal 0.010 m + 1.0 ppm (0.033 ft + 1.0 ppm)
- Vertical 0.020 m + 1.0 ppm (0.065 ft + 1.0 ppm)

Real-Time Kinematic Position (fine mode)

- 99.9% reliability
- Typical 2 second initialization for baselines < 20 km

Datalogging Characteristics

Recording Interval

- 0.1 - 999 seconds

Physical Characteristics

Size

- Unit: 26.9 x 12.5 x 14 cm (10.6x4.9x5.5 inch)
- Antenna: 19 cm dia x 10.1 cm h (7.5 x 4.0 inch)

Weight

- Receiver Module: 1.371 kg (3.02 lb)
- Antenna Module: 0.64 kg (1.17 lb)
- Power Module: 0.52 kg (0.96 lb)

Front Panel

- Eight-character alphanumeric LED display
- 4 tri-color LEDs
- 5-key keyboard

Memory

- 48 hours of 1 sec. raw GPS data with 64 MB Secure digital
- 128 MB SD card available

I/O Interface

- RS232, RS232/422, USB, Bluetooth

Environmental Characteristics

Receiver

- Operating temperature: -30° to +55°C (-22° to +131°F)
- Storage temperature: -40° to +85°C (-40° to +185°F)
- Meets IP54 for moisture
- Shock: 1.5 m (4.92 ft) pole drop
- Vibration: MIL-STD-810F Method 514.4 (I-3.1.1, I-3.4.8, I-3.4.9)

Power Characteristics

- Max-Run battery life > 14 hrs.
- 10-28 VDC input
- Regulated 12 VDC output on serial ports

Controller Language Support

- English, French, German, Spanish

System Components

Standard

- Z-Max.Net GNSS receiver
- GNSS antenna
- Power module, charger included
- System bag
- Hard-shell shipping case

Communication Module[3]

- Magellan UHF
- Pacific Crest
- GSM/GPRS Tri-band
- GSM/GPRS Dual-band (US)
- GSM/GPRS EU + Magellan UHF
- GSM/GPRS EU + PacCrest UHF
- GSM/GPRS US + Magellan UHF
- GSM/GPRS US + PacCrest UHF

Field Terminal kit with FAST Survey[3]

- MobileMapper CE
- Allegro CX from Juniper

Other[3]

- Magellan UHF transmitter kit
- Pacific Crest transmitter kit
- RTK rover backpack kit
- Rechargeable battery kit

[1] Performance values assume minimum of five satellites, following the procedures recommended in the product manual. High-multipath areas, high PDOP values and periods of severe atmospheric conditions may degrade performance.

[2] Accuracy and TTFF specifications based on tests conducted in Nantes, France, and Moscow. Tests in different locations under different conditions may produce different results.

[3] System composition varies depending on the chosen configuration

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Office Software Suite - GNSS Solutions

Key software functions include:

- Integrated transformation and grid system computations allow for processing, adjusting, reporting and exporting point positions in user-selected or user-defined systems
- Pre-defined datums along with user-defined capabilities using the 7-parameter method of computing and applying datum transformation parameters
- Survey mission planning
- Automatic vector processing
- Least-squares network adjustment
- Data analysis and quality control tools
- Coordinate transformations
- Reporting
- Exporting
- Geoid 03
- English, Spanish, French, German language support

System Requirement

- Windows 2000 / XP
- Pentium® 133 or higher
- 32 MB RAM
- 90 MB disk space required for installation

Field Software Suite – FAST Survey

Key software functions include:

- Map view
- Geodetic geometry: intersection, azimuth/distance, offsetting, poly-line, curve, area
- Z-Max.Net GPS support : configuration, monitoring and control
- Coordinate system support: predefined grid systems, predefined datums, projections, Geoids, local grid
- Data import/export: DXF, SHP, RW5, LandXML, …
- Survey utilities: calculator, RW5 file viewing
- Compatibility with optical surveying instruments
- Road construction

Supported Hardware

- MobileMapper CE
- Juniper Allegro CX

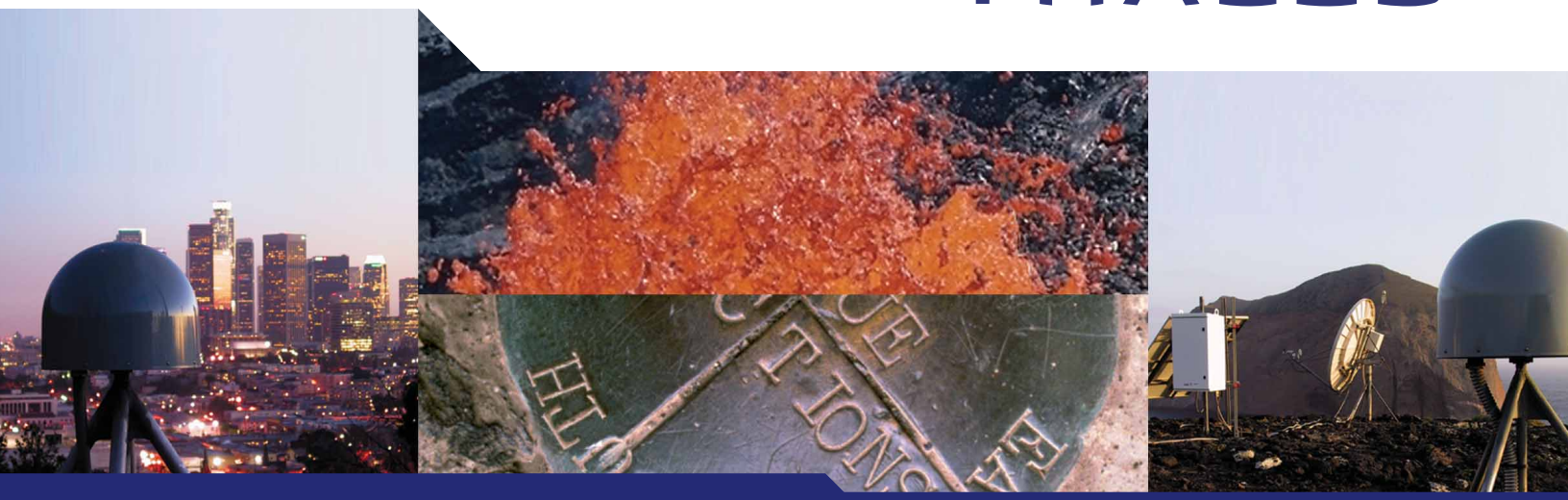
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MAGELLAN®
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THALES



Choke Ring Antenna

Overview

The Thales Choke Ring Antenna retains the original International GPS Service (IGS) design and is thus fully compliant with the requirements for IGS permanent stations. The choke ring is machined from a single billet of 6061-T6 aluminum. The choke ring includes a Dorne & Margolin C146-10 vertical dipole element. The Choke Ring Antenna provides proven technology and reliability and is the standard for high-end reference applications.

Proven Design

The Thales Choke Ring is a proven design and is used in dozens of high-end networks around the world. These networks include the IGS, Southern California Integrated GPS Network (S.C.I.G.N.), the Ordnance Survey in the United Kingdom and the China State Seismological Bureau (CSSB). The antenna consists of a ground plate with five concentric ring structures, a Dorne & Margolin C146-10 dipole element and a proprietary low-noise amplifier (LNA). The choke ring design significantly mitigates multipath by attenuating reflected GPS signals, thereby improving the quality of the GPS observables.

Thales LNA And Dorne & Margolin Element

The patented Thales pre-filtered low-noise amplifier (LNA) exhibits superior low-noise performance. U.S. Patent #5,347,546 covers the method for obtaining low losses and frequency selectivity at the same time. It operates over a 5 to 15 volt DC antenna supply, and includes RF filtering for excellent out-of-band interference rejection.



GPS Industry Leader

Thales reference station products continue to raise the industry standard for high-precision continuous operation. The Choke Ring Antenna provides great value to our customers, combining the field-tested IGS design with advanced GPS choke ring technology at an affordable price.

CHOKE RING ANTENNA

TECHNICAL SPECIFICATIONS

Standard Features

Billet Forged Choke Ring Antenna

- Billet aluminum construction, machined from a single piece of 6061-T6 aluminum
- Accepted IGS design
- Dorne & Margolin C146-10 element
- Conductive gaskets for antenna stability in humid conditions
- North marker for back-sighting alignment
- Gold alodine anti-oxidation coating
- Proprietary Thales low-noise amplifier (LNA), 5 to 15 volt operation

Options

Billet Forged Choke Ring Antenna

- Available Radomes
  - Thales conical snow dome
  - SCIGN short hemispherical radome
- Carrying bag
- Line amplifier
- Low-loss antenna cable

Thales Choke Ring Antenna Specifications

Temperature

Operating	–55°C to +65°C
Storage	–55°C to +75°C

Humidity
100%

Frequency
L1 1575.42 ± 10.23 MHz
L1 1227.60 ± 10.23 MHz

Polarization
RHCP

Antenna Gain
+5dBiC @ ZENITH
–4dBiC @ 5° ELEVATION

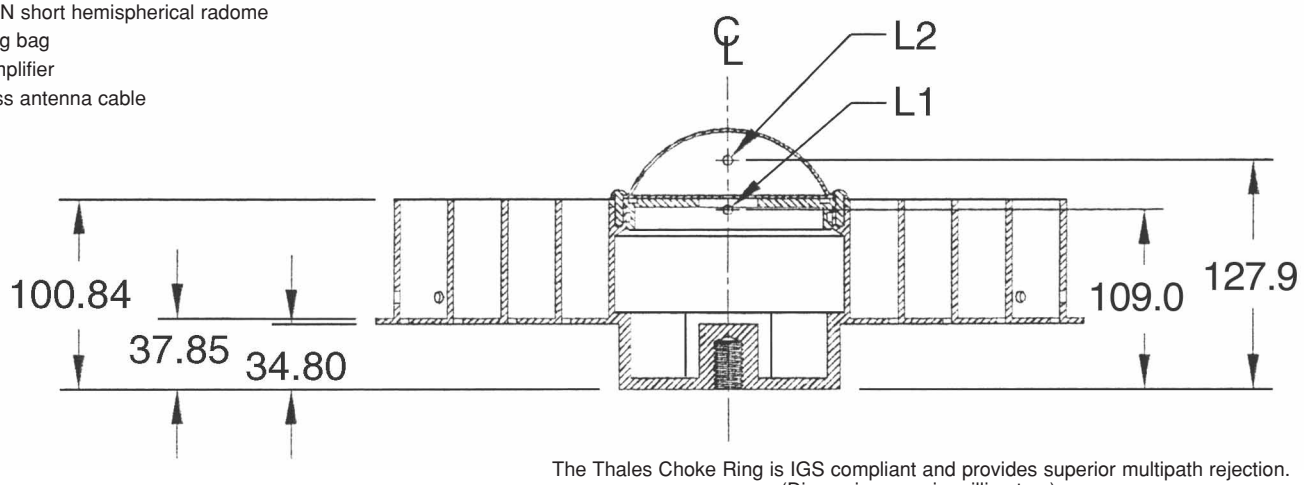
DC Power
5–15V, 45mA TYP

LNA Gain L1
38dB ± 3dB

LNA Gain L2
39dB ± 3dB

Output
50 OHM, TYPE N

Weight
4.7 kg (10.5 lbs)



The Thales Choke Ring is IGS compliant and provides superior multipath rejection.
(Dimensions are in millimeters).

Thales
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THALES

Thales follows a policy of continuous product improvement; specifications and descriptions are thus subject to change without notice. Please contact Thales for the latest product information.
© 2005 Thales S.A. All rights reserved. Choke Ring Antenna is a trademark of Thales. All other product and brand names are trademarks or registered trademarks of their respective holders. Photos #1 & #4 by John Galetzka, USGS-SCIGN Rev (3.05) **part # 830238B**

ODOM

HYDROTRAC™

odom
HYDROGRAPHIC SYSTEMS

- IDEAL FOR SMALL BOATS AND HARSH CONDITIONS
- FREQUENCY AGILE
- HIGH RESOLUTION THERMAL PRINTER
- INTERNAL DGPS (OPTIONAL)
- WATERPROOF
- FLASH UPGRADEABLE
- SIDE SCAN OPTION



SINGLE FREQUENCY PORTABLE HYDROGRAHIC ECHO SOUNDER

ODOM

HYDROTRAC™

Specifically designed for work in less-than-ideal circumstances on small survey boats and inflatable watercraft, the **Hydrotrac™** offers compact portability and the confidence of knowing you're using an Odom product. It is completely waterproof and comes equipped with the same advanced features you've come to trust and depend on in Odom echo sounders.



Buy Odom – invest in your peace of mind.

SPECIFICATIONS

Environmental Operating Conditions:
- 0 – 50 C

Frequency Agile
- Operator selectable – 24, 33, 40, 200, 210 and 340 kHz

Output Power
- 600 watts

Power Requirement
- 11-28 V DC (standard)
- 110/220 V AC (optional)

Communication
- 2 RS232 or RS422 ports

Depth Range
- MAX = 600 m/1968 ft

Resolution
- 0.1 ft/0.01 m

Accuracy
- 8.5 in/216 mm thermal printer (fax paper)
- LCD display (1 in high)
- Sealed keypad controls

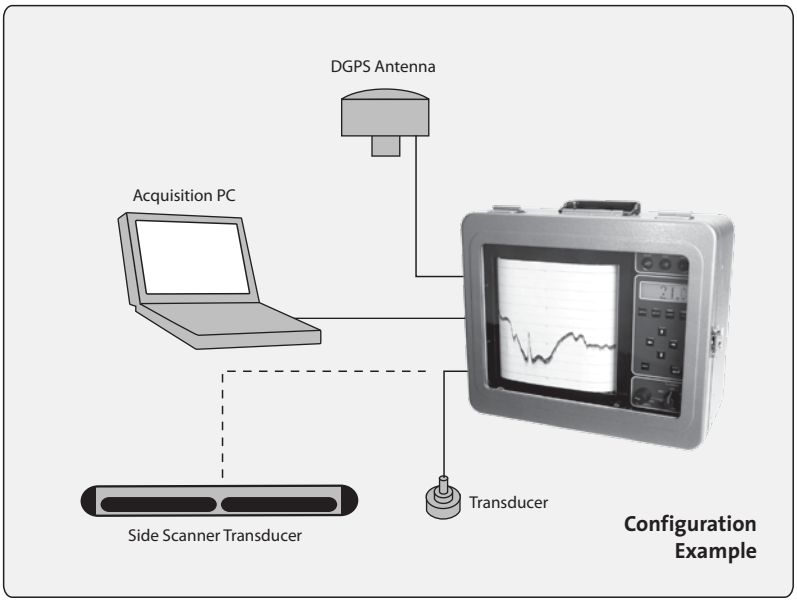
Weight
- (24.8 lbs/11.25 kg)

Dimensions
- (14.5 h x 16.5 w x 8 d in or 36.83 h x 41.91 w x 20.32 d cm)

Controls
- Sensitivity
- Chart on/off and advance
- Event mark (internal selectable timer)
- Transmit power (high/med/low)

Touch Pad Settings
- Draft, velocity and tide inputs
- Time and date
- Scale width and center
- Blanking
- Calibration gate
- Alarm filter
- Fix interval
- Chart speed
- HELP function (prints on chart)
- Current parameters (prints on chart)

Features
- Manual/remote mark command
- Auto scale change (phasing)
- GPS input
- Heave input from motion sensor
- Annotation printed on chart
- Auto pulse length, TVG
- Output: NMEA, ECHOTRAC, DESO 25, etc.
- Waterproof (with cover in place)
- Accuracy: 200 kHz – 1 cm 0.1% of depth value (corrected for sound velocity); 33 kHz – 10 cm 0.1% of depth value (corrected for sound velocity)
- Fix mark annotation: date, time, fix no., depth (and GPS if input)
- Optional 200 kHz or 340 kHz side scan transducer
- Optional built-in DGPS
- Optional remote display
- Flash memory upgradeable
- Built-in simulator
- Software included: Comlog
- Operation and installation manuals provided on CD



Configuration Example

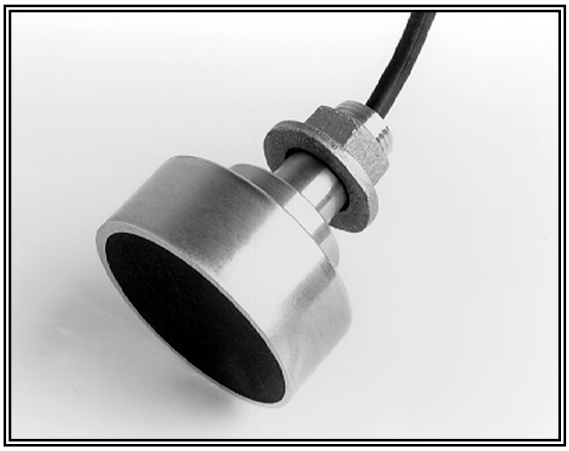
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HYDROGRAPHIC SYSTEMS

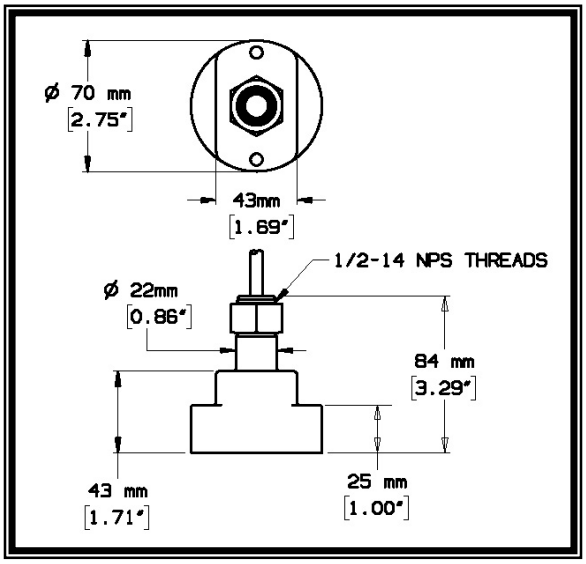
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Odom Hydrographic Systems, Inc.
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225.769.3051, Facsimile 225.766.5122

SMBB200-9





Performance Data

Frequency	200kHz - BClq
Beam Width	9°
Q (transmit)	2.5
Rated RMS Power	500 W
Balanced Impedance	60 ohms
Peak Figure of Merit	-16
Bandwidth	
Acoustic Window Material	Urethane
Threads	½" –14NPS
Cable Type	C33 (2-20 AWG)
Cable Size	6mm
Weight	1.3Kg.

Broadband with superlow Q of 2.5. Small housing with short stem used primarily for navigation and survey applications. This model is usually mounted on an extension tube but is adaptable to portable survey and navigation systems. It contains a transformer which can be used to match the impedance of the echosounder or allow the use of longer cables. The transducer is available in either a bronze or stainless steel housing. Model SS510 provides good definition in hard bottoms with side lobes.

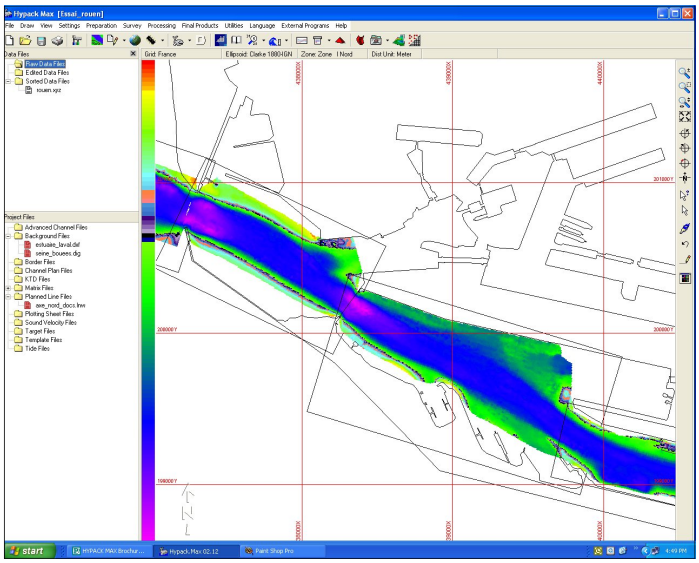
HYPACK®



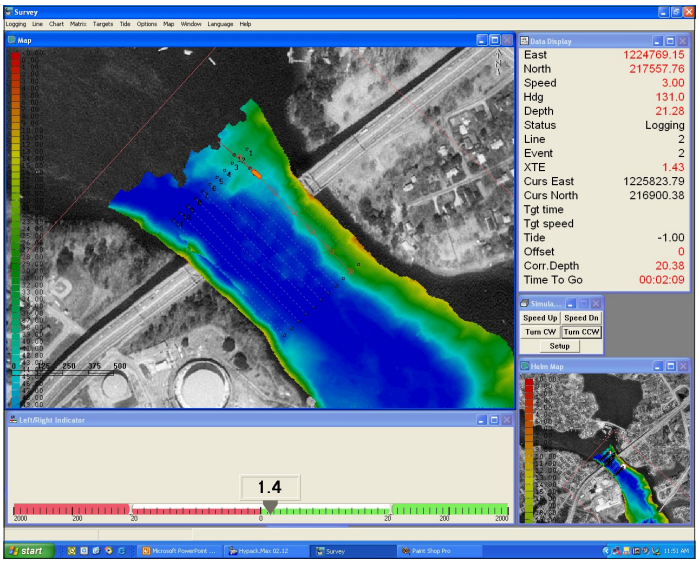
HYDROGRAPHIC SURVEY SOFTWARE

HYPACK®

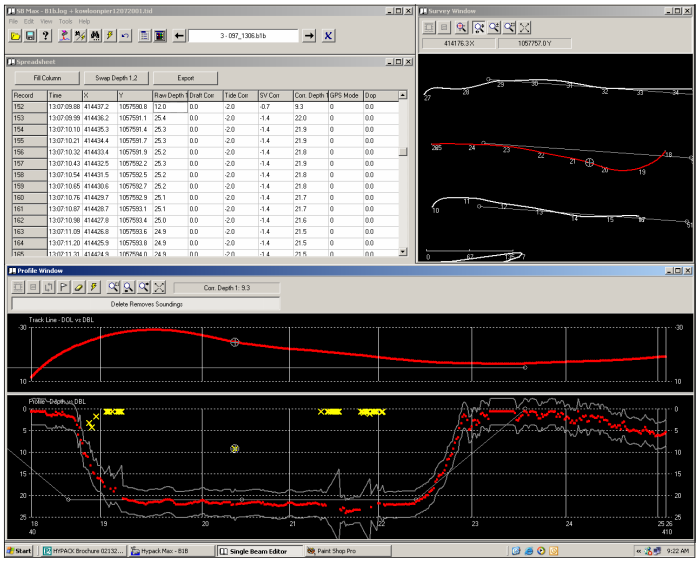
HYPACK® is one of the most widely used hydrographic surveying packages in the world, with over 3,000 users. It provides the surveyor with all of the tools needed to design their survey, collect data, process it, reduce it, and generate final products. Whether you are collecting hydrographic survey data or environmental data, or positioning your vessel in an engineering project, HYPACK® provides the tools needed to complete your job. With users spanning the range from small vessel surveys with just a GPS and single beam echosounder to large survey ships with networked sensors and systems, HYPACK® gives you the power needed to accomplish your task in a system your surveyors can master.



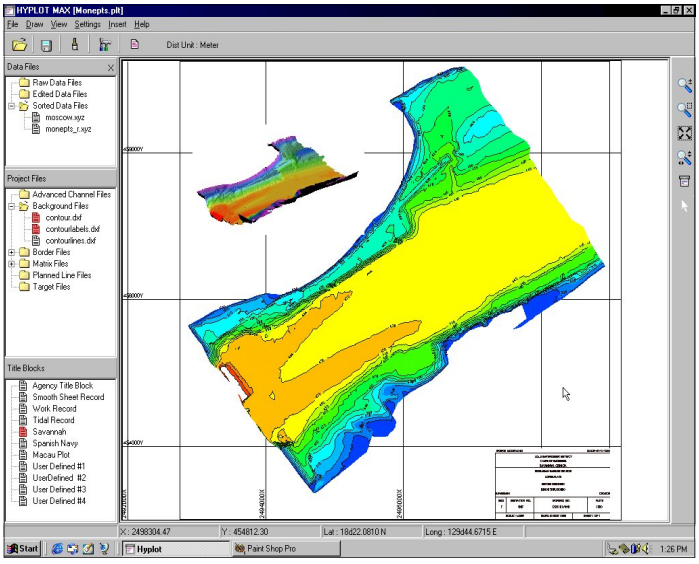
SURVEY DESIGN: HYPACK® allows you to create a 'Project' that contains all of your survey information for each job. You can easily define your geodetic basis, selecting from existing national grids or defining your own projection or local grid. HYPACK® also allows you to import background files in a variety of formats, including S-57, OrthoTif, ARCS, DXF, DGN, BSB and VPF. These files can be displayed while you create your planned lines, survey, edit and plot your results.



SURVEY: HYPACK® contains interface drivers to over 200 devices includings positioning systems, echosounders, heave-pitch-roll sensors, gyros and other types of equipment. SURVEY supports a single vessel or multiple vessels, along with towfish and ROVs. Data is logged with incredible precision (<1mSec). Survey data and windows can be broadcast over a network to any other computer or saved to a file using our Shared Memory Output routines.



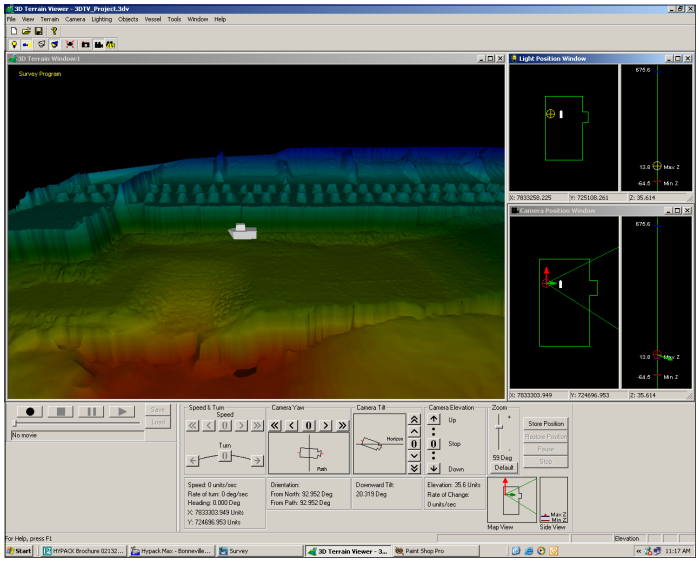
EDITING: The SINGLE BEAM EDITOR program is used to quickly review your survey data and to automatically and/or manually remove outliers. Sounding data is simultaneously displayed in plan, spreadsheet, and profile views with the channel design info drawn in the backgrounds. Routines developed by **HYPACK®** from collaboration with the U.S. Army Corps of Engineers to integrate water level corrections based on RTK GPS elevation info are a standard part of package.



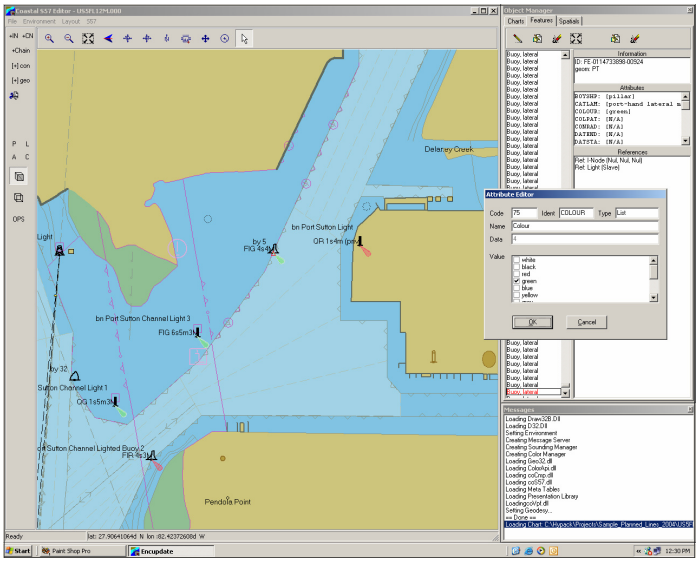
FINAL PRODUCTS: The ability to create the final products you need separates **HYPACK®** from the rest. The plotting program generates professional smooth sheets with soundings, grids, graphics and contours in a WYSIWYG display. The VOLUMES program is the de facto standard of the U.S. Army Corps of Engineers for the computation of quantities in dredging projects. TIN MODEL creates surface models that can be used for contouring, volume computations and surface visualization.

HYPACK®

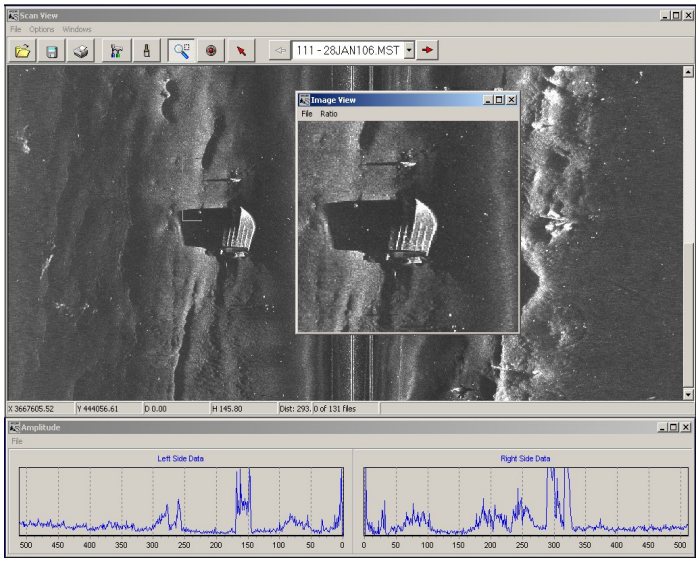
Support: An important factor in the purchase of any hydrographic survey system is the support provided to the end-user. **HYPACK®** prides itself on taking good care of our users. A trained, professional staff is on-call to answer your questions, develop custom device drivers or modify programs to meet your needs. **HYPACK®** training seminars are held annually in many countries to provide you with the latest information. We continue to update our training materials every year to make it easier for you to get the most out of our products. Our latest training material contains PowerPoint presentations with embedded AVI demonstrations on over 100 topics. Our bi-monthly newsletter, 'Sounding Better' is published on our web site (www.hypack.com) and contains technical articles on how to get the most out of your package.



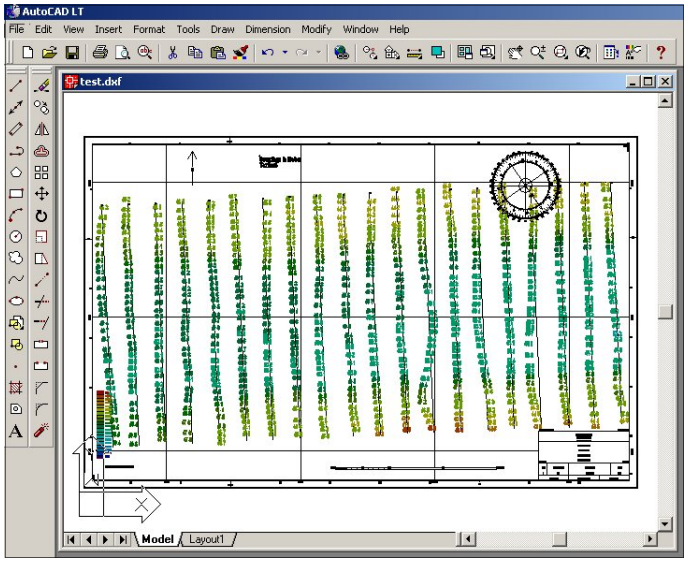
DATA VISUALIZATION: The TIN MODEL and 3D TERRAIN VIEWER (3DTV) programs of **HYPACK®** provide fantastic tools to view and present your data. 3DTV allows you to fly a 'camera' across your edited XYZ surface and display the results or save them to a AVI file for distribution to your clients. 3DTV also allows you to position the camera relative to the actual vessel position, showing the vessel in real time against the bottom surface.



ENCEdit is a new **HYPACK®** module that allows you to create, modify and verify ENC data in S-57 format. ENCEdit provides you with tools to re-attribute, create, move or delete existing features. You can also create new features by manually entering coordinates, by importing data from DXF/DGN, or by transferring targets in real time from SURVEY directly into ENCEdit.



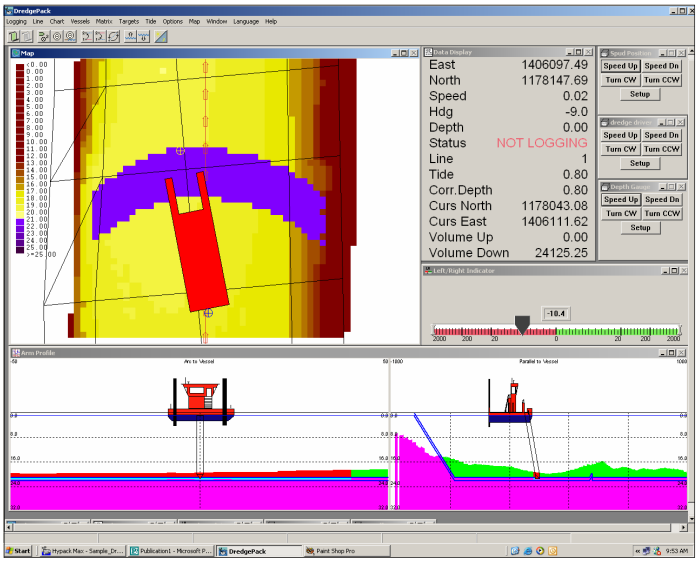
Side Scan Sonar (SSS) Support: **HYPACK®** provides support of SSS systems in its basic package. All analog and several digital side scan systems can be utilized with the SIDE SCAN SURVEY program. Users can display the real time data and perform targeting in real time or post-processing. A program that generates side scan mosaics in GeoTIF format allows you to plot your results in **HYPACK®** or export them to your GIS.



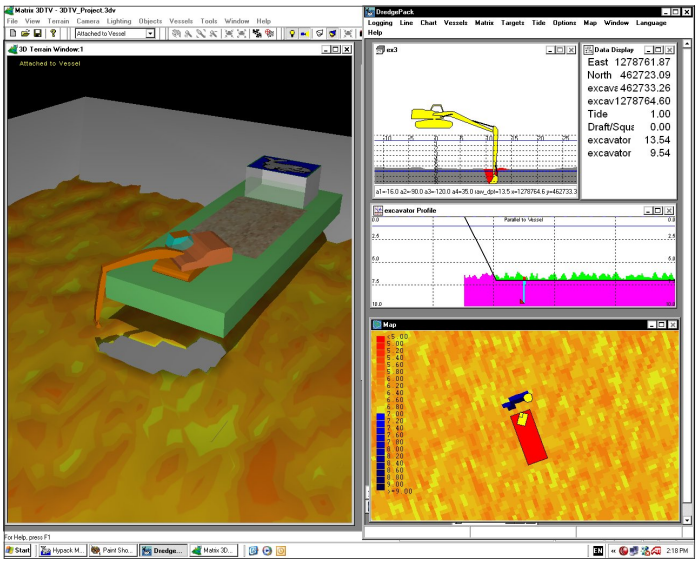
Export to CAD: Many of our users are interested in exporting their survey data into their CAD/GIS package. **HYPACK®** has several tools to import/export via DXF/DGN. The EXPORT TO CAD program takes all of the our files and converts them to DXF and DGN. The plotting sheets and sectional plots can also be exported directly to DXF. Users can create planned lines in their CAD/GIS program and import them into **HYPACK®**.

DREDGEPACK®

DREDGEPACK® is a specially modified version of **HYPACK®** used for providing precise digging information on dredges. It allows you to see exactly where you are digging, how deeply you are digging and how deeply you need to dig. With the ADVANCED CHANNEL DESIGN program, you can create complex dredging plans. Real time cross sections are provided to show you the design profile, the depth of the cutting tool and the material that has to be removed.

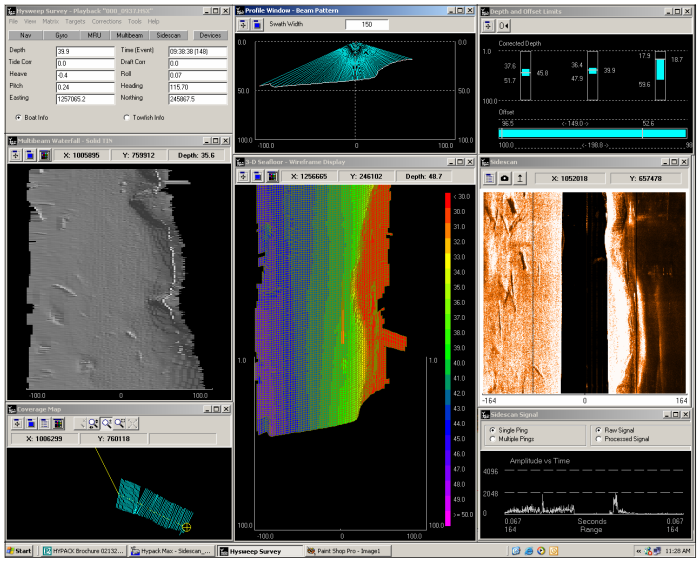


DREDGEPACK® runs on cutter suction, hopper, excavator and bucket-style dredges. It can store a history of the dredge's position, draft, digging tool depth and digging status in order to meet reporting requirements. DREDGEPACK® has been designed to run with a minimum of user intervention. Make sure you are maximizing your dredge's efficiency with DREDGEPACK®

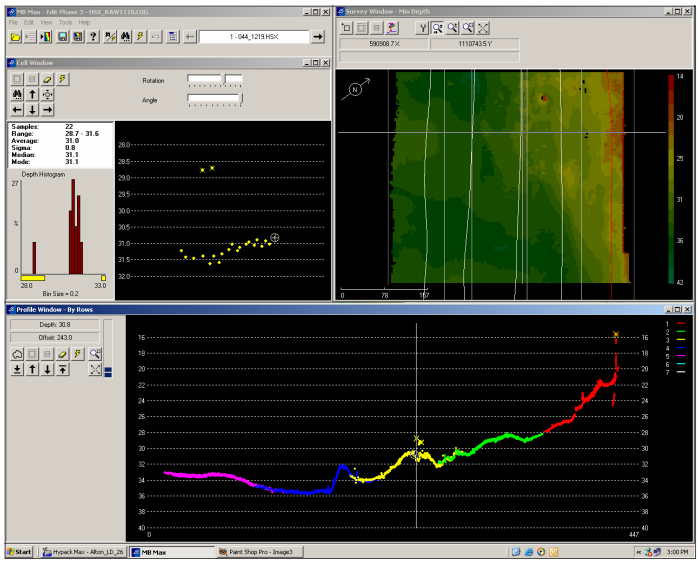


HYSWEEP®

HYSWEEP® is an optional module that integrates the collection and processing of multibeam and multiple transducer sonar systems into **HYPACK®.** Time and again, surveyors switch to HYSWEEP® due to the powerful tools and the ease-of-use of the package. Survey data collected in **HYSWEEP®** is fully integrated with the final products of **HYPACK®**. More surveyors use **HYSWEEP®** for multibeam data collection and processing than any other multibeam software package.



HYSWEEP® SURVEY: The data collection program of **HYSWEEP®** runs simultaneously with the SURVEY program of **HYPACK®**. It provides real time display, QC functions and data logging for most commercially available multibeam systems, including those from Atlas, Odom, Reson, Sea Beam and Simrad. A coverage map lets you examine the bottom coverage in real time, ensuring that you have 100% or 200% coverage before leaving the area.



MULTIBEAM EDITING: Multibeam data editing, sonar alignment calibration and system performance testing are all provided in the powerful MULTIBEAM EDITOR of **HYSWEEP®**. The program performs automatic or manual filtering, using geometric and statistical methods. It also contains the Performance Test that measures the overall performance of your system versus beam angle as required by USACE. **HYSWEEP®** can also use water level corrections created from RTK GPS elevations.

HYPACK, Inc.

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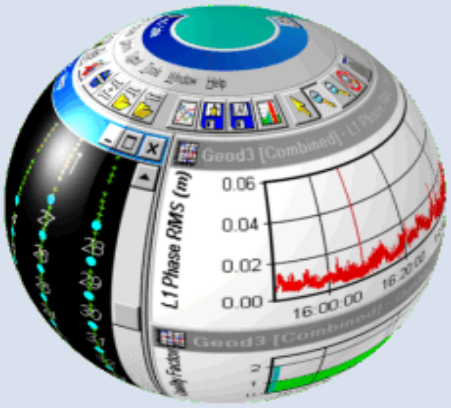
GrafNav/GrafNet

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?
- Our 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.



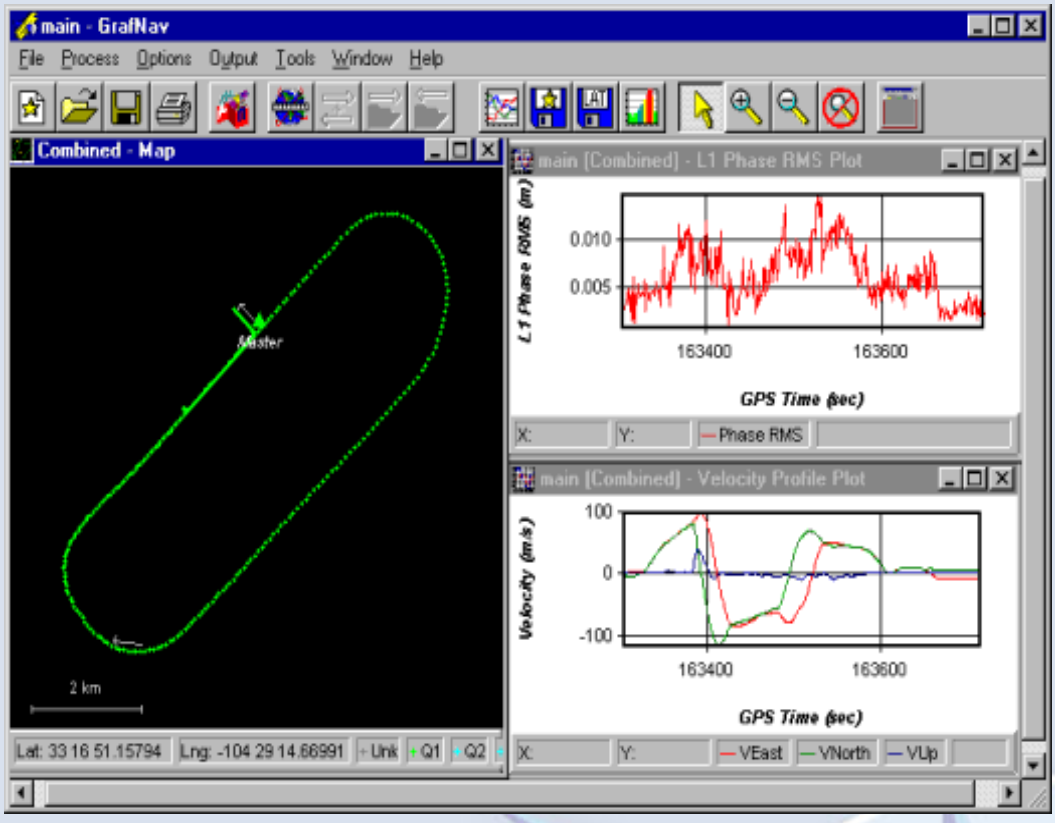
Waypoint supports binary data formats from most GPS manufacturers. However, for those users with an inexpensive GPS handheld receiver, you may not be able to use our software. GrafNav/GrafNet and its lower cost cousin GrafNav Lite can process data from OEM GPS receiver cores, costing as little as $100, 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.

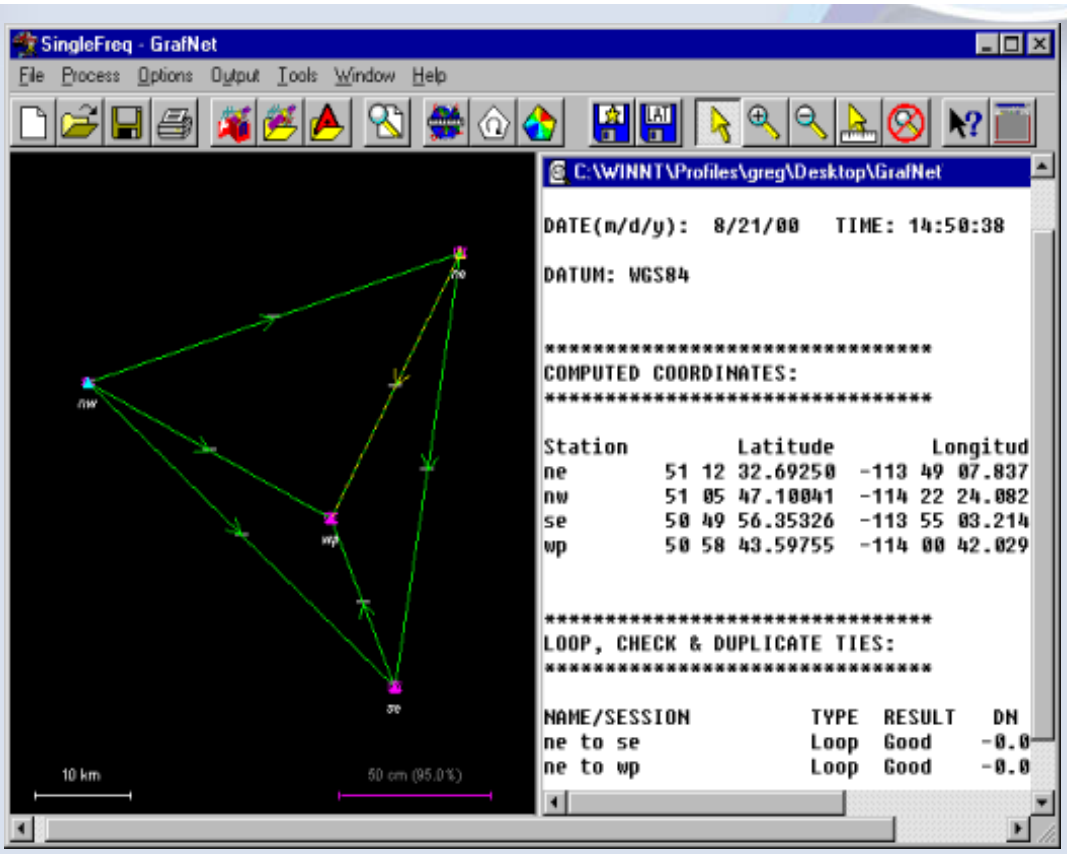
What is included with GrafNav/GrafNet?

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:

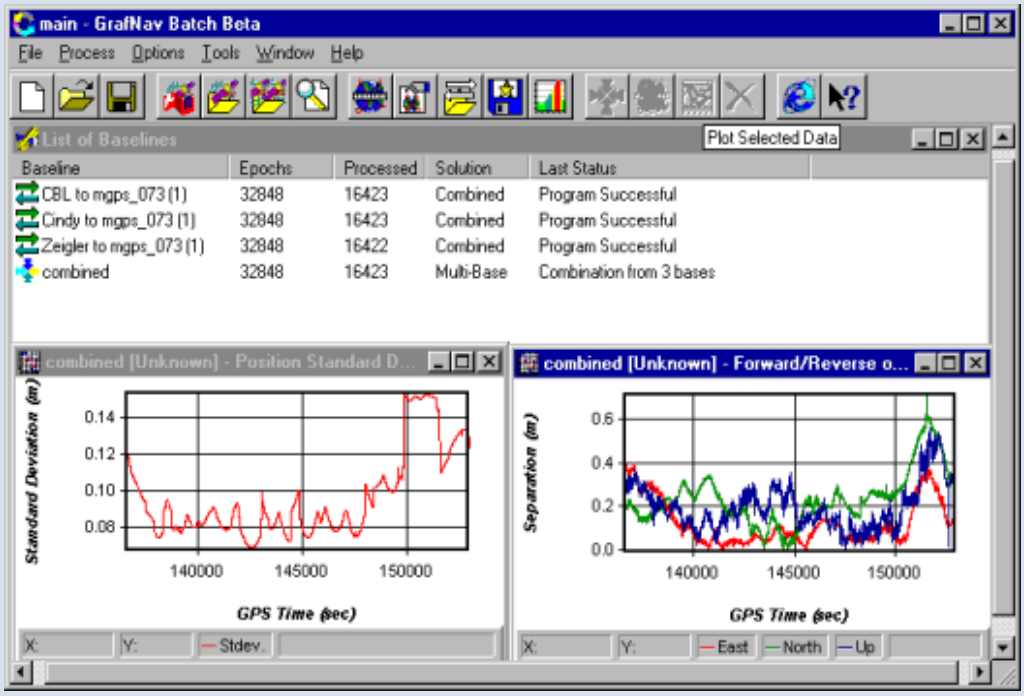
- **GrafNav** processes data for one baseline (e.g. one base and one remote). GrafNav is normally used for kinematic data which it is extremely well suited for. It can also process single static baselines. Receiver types can be mixed and matched via the use of a common format.



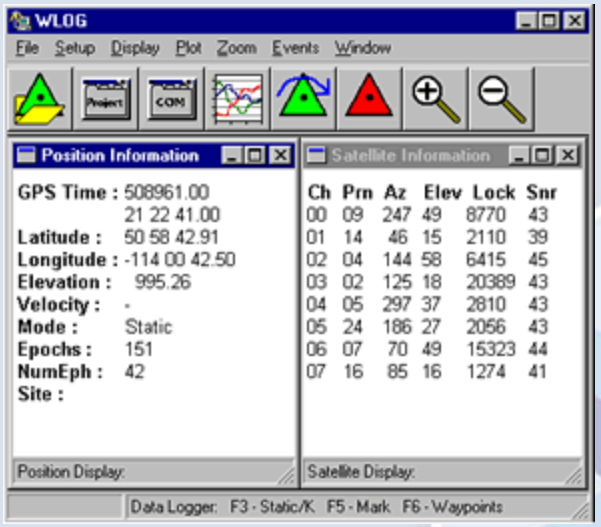
- **GrafNet** automatically matches up common time periods from GPS observation files and forms a network of baselines that can be automatically processed. GrafNet can also perform a network adjustment for accurate computation of station coordinates and their standard deviations.



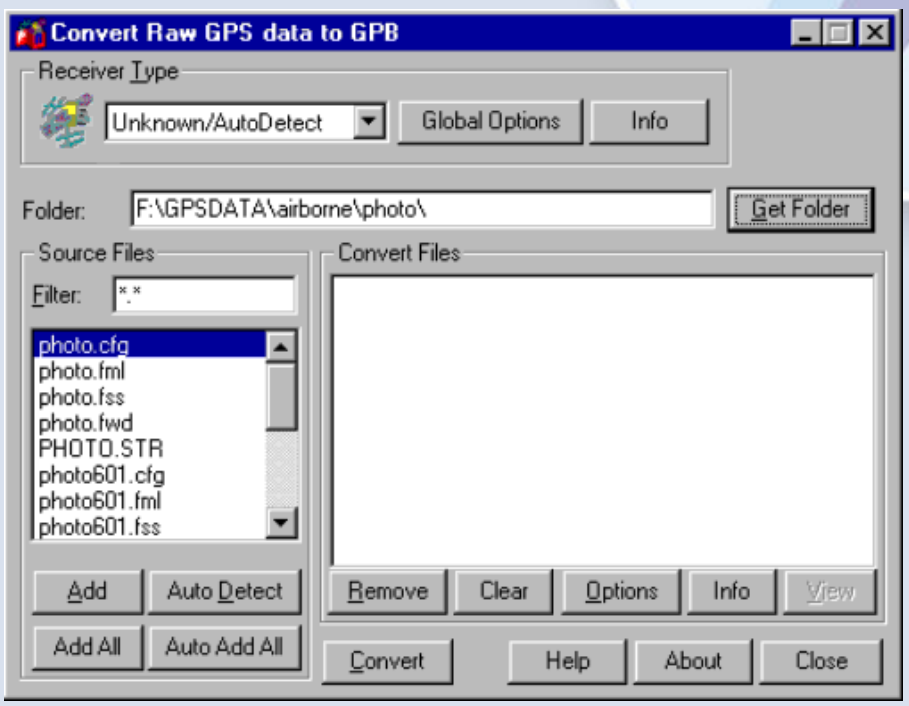
- **GrafNav Batch** is used to "batch process" multiple kinematic or static GrafNav baselines. Most of the capabilities of GrafNav are contained in GrafNav Batch. With version 6.02, the ability to combine baselines computed for the same remote but from different base stations will be added for up to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



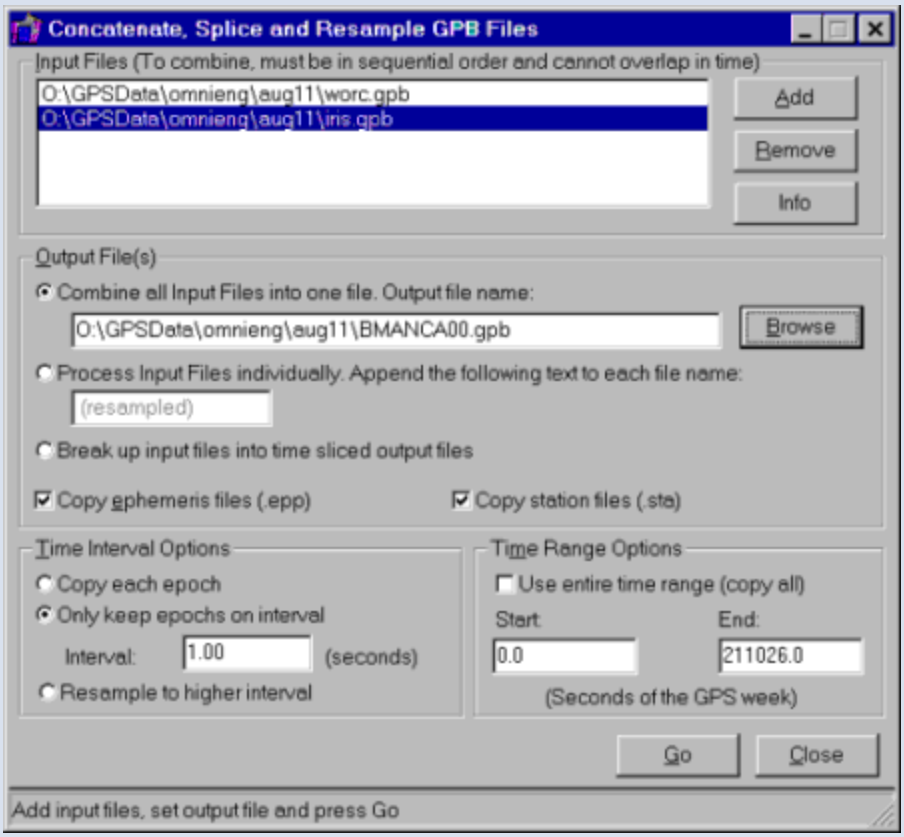
- A **Data Logger** is included with GrafNav/GrafNet that collects GPS raw data from a number of GPS receivers (see below). Versions are available for DOS, Windows 9x/2000/NT/XP, and Windows CE.



- 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.



Our Philosophy

The philosophy behind GrafNav/GrafNet post-processing software can 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 be as fast and easy as possible. GPS post-processing 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, addition modules do not 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

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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*e-6 * 40,000=0.06 m or 6 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 ½ 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:

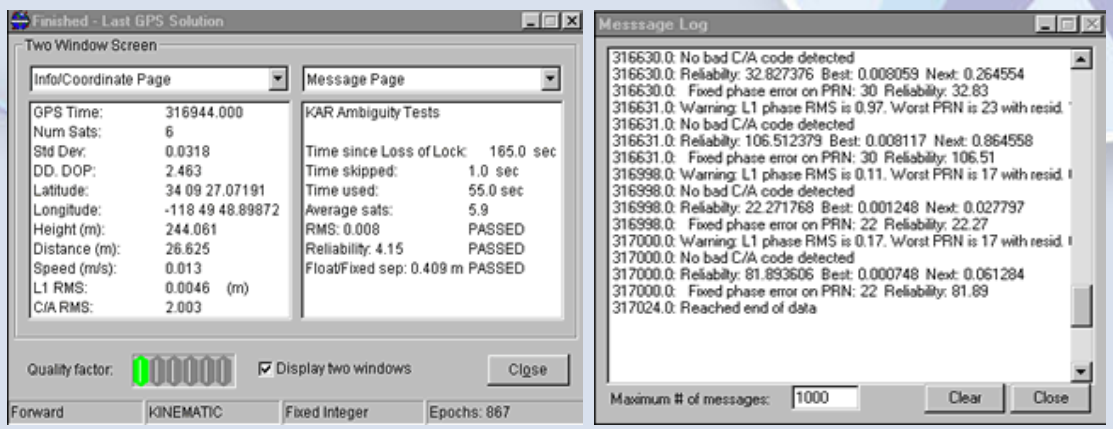
Baseline	Length	Single Frequency accuracy	Dual Frequency accuracy
Short	0 - 5 km	2 cm + 1 PPM*	2 cm + 1 PPM
Medium	5 - 35 km	5 cm + 4PPM	5 cm + 2 PPM
Long	35+ km	10 cm + 4 PPM	10 cm + 2 PPM

* 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:



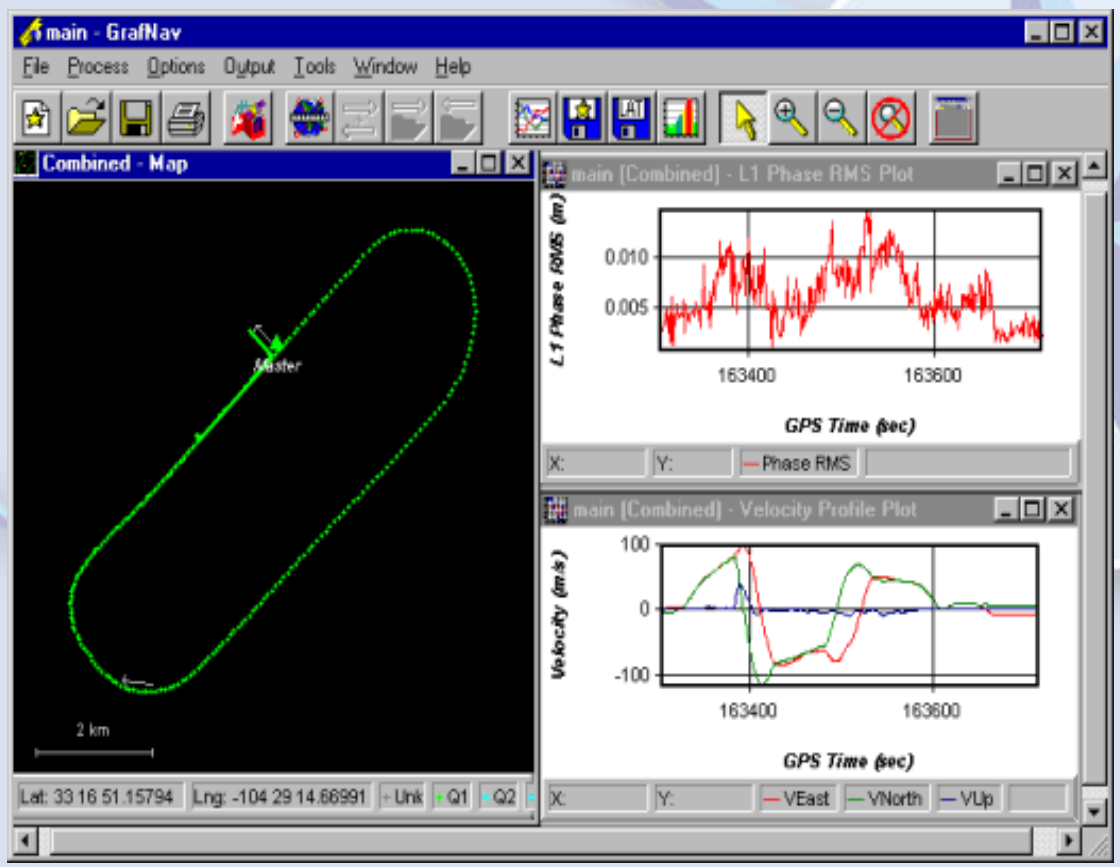
- **Fast processing** - The GrafNav kernel is one of the fastest on the market. It will process ~0.8 epochs per MHz per second on a Pentium II. For example, a 400 MHz machine will process about 320 epochs/second, which translates into 45 seconds of processing time for 4 hour data set collected at 1 Hz.
- **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 completly 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 Ashtech GG-24 GPS/Glonass Receivers and Waypoint's GrafNav Post-Processing Software).
- **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 about 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).
- **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 (see Quality Control). In addition to a mapping screen, 26 data

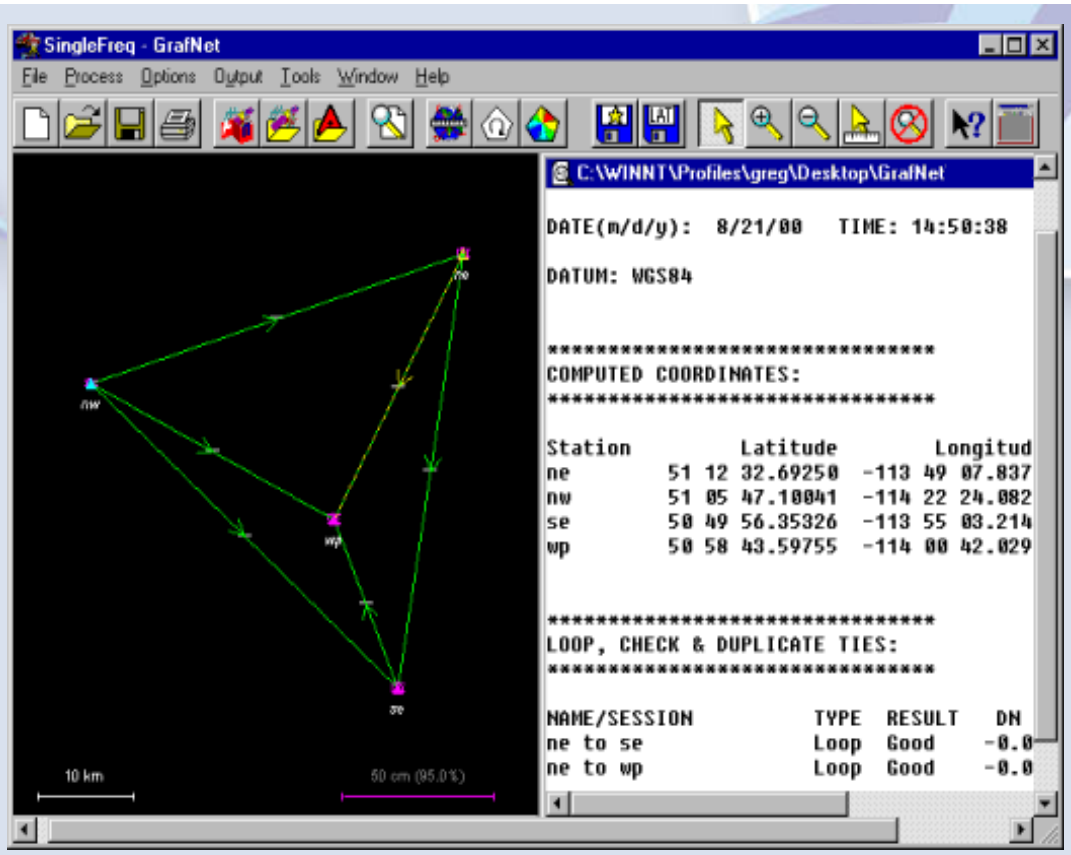
graphs can be viewed as well. All of this can be printed to your laser or color printer.

- **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:



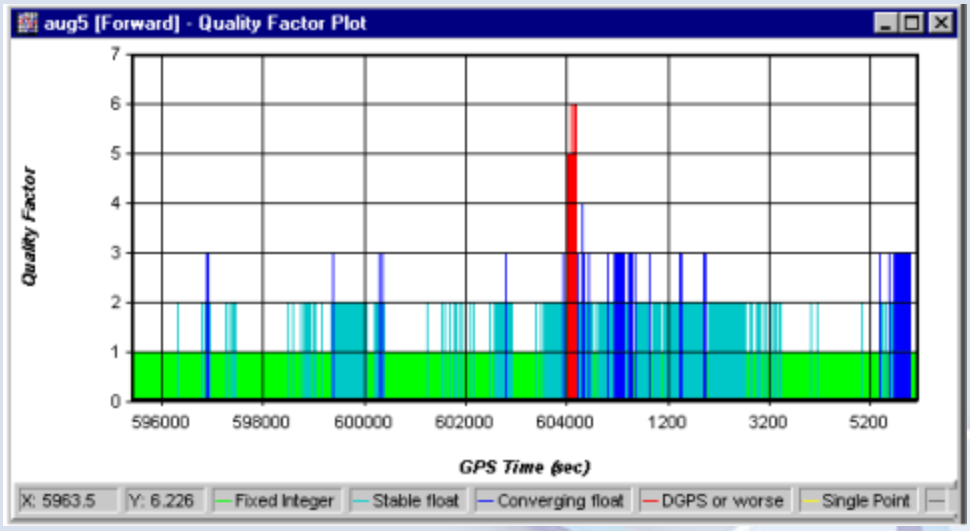


- **Trivial Baseline Removal** - GrafNet can automatically (or manually) remove trivial baselines in a GPS static network.
- **Network Adjustment** - An easy-to-use network adjustment is included with GrafNet. For users requiring more advanced features that are not provided by the built-in network adjustment (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.

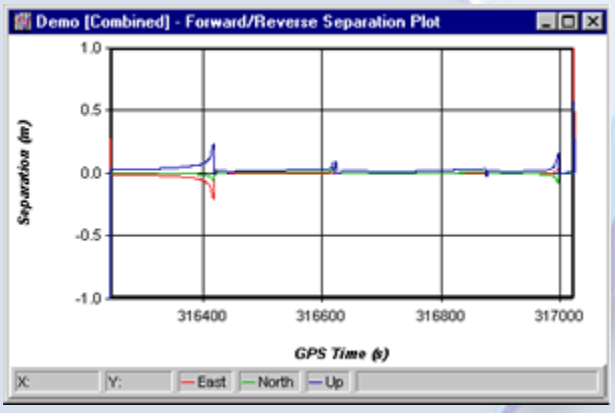
Quality Control

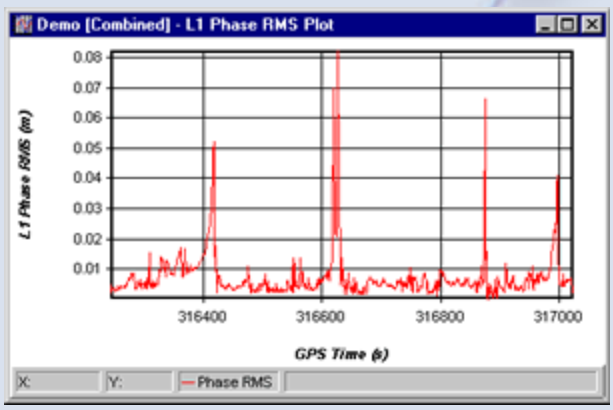
GrafNav/GrafNet is one of the best quality control (QC) tools available.

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 9x/2000/NT/XP** - 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 9x/2000/NT/XP, 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.

See Supported GPS Receivers to find out which GPS receivers are supported under the various operating systems.

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 9x/2000/NT/XP data logger, DOS data logger and the Windows CE data logger.

GPS Receiver Manufacturer	Receiver Model/ Format	Post-processing Convert (offline)	Data Loggers		
			Win9x/2K/ NT/XP	DOS	WinCE
Allen Osborne	TurboBinary	%			
Ashtech Real-Time	All models	*	*	*	*
Ashtech B-File	All models	*			
CMC	AllStar	*	*	*	*
CMC	SuperStar II	*	*	*	*
Conexant	Jupiter	*	*		
CSI	DGPS MAX	*	*		*

Garmin	25/35	*	*		
Javad	All models	*	*		*
Leica/ Magnavox	MX series	*			
Leica	SR series	*			
Leica	System 500	*			
Leica	MC1000	*			
Magellan	CAR/MOB	*			
Motorola	VP Oncore	*	*	*	
NAVCOM	OEM GPS	*	*		*
NavSymm/ Parthus	XR5/XR6		*	*	#
NavSymm/ Parthus	XR7	#	*		*
NavSys	AGR	&			
NovAtel	OEM2	*	*	*	*
NovAtel	OEM3	*	*	*	*
NovAtel	OEM4	*	*		*
Rinex	Most flavours	*			
Rockwell	PLGR series	%		%	
Rockwell	NAVCOR	*			
Septentrio	SBF	*			
SIRF	Star II	*			
Trimble	4000/DAT^	*	*		
Trimble	4000/RT1^	&	#		#
Trimble	CMR	&			
Trimble	TSIP	*			

Trimble	Force5/TIPY	*			
Trimble	5700	*	*		
Trimble	SSx	*	*		
UKOOA		&			

* Implemented

& Data logger available from Waypoint but not part of the CD distribution

Planned in the near future

^ Includes all 4000 series units (i.e. 4xxxx)

% 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

For more information on support and upgrades, see our Support and Upgrades page.

Customization

If 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. Waypoint has their own GPS/INS post-processor.For more information see Inertial Explorer section of the website.
- **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 makes 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 Ashtech G-12 Receivers and Waypoint's High Precision GrafMov Software)

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- **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 Seismic Surveying under Tree Canopy Using Ashtech GG-24 GPS/Glonass Receivers and Waypoint's GrafNav Post-Processing Software).

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