A NovAtel Precise Positioning Product:

RTKNAV/RTSTATIC

Includes Developers Kit Documentation
For Windows 95/98/2000/NT/XP

User Manual

RTKNAV/RTSTATIC User Manual

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CHAPTER 1 INTRODUCTION

This chapter gives instructions on how to install RTKNav and includes trouble-shooting tips. Descriptions of the various components of RTKNav are given, followed by an explanation of some of the communication concepts used in this manual. RTKNav comes with the developer's kit documentation, which is the collective name for RtEngine, RtDll and SIOGPS. All of these modules are explained below.

Section 1 What is RTKNav?

RTKNav is a real-time processing program that is used to obtain sub-metre, sub-decimetre or centimetre accuracies. The accuracy obtained depends very much on the conditions of data collection, receivers used and application dynamics. RTKNav requires raw data to work (pseudoranges, carrier phase, etc…). It will not compute corrections from RTCM Type1. In such a case, a DGPS receiver should be used.

Basically, RTKNav applications fall into three categories:

- **Forward RTK processing** – The base station transmits raw data through a radio link to the rover, where RTKNav is running. This is the master input stream. At the rover, a GPS receiver is connected directly to RTKNav. This is the remote. The user would normally use RTKNav to navigate or track the location of the vessel, vehicle or aircraft.

- **Multi-remote Inverse RTK** – RTKNav is running at the base station, where it is connected directly to the master receiver. One to 20 mobile units are continuously transmitting their raw data back to the base for processing. The base may either be moving or static. RTKNav will plot the location of each of the mobile units. Their solution can also be sent to another application.

- **Monitoring** – RTKNav is tracking a number of near-stationary receivers to determine their movement. In this application, accuracy is very important. RTKNav computes the epoch-wise kinematic location of each, and RtStatic also computes a static fixed integer position for even higher accuracy.

Currently, RTKNav supports the following GPS receiver inputs:

- Ashtech AC12/G12/DG16/MACM/Z12/Z12DBEN/MACM_GSU1/MACM_GSU2
- Canadian Marconi AllStar/SuperStar
- Javad GRIL/OEM
- Parthus XR6/XR7
- Navcom NCT
- NovAtel 2151/3151/OEM4/Millenium
- Rockwell Jupiter
- Trimble 4x00/SSx

RTKNav offers a full-featured Windows interface. This interface comes with an easy-to-use Configuration Wizard, plots up to 20 remotes, and shows the tracking status of each connected receiver. A simple red-yellow-green light means that system operation can be checked by quick inspection. For moving baseline applications, a bull's-eye view is possible, along with range and bearing display. Waypoint navigation is also supported.

For more information on RTKNav, please see 0.

Section 2 What is RtStatic?

Waypoint has added a major new feature called RtStatic to its RTKNav real-time kinematic processing package. This option is aimed at near real-time deformation monitoring applications.

RtStatic uses Waypoint's GrafNav processing engine to provide Fixed Static solutions in near real-time, while the standard RTK engine produces kinematic real-time solutions on a per epoch basis. Filtering of the time history of the Fixed Static solutions produces millimetre level coordinate changes on slow moving features such as slopes or dams.

Simultaneously, the standard kinematic engine processes the same data in real-time to monitor fast moving events in standard kinematic fashion. On short baselines, single or dual frequency receivers can be used with similar precision. Up to 20 base/remote combinations can be processed on the same computer platform. Raw input or processed output data can be transferred in real-time over serial or network connections.

Additionally, users have the ability to rebroadcast data collected in real-time over a network or over the Internet, thus allowing other instances of RtStatic on other computers to process all, or a subset of the data that you are processing. Furthemore, data can be rebroadcast so that other instances of RtStatic on the same computer can be used to process a subset of the data.

For more information on RtStatic, please see Chapter 3 .

Section 3 What is RtEngine?

RtEngine is a command line version of RTKNav. It is usually called from the Windows DOS Prompt. RtEngine does not have any of the graphics that RTKNav has, but with the command interface, it is a very powerful tool. RtEngine requires Windows 95, 98, NT, 2000 or XP to run. It will not run under DOS.

See Chapter 8 for a description of how to use RtEngine.

Section 4 What are RtDLL & SioGps?

RtDLL is the GPS differential processing engine used by RTKNav and RtEngine. Software developers may be interested in this package, as it allows them to add full RTK processing capabilities to their own software. The later chapters of this manual discuss how to access

RtDLL. Users must purchase the development kit in order to obtain the sample source code and header files necessary to utilize the DLL.

SioGps is the serial/network communications DLL used by RtEngine, RTKNav and the GPS Data logger. This DLL has many functions within it and can be used in a number of ways. For instance, a user can collect GPS data using their own communications routines and use a DecodeOneByte routine to unravel the necessary raw data logs in the GPS data. A user can also use the serial and network communications routines to connect directly the GPS receiver. Like RtDLL, the development kit must be purchased to access these routines.

See Chapter 7 for more information on RtDll and Chapter 9 for SIOGPS.

Section 5 What You Need To Start

In order to get RTKNav running, the following items are required:

- Computer with RTKNav installed. See Section 6 for installation instructions. The processor should be a Pentium or faster.
- At least two serial ports. Unless TCP/IP data input is utilized, RTKNav requires one serial port for each GPS receiver it is connected to (either directly or via a radio link). An easy way to get started is to use a USB multi-port serial device.
- For the first try, using a direct (serial) connection is easiest. This way any problems due specifically to the radio link can be isolated later.
- At least two suitable GPS receivers are also required. One is the master and the remaining ones would act as mobiles (i.e. remotes). The receivers should have an open view of the sky in order to work with RTKNav. Placing them in a window may not provide enough satellites for navigation.
- A serial port is also required if you wish to output serial records to another device. Note that this can also be performed via TCP/IP (TCP mode only).
- The hardware key must be connected to the parallel or USB port.

Section 6 Installing RTKNav

Installing RTKNav is quite simple, and can be done by performing the following steps:

1. Insert the CD into the drive. If you have downloaded the setup program from Waypoint's FTP site, then please note the directory containing the Setup.exe program
2. From the Windows Start Menu, select **Run**
3. Click on **Browse**, and move to the drive or directory containing Setup.exe (i.e. select your CD-ROM drive for CD installation)
4. Select Setup.exe and press **OK**
5. Follow the instructions
6. For NT users, you must re-boot your machine before the hardlock drivers will take effect. Users of Windows 9x and XP do not need to reboot.

Section 7 Sentinel Hardlock Problems

Currently, this product only works with two types of hardware key, both of which are manufactured by Sentinel. The Sentinel parallel-port locks are beige colored, while the USB keys are purple. Encoded in their memory is the key's serial number, software type (i.e. GrafNav/GrafNet, RtkNav, RtStatic, POSGPS, etc.) and version number. The memory may also contain the demonstration status if applicable. The information on the Sentinel lock's memory can be read using the *Hardlock Upgrade Utility*, which can be accessed from the software's program group in the Start Menu.

There are currently no known compatibility issues with these hardlocks. The most frequent cause of problems is due to drivers not being installed. The error message for such an error is 'FATAL ERR – Hardlock error! Unable to open Sentinel hardware lock driver – Install driver (error code 12)'. In Windows 95/98, the hardlock will work without the drivers even being installed. However, for Windows 2000 and NT, it is important that the drivers are installed, and the system is restarted.

Another common cause of problems is an incompatible version number for the software type between the processor and key. In this case, you will need to contact your dealer. This returns one of two error messages, 'FATAL ERR – Hardlock error! Hardware key is intended for a software version older than what is being used – reinstall older version or upgrade key'.

There has been a few cases where failed or intermittent locks have been encountered. These usually return an error labeled 'FATAL ERR – Hardlock error! Waypoint hardware key not found – Check printer port (error code 3)'. Test procedures have improved, but if the problem occurs, the lock will need to be replaced. Note that an RMA number is required before a shipment will be accepted. Please contact you dealer for instructions.

Otherwise, the error code number that is shown in the error message corresponds to the following:

Table 1.1: Definition of Hardlock Error Codes

ERROR CODE	ERROR MESSAGE	DESCRIPTION
0	SUCCESS	
1	INVALID FUNCTION CODE	See your language's Include File for valid API function codes. Generally, this error should not occur if you are using a Rainbow-provided interface to communicate with the driver.

2	INVALID PACKET	A checksum error was detected in the command packet, indicating an internal inconsistency. The packet record structure may have been tampered with. Generally, this error should not occur if you are using a Rainbow-provided interface to communicate with the driver.
3	UNIT NOT FOUND	The specific unit could not be found. Make sure you are sending the correct information to find the unit. This error is returned by other functions if the unit has disappeared (i.e. it is unplugged).
4	ACCESS DENIED	You attempted to perform an illegal action on a word. For example, you may have tried to read an algorithm/hidden word, write to a locked word, or decrement a word that is not a data nor counter word.
5	INVALID MEMORY ADDRESS	You specified an invalid Sentinel SuperPro memory address. Valid addresses are 0-63 decimal (0-3F hex). Cells 0-7 are invalid for many operations. Algorithm descriptors must be referenced by the first (even) address.
6	INVALID ACCESS CODE	You specified an invalid access code. The access code must be 0 (read/write data), 1 (read-only data), 2 (counter) or 3 (algorithm/hidden).
7	PORT IS BUSY	The requested operation could not be completed because the port is busy. This can happen if there is considerable printer activity, or if a unit on the port is performing a write operation and is blocking the port. Try the function again.
8	WRITE NOT READY	The write or decrement could not be performed due to a momentary lack of sufficient power. Try the operation again.
9	NO PORT FOUND	No parallel ports could be found on the workstation.
10	ALREADY ZERO	You tried to decrement a counter or data word that already contains the value 0. If you are using the counter to control demo program executions, this condition may occur after the corresponding algorithm descriptor has been reactivated with its activation password.

12	DRIVER NOT INSTALLED	The system device driver was not installed or detected. Communication with the unit was not possible. Please verify that the device driver is properly loaded.
13	COMMUNICATIONS ERROR	The system device driver is having problems communicating with the unit. Please verfiy that the device driver is properly installed.
18	VERSION NOT SUPPORTED	The current system device driver is outdated. Please update the system device driver.
19	OS ENVIRONMENT NOT SUPPORTED	The Operating System or Environment is currently not supported by the client library. Please contact Technical Support.
20	QUERY TOO LONG	The maximum query string supported is 56 characters. Send a shorter string.
30	DRIVER IS BUSY	The system device driver is busy. Try the operation again.
31	PORT ALLOCATION FAILURE	Failed to allocate a parallel port through the Operating System's parallel port contention handler.
32	PORT RELEASE FAILURE	Failed to release a previously allocated parallel port through the Operating System's parallel port contention handler.
39	ACQUIRE PORT TIMEOUT	Failed to acquire access to a parallel port within the defined time-out.
42	SIGNAL NOT SUPPORTED	The particular machine does not support a signal line. For example, an attempt was made to use the ACK line on a NEC 9800 computer. The NEC 9800 does not have an ACK line, and therefore, this error is reported.
57	INITIALIZE NOT CALLED	Failed to call the client library's initialize API. This API must be called prior to the API that generated this error.
58	DRIVER TYPE NOT SUPPORTED	The type of driver access, either direct I/O or system driver, is not support for the defined Operating System and client library.
59	FAILURE ON DRIVER COMMUNICATION	The client library failed to communicate with a Rainbow sytem driver.
60	SERVER PROBABLY NOT UP	The server is not responding; the client has timed-out.
61	UNKNOWN HOST	The server host is unknown. The server is not on the network, or an invalid host name was specified.
62	SEND TO FAILED	The client was unable to send a message to the server.

63	SOCKET CREATION FAILED	The client was unable to open a network socket. Make sure the TCP/IP or IPX protocol is properly installed on the system.
64	NO RESOURCES	Could not locate enough licensing requirements. Insufficient resources (such as memory) are available to complete the request, or an error occurred in attempting to allocate the needed memory.
65	BROADCAST NOT SUPPORTED	The broadcast is not supported by the network interface on the system.
66	BAD SERVER MESSAGE	Could not understand a message received from the server. An error occurred in decrypting (or decoding) a server message at the client end.
67	NO SERVER RUNNING	Cannot communicate to the server. Verify that the server is running. The server on the specified host may not be available for processing the request.
68	NO NETWORK	Unable to communicate with the specified host. Network communication problems encountered.
69	NO SERVER RESPONSE	No server responded to the client broadcast. There is no server running in the subnet, or no server in the subnet has the desired key connected.
70	NO LICENSE AVAILABLE	All licenses are currently in use. Server has no more licenses available for this request.
71	INVALID LICENSE	The license is no longer valid. License expired due to time-out.
72	INVALID OPERATION	The specified operation cannot be performed. Tried to set the contact server after obtaining a license, or tried to call FindFirstUnit function on a packet that already has a license.
73	BUFFER TOO SMALL	The size of the buffer is no sufficient to hold the expected data.
74	INTERNAL ERROR	An internal error, such as failure to encrypt or decrypt a message being sent or received, has occurred.
75	PACKET ALREADY INITIALIZED	The packet being initialized was already initialized.
255	INVALID STATUS	An invalid status code was returned.

The Alladin (black) hardlock is no longer supported. Therefore, if you have such a key, then it must be exchanged for one of the Sentinel keys. There may be an upgrade charge for this.

Section 8 Utilities

The following utilities are also included with the software:

- **Concatenate, Slice and Resample**
  A raw GPS data utility that can edit raw data files produced by RtkNav. If users choose to log in the raw binary format of the GPS receiver, the files will have to be converted to Waypoint's format before this utility can be used.

- **GPB Viewer**
  This utility will allow you to view the raw binary data collected by the GPS receiver in order to detect any problems. Measurement values and position records are among the fields that can be viewed here.

- **GPS Data Logger**
  This utility is included to facilitate GPS data logging directly from a variety of GPS receivers under a Windows 95, 98, 2000, XP and NT environment. Features such as tagging stations and satellite lock plots are included as well. Logging can be performed directly into Waypoint's custom format. Refer to Table 1.2 for supported receivers.

Table 1.2: Receivers Supported for Data Logger

MAKE	MODEL	DATA LOGGING	
		WINDOWS	WINCE
CMC	Allstar	✓	✓
	Superstar II	✓	✓
Conexant	Jupiter	✓	
CSI	DGPS MAX	✓	✓
Garmin	25 series	✓	
	35 series	✓	
Javad	All models	✓	✓
Motorola	VP Oncore	✓	
NAVCOM	OEM GPS	✓	✓
NavSymm/ Parthus	XR5	✓	✓
	XR6	✓	✓
	XR7	✓	✓
NovAtel	OEM2	✓	✓
	OEM3	✓	✓
	OEM4	✓	✓
Thales	Real-Time	✓	✓
Trimble	4000 series	✓	✓
	(DAT)	✓	
	4000 series (RT)	✓	
	5700	✓	
	SSx		
U-Blox	Antaris	✓	✓

Section 9 What else is contained on the CD?

The CD Distribution contains the following directories (additional to the setup file):

- **Hardlock**
  This directory contains the drivers necessary for Windows 2000, NT and XP installation. All hardlock drivers should be installed automatically during installation.

- **Geoid**
  This directory contains geoid files for U.S. (Alaska96, Geoid96, Geoid99, Geoid03), Mexico97, Australia (AusGeoid93 and AusGeoid98) and the World (EGM96). These files allow mean-sea-level (orthometric) heights to be computed using GrafNav and GrafNet. Files are in the WPG (Waypoint Geoid) format. For Canada, files must be downloaded from the Geodetic Survey Division of Geomatics Canada. Other regions of the world are also available.

- **ManualPdf**
  Contains this manual, as well as the MultiEngine manual, in Adobe Acrobat format.

Section 10 Communications definitions and concepts

The following section describes some of the terms used in the next Chapter. If you are unfamiliar with terms relating to serial and network communication ports, this may be useful to you.

When starting an RTKNav project, you will need to know a number of items relating to serial comports and network ports, among other things. Some of these, especially those related to networks, are briefly explained below.

NOTE: In the following discussion, the term Win32 will be used to denote Win95, Win98, Win2000, Win XP and Win NT. RTKNav has been extensively tested on all of these operating systems.

- **Assigned Port Number –** RTKNav, RtEngine and SioGPS.DLL use an assigned port number to reference a serial or network port. Assigned port numbers range 1 – 1023, and they have no correlation to serial comports or network port numbers. Assignment is usually sequential.

- **Comport (computer)-** The Windows system defines a number of serial communications ports, depending on what serial devices you have installed. Generally, you will have COM1 and COM2. Your mouse may use one of these. Serial boards or Serial - USB devices will show in the Win32 system as COM ports. RTKNav is designed to read the Win32 system and determine which COM ports you have and are available for reading measurement data from your GPS receivers. **COM ports are usually defined in the region COM 1 – COM20.**

- **Comport (GPS receivers)** – Currently virtually all GPS receivers have one or more serial comports. RTKNav can communicate from your computer comport to either GPS receiver port A or B Note that RTKNav has two-way communication with the receivers and will **send configuration commands to your GPS receivers.**

- **Baud Rate** – RTKNav will ask you to choose the data rate at which you wish to communicate over your serial port. Baud rates from 4800 bits per second to 115200 bits per second are supported. RTKNav will run reliably up to 115200 bps (baud). Your GPS receiver must support the same baud rate as your computer. RTKNav will poll the receiver to set its baud rate to the correct setting, providing the receiver supports that rate.

- **Network Port –** RTKNav will send or read GPS data that has been broadcast over a network. The term network port is used here to describe a communication port through which a data stream is being sent over a local or wide-area network.

- **Network Port Number -** Like COM ports, network ports are assigned numbers so that each data stream is identified with an associated integer number. Network port numbers from 1 to 1024 are generally reserved for use by the operating system, FTP, Internet and so on. The maximum port number allowed is 65356. RTKNav defaults to **port numbers starting at 6001**. **RtkNav will attempt to assign different port numbers for you.** You are free to type in your own port numbers. These port numbers will uniquely identify each GPS binary data stream or each output ASCII data stream from RTKNav to other network users.

- **IP Address** – Each computer on a local or wide are network is given a unique set of 4 numbers which identify this computer to all other computers on the network. Local network computers (nodes) will tend to have IP addresses such as 192.xxx.xxx.xxx. Computers that have so-called static IP addresses are capable of receiving data over the Internet. RTKNav uses these addresses in TCP mode to send data anywhere.

- **Network Protocol** – RTKNav supports 3 types of network data protocol. Your choice of data protocol will depend on the operating system that you have and whether you wish to send the data over your local network or over the Internet to a remote location. Local networks would be the network in your office or say on your ship. Wide are networks that communicate all over the world on Internet connections.

  The 3 types of network protocols supported are:

  a) **UDP protocol** – UDP protocol is used strictly on local networks. If you wish to send data to your own computer or another computer in your office, then UDP is a good choice. If a data stream is sent on UDP protocol, then the data will automatically be sent to every computer in the local network. To receive this data stream, you must be receiving in UDP protocol and must be on the same port number as the sender. For instance if RTKNav is asked to re-broadcast a serial data stream from a NovAtel GPS receiver by UDP on port 5001, then every computer on the local network will receive UDP data on port 5001. The receiver must specify UDP, port 5001 to get the data into another instance of RTKNav running somewhere else on the network.

Note that in Win32 operating systems, UDP is always assigned an IP address of 255.255.255.255. This may not be true for UNIX-based systems. UDP should work on Win95, 98, 2000 and NT.

b) MULTICAST protocol – Like UDP, MULTICAST is an ideal choice for local networks. It is only meant for sending or receiving from computers near you. Note that all protocols, including MULTICAST will "loop" network data to your own computer. This means that you can use network ports to send data to another instance of RTKNav on your own computer. MULTICAST like UDP sends data to every computer in a local network. The difference between UDP and MULTICAST is that a MULTICAST user must type in an IP address. This address is actually denoting a user group. All MULTICAST Win32 users must join a group with an IP addresses of between 224.0.0.0 and 240.0.0.0. RTKNav defaults to a user group address of 234.5.6.7.

MULTICAST users must type in a group IP address, whether they are sending or receiving data.

NOTE: MULTICAST may not work on some Win95 computers. UDP may be used in an equivalent fashion.

c) TCP protocol – TCP may be used in either local or wide-area networks. Local network users will probably not use TCP since in TCP, you must know the IP address of the computer that you are sending data to. TCP is used to send data over the Internet and must be used to send data outside your local network. In principle, this protocol will send your data to any point in the world, which has a static IP address and is on the internet.

TCP users do not have to know an IP address if they are receiving data. The computer that is sending data to you must know your local IP address. To obtain the IP address of your computer, open a command line prompt by going to *Windows Start Menu | Run…* Type "cmd" into the blank space and click **OK**. In the DOS window that appears, type in "ipconfig /all". A display should appear showing your local IP address.

- **Re-Broadcast Data** – This functionality allows a user to collect GPS raw binary data from a serial port and send this data over a local or wide area network to another window on your computer, another RTKNav user in your local network (UDP or MULTICAST protocol) or another RTKNav user in some other part of the world (TCP protocol). This allows multiple instances of RTKNav to process the same data from the same group of GPS receivers. This may be useful, if you want one copy of RTKNav to process data from your entire group of GPS receivers, while another copy only examines data from a subset of your receiver group. You might also find this useful, if you simply wish to have some other remote computer store your raw binary measurement for future post-processing.

  Note that RTKNav instances receiving data over a network can also re-broadcast this data to other network ports.

CHAPTER 2 RTKNAV

RTKNav is a Windows 95/98/2000/XP/NT real-time GPS processing program. It that has a graphical user interface that allows the user to easily navigate the program and its processing options. RTKNav also has the ability to support one base station receiver and one or more remote station receivers.

Real-time GPS measurement data can be received on either serial or network ports. This binary measurement information can also be re-directed (re-broadcast) to local or wide-area network ports to allow other instances of RTKNav to process the same data at another location or even on the same computer. One use for this might be to allow a second copy of RTKNav to process only one of several baselines in order to examine its particular behaviour. The original instance of RTKNav would collect and process all of the baseline information.

As well, the processed data information can be output in a number of ASCII formats to either serial or networks ports. This allows other programs to receive processed high precision coordinate and quality information either locally or by the Internet.

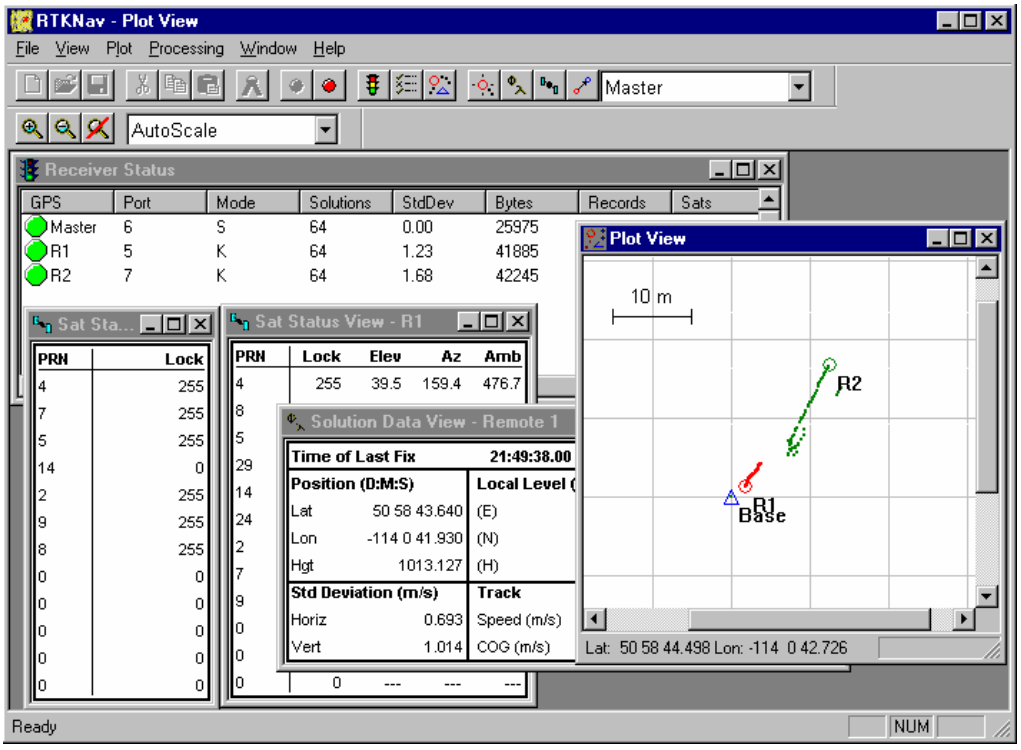


Figure 2.1: RTKNav Project

Section 1 Getting Started

The following section describes step-by-step how to start using RTKNav.

2.1.1 Running RTKNav

Before processing, the user must start a new project or open an existing project. RTKNav initially creates two project files, an IN file and a CFG file. The IN file mainly contains information about communication ports. The processing engine RtGpsX.dll uses the CFG file to perform GPS processing functions. To get started, the user must first define the GPS receiver types and communication parameters.

First-time users should review the following sections very carefully.

Steps to begin a new project and start real-time GPS processing:

Step 1: Start up RTKNavRx.EXE
The figure below illustrates how to launch RtkNavRx.exe. **Go to the Windows Start menu as indicated.** Choose either RtkNavR3 or RtkNavR20.

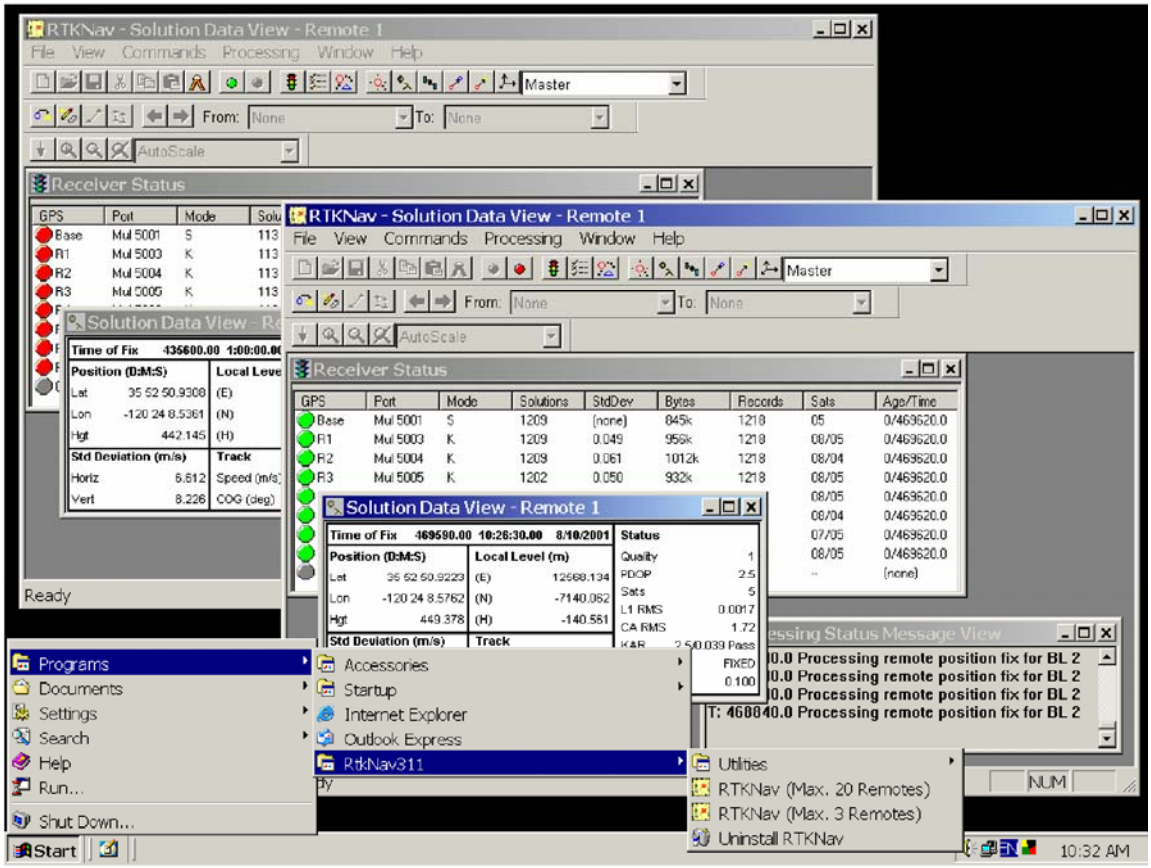


Figure 2.2: Using the Start Menu to Launch RTKNav.

Note that in the above diagram, RtkNavR3 and RtkNavR20 are running on the same host computer. Additionally, in this figure, RtkNavR3 is re-broadcasting its serial data over the network using MultiCast protocol. RtkNavR20 is re-computing the project with the same data as RtkNavR3. Using the network capability, RtkNavR3 and/or RtkNavR20 can use the same data at many remote locations on your local or wide-area network.

When Should you use RtkNavR3 versus RtkNavR20?

Users who have purchased RtkNavR1 or RtkNavR3 should use RtkNavR3, as RtkNavR20 takes up considerably more memory and CPU. RtkNavR20 should only be used by if you have more than 3 remote GPS receivers on line.

2.1.2 Start New Project

Step 2: Create a New Project

Select *File* | *New Project* and type a filename for your project. See Figure 2.3.

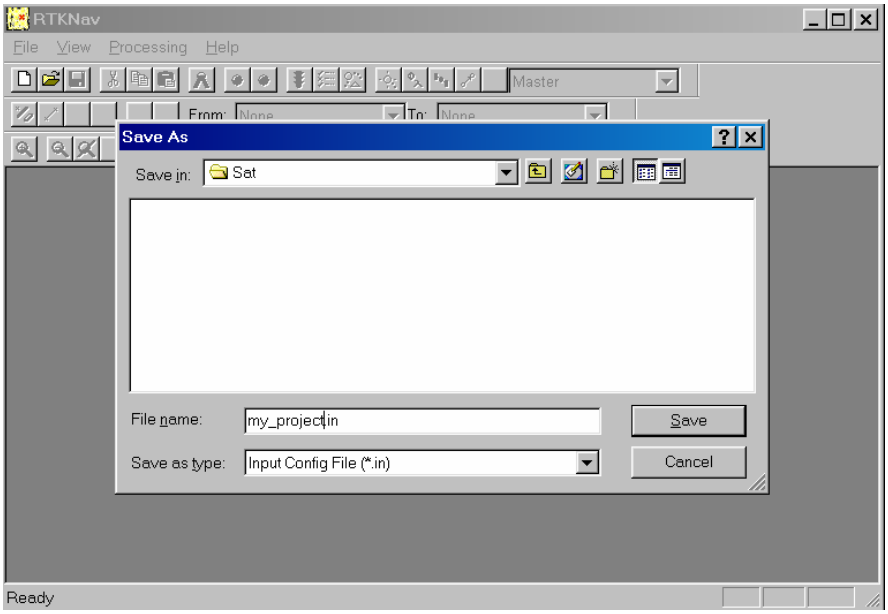


Figure 2.3: Start a New Project

The IN file will contain communication parameters necessary for data input and output. If you have already defined an IN file for your project, then simply go to *File* | *Open Project* to load it.

Step 3: Add Receivers to the Project

Next, a *Configure Project* window will be displayed. See Figure 2.4.

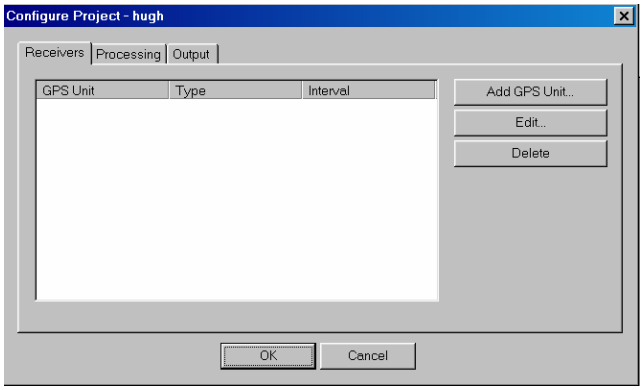


Figure 2.4: Configure Communication Input and Output

Click on **Add GPS Unit…** You will continue to use this button until the base receiver and all of the remote receivers have been added to the project.

Step 4: Define the Communication Parameters
The next dialog box to appear is shown below, in Figure 2.5.

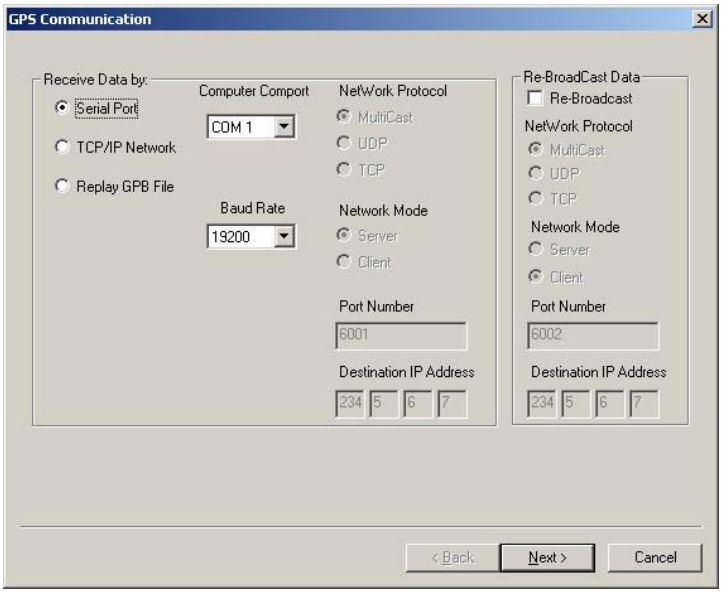


Figure 2.5: Serial Communication Parameters for your Computer

In Figure 2.5, we are assuming that you will utilize serial port COM1 on your computer at a baud rate of 9600 in order to communicate with this GPS receiver. RTKNav will recognize any COM port that Windows has available on your system. Baud rates of up to 115200 are allowed and are reliable.

You may also choose to receive binary GPS data from a local or wide area network port. To receive GPS measurement data by network, click on **TCP/IP Network**, as seen below.

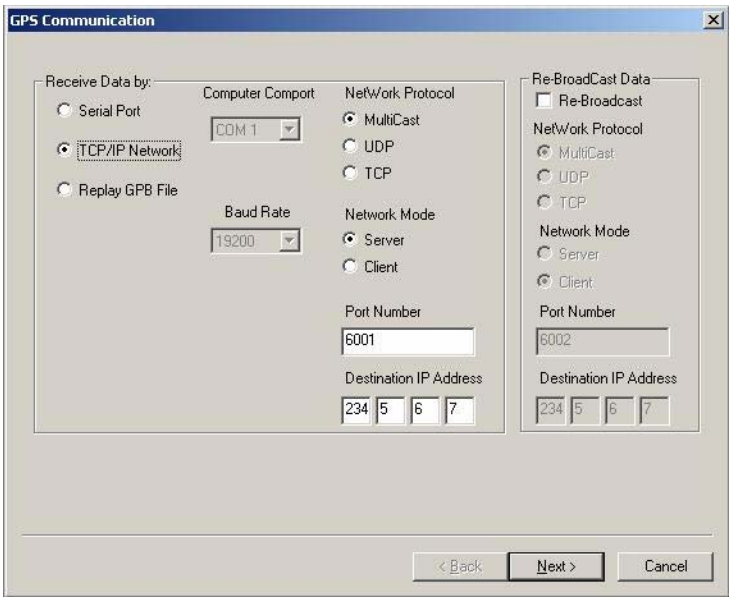


Figure 2.6: Receiving GPS data by Network Port

In Figure 2.6 above, we are requesting RTKNav to receive GPS binary data on a MultiCast network protocol. Note that Multicast protocol can only be used on a local network. All network computers wishing to receive this data must have the same MultiCast IP address. In Win32, this must be an address between 224.0.0.0 and 240.0.0.0. Port 6001 is an arbitrary port number that uniquely identifies this data stream to the network. Each GPS receiver must have its own network Port Number. RTKNav tries to assign a different Port Number to each network data stream for you, starting at port 6001. You should be very cautious about using port numbers of less than 1024, as they are usually reserved for use by the computer's operating system. The maximum port number is 65356. In MultiCast mode, all computers on a local network can use the IP address given and the given port number to receive this data stream. **NOTE: Win95 computers may not support MultiCast. You may have to use UDP or TCP.**

UDP mode is exactly like MultiCast protocol, except that Win32 only defines one local IP address for UDP. This is address 255.255.255.255. Every computer on a local network that uses the Port Number typed into the dialog box (6001 in this case) will receive this GPS data stream from the receiver. Note that like MultiCast, this data will “loop back” to your own computer, if you wish to run more than one copy of RTKNav on your computer. See the note on Re-Broadcasting below.

TCP mode is a point-to-point communication that can be used in either local or wide area network. You do not need to know the IP address, to receive TCP data from an outside source. A GPS receiver or computer sending TCP data must know the IP address of your computer in order to send TCP data to you. If you know the static IP address of some user in a remote location (and they have no firewall in their system), you can send GPS data using the Re-Broadcast capability anywhere in the world. Use can also use our utility data logging program, WLOG.EXE.

Users can also replay GPB files through RTKNav to simulate the RTK processing with previously collected data. Users must have the data in GPB format and have proper overlap with master and remote files. See Section 2 for details on replaying GPB files.

Step 5: Re-Broadcast the GPS Data (optional)
You can Re-Broadcast your serial or network data to your own computer or to a computer anywhere on your network. This is very useful if you need some other user to simultaneously process the same data that you are collecting. This user does not have to be hooked directly to the GPS receivers. Only the original RTKNav has to be connected directly. For instance, let us say that you are connecting your computer COM1 to the GPS receiver as indicated below.

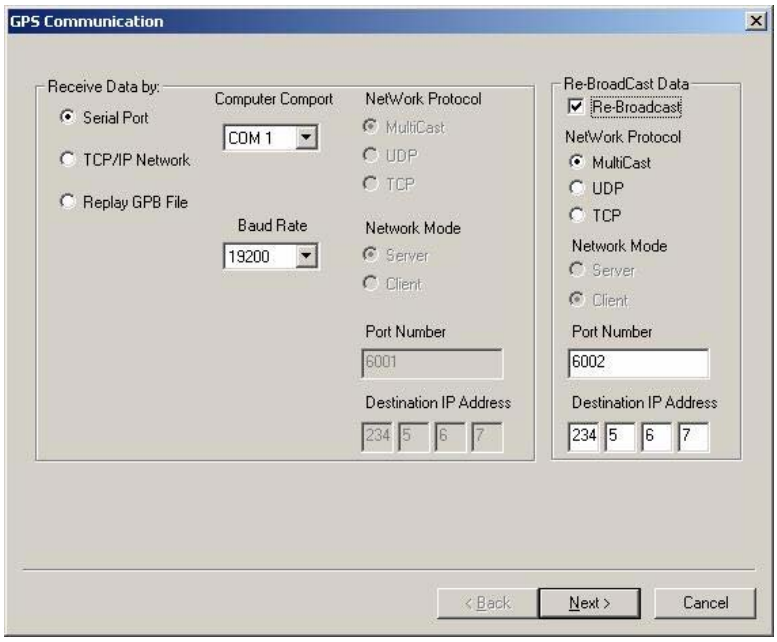


Figure 2.7: Re-broadcasting Data over a Network Port

In this case, COM 1 of your computer is directly linked to the GPS receiver at a baud rate of 115200 bps. By re-broadcasting the data on a MultiCast IP of 234.5.6.7 on Port 6002, any computer in the local network including the computer that you are working on will receive this GPS binary data, provided that they join MultiCast group 234.5.6.7, Port 6002. If you re-broadcast all or some of your GPS receiver data, you can run other instances of RTKNav to simultaneously process all or part of your survey on another window of your computer, another computer on your local network or in TCP mode, another computer somewhere else in the world (provided that they open a hole in their firewall security). Again, UDP protocol may be more appropriate for some users. Note that you cannot rebroadcast data when replaying GPB files.

Step 6: Choose the Receiver Type
If the unit is your base station, identify it as such. Please see Figure 2.8.

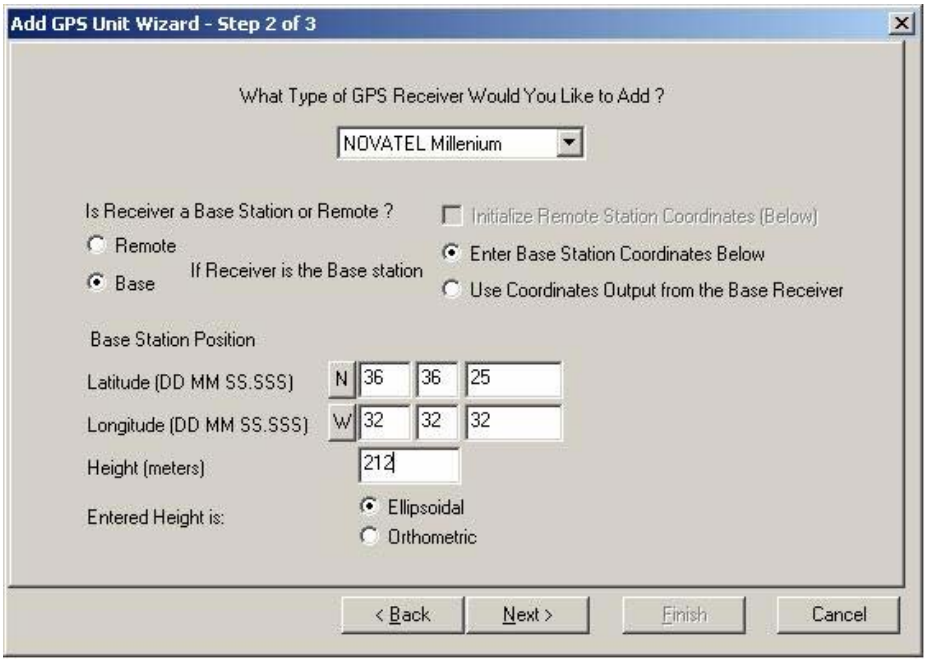


Figure 2.8: Identify the Base Station Receiver and Coordinates

Otherwise, identify the receiver as a remote unit, as demonstrated in Figure 2.9.

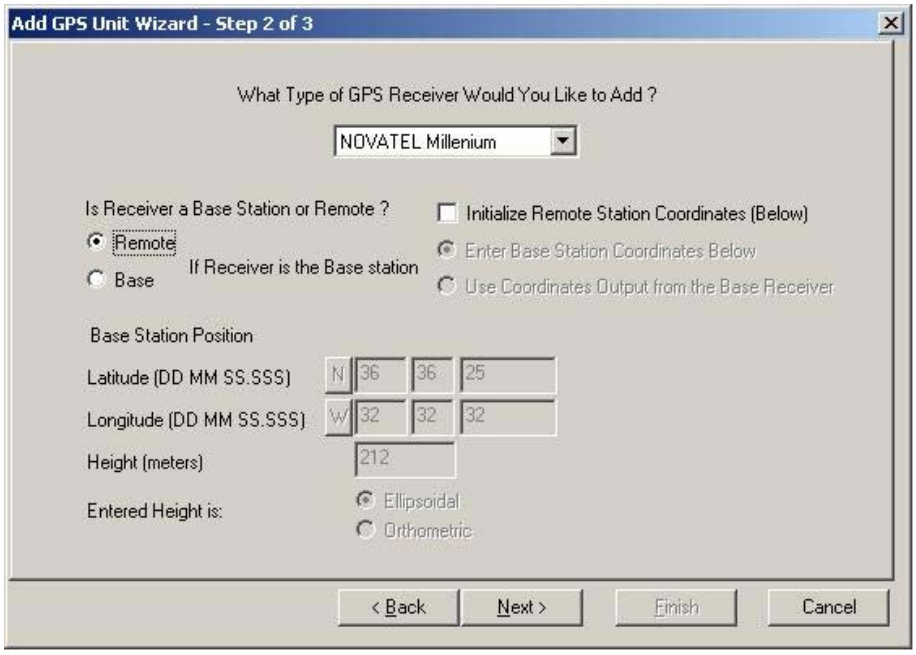


Figure 2.9: This is a Remote Receiver

A remote initialization can be performed here if the starting remote station coordinates are known. This can significantly increase the speed at which centimetre level positioning can be performed, and is especially important if the user is engaging RtStatic for deformation

monitoring applications (see Chapter 3 for more information on RtStatic). Orthometric heights can also be entered provided that there is complete geoid coverage of the area of interest. Refer to Section 2.3.10 for more information about geoids in RTKNav.

Step 7: Define the GPS Data Parameters

The next important step in configuring communication to this GPS receiver is to tell RTKNav whether the data will be kinematic or static, and whether you intend to log this data to hard disk, and at what data rate. It is also possible to configure either the primary or secondary GPS receiver comports.

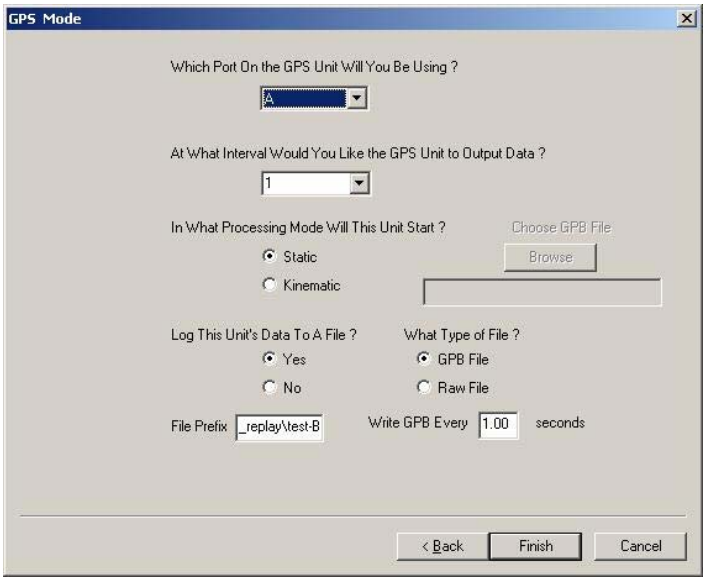


Figure 2.10: GPS Data Parameters

Figure 2.10 illustrates the final step in adding a GPS receiver. Some receivers have primary and secondary comports – A, B, C, or D. Data intervals can be as high as you wish. The dialog box does allow you to type a custom output data interval. Typical data intervals for real-time processing are from 1 to 10 Hz.

As previously mentioned, it is important to define whether the data will be static or kinematic in nature. Most applications will have static base stations but for moving baseline mode, define the base station data as kinematic. Also, for most applications, the remote receivers will also be kinematic. This is the default setting for remote units.

Finally, if you choose to log data to disk, it can be stored in either Waypoint's GPB binary measurement format, or it can be stored byte by byte as a raw file. The **GPB File** or **Raw File** modes may be useful if you plan to post-process the data for later analysis.

Click the **Finish** button.

Repeat **Step 3** through **Step 7** to add extra receivers (base or remotes) until you have finished adding and configuring all of your GPS receivers. Upon completion of this task, the dialog box seen in Figure 2.4 should look like that shown in Figure 2.11.

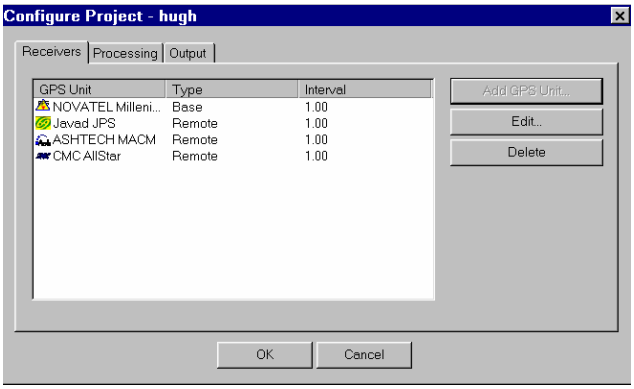


Figure 2.11: Base and Remote GPS Receivers have been added

2.1.3 Adding Output Ports

RTKNav allows you to send processed coordinate and quality information for each baseline out either a serial or network port. RTKNav also allows for multiple output ports, as well as so-called command ports. Command ports are two-way ports that an external user can utilize to receive data from and send commands to RTKNav. For instance, a user logged into a TELNET session will be able to start RTKNav from a remote location and send it a rich list of commands. In the following, however, we will limit the discussion to one output port.

Output ports send a combination of the following ASCII records out a serial or Ethernet port:

- $RTSOL,gpstime,R#,phi,lamda,ht,sdh,sdv,ve,vn,vh,nsats,S/K,qf,dd_dop,status
  status: 0-no solution, 1-single point, 2-DGPS, 3-RTK, 4-RTK(errors), 5-estimated RTK
- $RTSLE,gpstime,R#,phi,lamda,ht,sdh,sdv,ve,vn,vh,nsats,S/K,qf,dd_dop,status,F/L, CaRms,L1Rms
- $RTUTM,gpstime,R#,east,north,ht,zone,sdh,sdv,nsats,S/K,qf,dd_dop,status,F/L
- $RTSAT,gpstime,R#,nsats,prn1,elev1,az1,amb1,lock1,prn2,elev2,az2,amb2,lock2 ...
- $RTBIN,NBytes,hex values ....
- $RTSIO,gpstime,age,latency,num,M,time,nsats,R1,time,nsats,R2,time,nsats ...
- $RTKDC,gpstime,AllPF,ambPF,Rel,relPF,num_intersections
- $RTKAR,gpstime,R#,rms,rel,pass_fail(P/F),fltfixed,sec_used,sec_engaged,avg_sats, freq(S/D)

- $RTATT,gpstime,roll,pitch,heading,roll_sd,pitch_sd,heading_sd
- $RTVEC,gpstime,R#,east,north,up,sdhz,sdv,S/K,nsats,qf,status
- $GPGGA: see NMEA document
- $GPVTG: see NMEA document

A more complete description of these records can be found in Chapter 6 .

Step 8: Add an Output Port
To add an output port, go to *View* | *Project Configuration*, as seen in Figure 2.12.

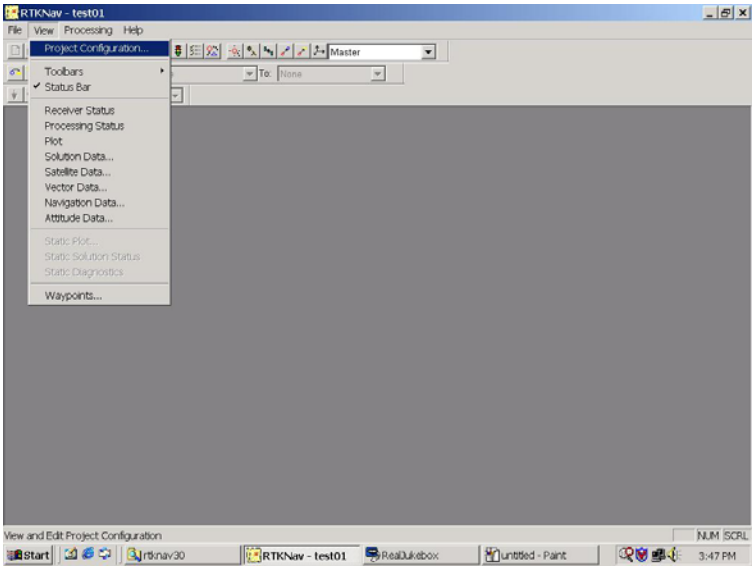


Figure 2.12: Starting to Add an Output Port

The *Project Configuration*, depicted in Figure 2.11, should appear.

To begin the process of adding the communication parameters for an output port, click on the *Output* tab. The dialog box shown in Figure 2.13 will appear.

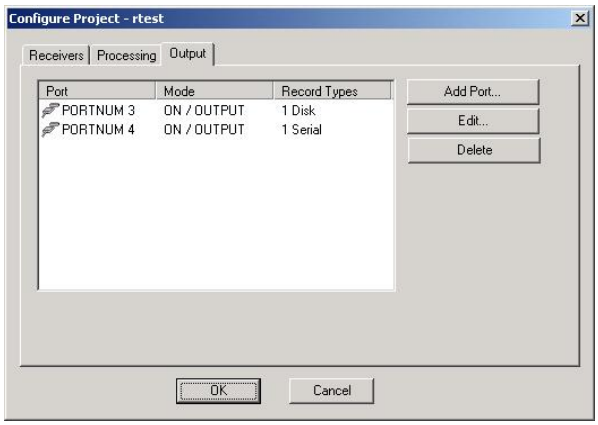


Figure 2.13: Output Data

Click on **Add Port…** to open the *Output Communication* window, shown in Figure 2.14.

Step 9: Define the Output Port Communications Parameters

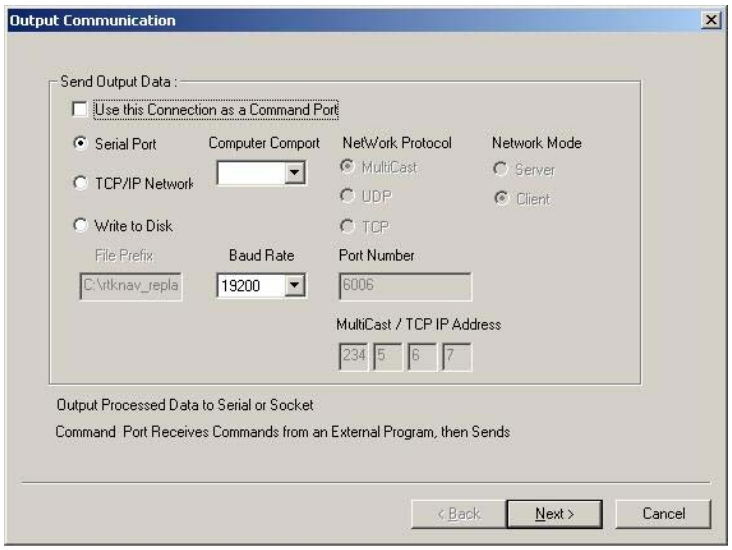


Figure 2.14: Sending Output Strings by Serial Port

You can choose to send the output ASCII data to serial or network ports, or to write to disk. If you choose write to disk, your output file will be saved in your working directory and will be given the same name as your project, with an optional file prefix. For more information regarding the other options in this window, please see the discussion on network protocols in Step 4.

There are some slight differences between sending and receiving data on Ethernet ports. To send data by network port, you must specify the IP address of the output destination. In the case of MultiCast, once again you must join a MultiCast group all on the same IP address defined between 224.0.0.0 and 240.0.0.0. UDP users on Win32 machines will have to use IP address 255.255.255.255. TCP users must know the IP address of their target computer, whether local or

wide area. For wide area networks, this is typically a static IP address. The network mode must also be set to client or server if TCP/IP mode is selected.

Clicking the **Next** button brings up the final step in the process.

Step 10: Select the Output ASCII Record Types
To add a selection of ASCII records for output, select a record type. Before clicking the **Add** button, be sure to select the interval on which you want this record outputted. See Figure 2.15.

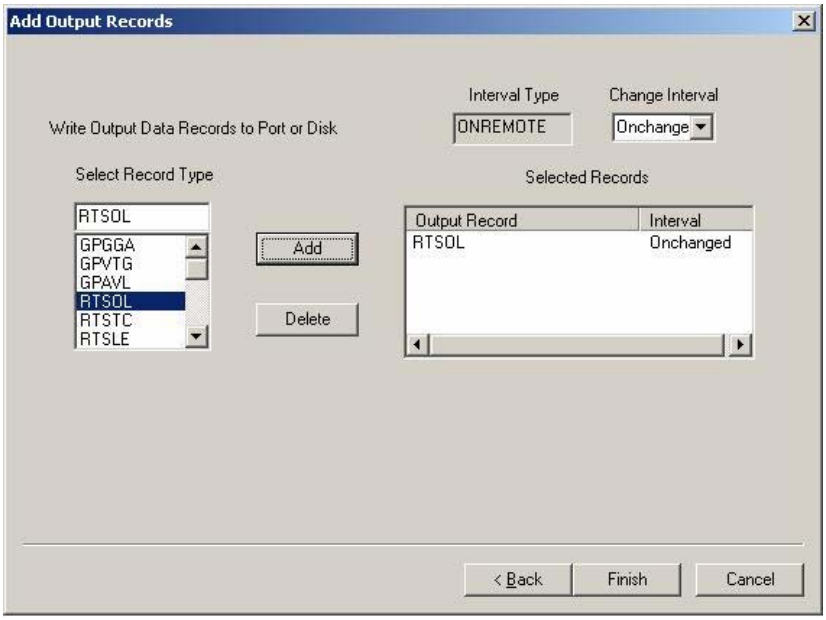


Figure 2.15: Sending Output Data by Network Port

Click the **Finish** button to complete the addition of your output port.

Section 2 Replaying Data in RTKNav

If a user has already collected GPS data in GPB format, they can relay it through the RTKNav processor to simulate the real-time processing. Some notes about replaying data in RTKNav:

- The GPB files must have overlap so that the base and remotes can be processed differentially. RTKNav can handle data gaps. If necessary use the *Concatenate, Slice and Resample* utility.
- There must be at least one valid ephemeris file (EPP file) that spans the entire period. Precise ephemeris files (SP3 files) cannot be used.
- Events in station files (STA files) are not used.
- Geoid undulations can be applied. See Section 2.3.10 for details on utilizing geoids in RTKNav.

To replay GPB files, start up a new RTKNav project by clicking *File* | *New Project*. In the project configuration window, click **Add GPS Unit**. In the *GPS Communication* window, select **Replay GPB File**, as shown in Figure 2.16 below. Click **Next**.

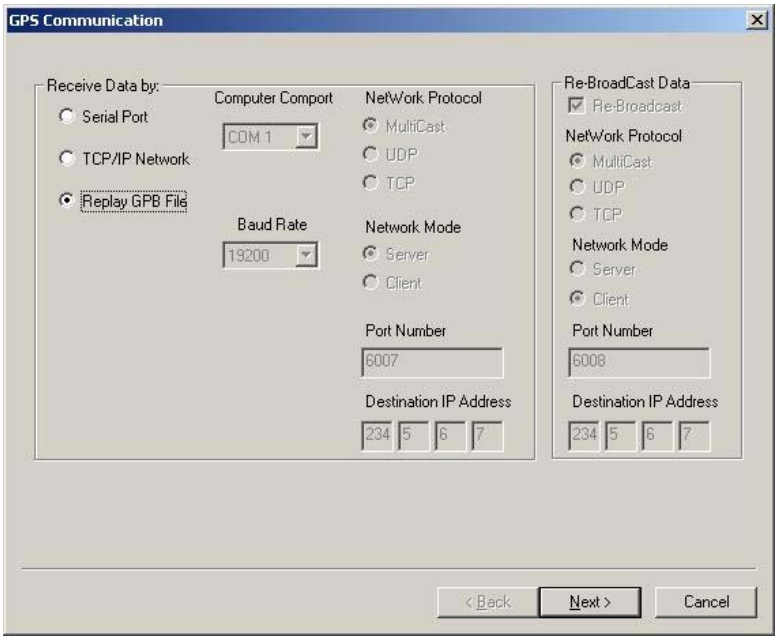


Figure 2.16: Replay GPB file setup

In the *Select GPS Type* window, identify the unit as either the master or the remote file, as shown in Figure 2.8 and Figure 2.9. Enter the base station coordinates if it is a base station, and specify the elevation value as ellipsoidal or orthometric. Click **Next**.

Finally, in the *GPS Mode* window, the user must locate the path of the GPB file and an appropriate ephemeris (EPP file) to go along with it. See Figure 2.17.

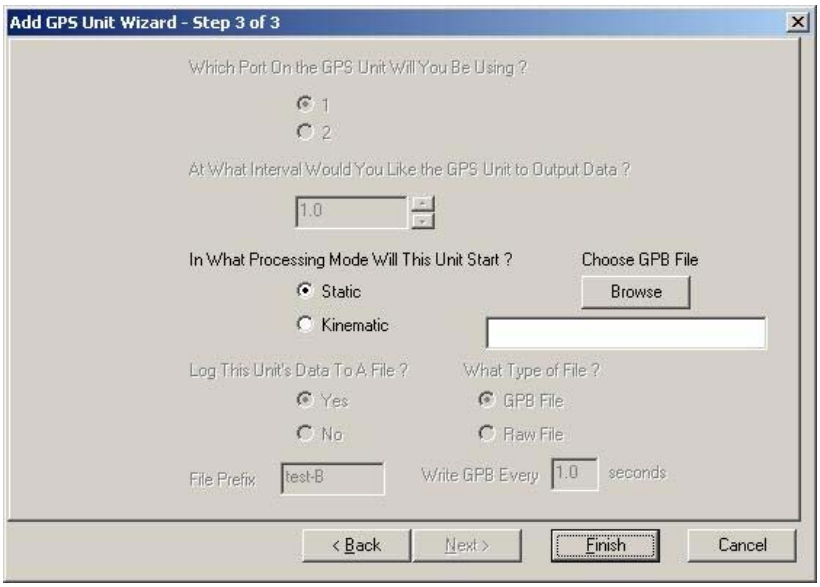


Figure 2.17: Locate the path of the GPB file

The user must also specify whether this data is static or kinematic for the receiver added. The user should also check the mode in *GPB Viewer* (see Chapter 4 Section 2) as well to make sure that the GPB file has the appropriate static/kinematic mode. Click **Finish**.

Repeat the process for the other GPB files to add them to the project. Once complete, the *Configure Project* window will look like that shown in Figure 2.18.

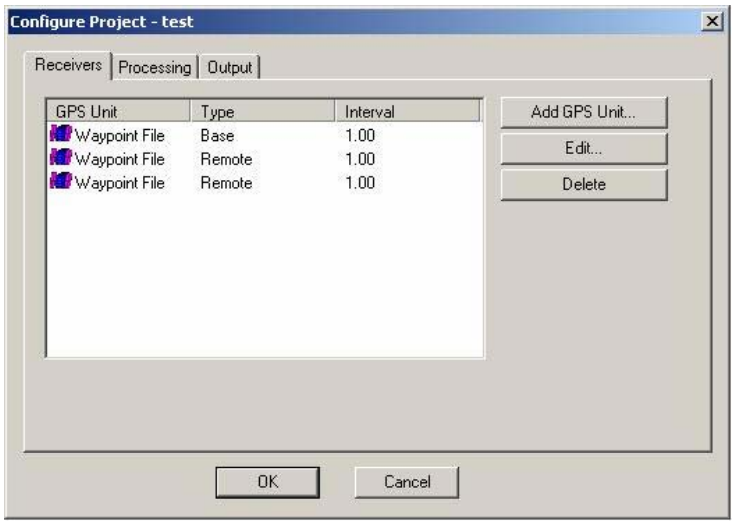


Figure 2.18: Replay GPB Files Project Configuration Window

Select the *Processing* tab and configure the processing options for the project. For more information on processing options, see Section 3 . Select the *Output* tab and define different methods/formats of output. For more information on outputting data, see Section 2.1.3 . The

number of data buffers must be increased when replaying data. Otherwise, the project will stop processing prematurely. See Section 2.3.4 for more details.

Section 3 Options

2.3.1 GPS Processing Settings

The processing engine that provides RTKNav with coordinate information is called RtGPsx.dll. RtGps.dll is capable of processing the following ways:

- **Float Code/Phase** – no ambiguity determination; accuracy: sub-metre to decimetre
- **On-the-Fly Ambiguity Determination** – kinematic ambiguity resolution (KAR) with code/phase measurements; accuracy: centimetre level. This can be invoked for either single or dual frequency measurements
- **Code-Only Processing** – accuracy: 1 to 5 metres

The default processing mode for RTKNav is single frequency float code/phase, with the base station being considered static and the remotes being considered kinematic.

Users may need to change these default settings if they wish to achieve any of the following:

- Dual frequency processing
- Use of on-the-fly kinematic ambiguity resolution
- Use of code-only processing
- If you wish to change the time allowed for which data must be received from all remotes before processing is allowed.
- Moving baseline processing
- Heading and pitch determination
- Use of RtStatic DLL for a fixed static solution

Step 11: Choose Your Processing Configuration
To view the *Configure Project* dialog box, go to *View* | *Project Configuration…* Then, to view the processing settings, click on the *Processing* tab. See Figure 2.19.

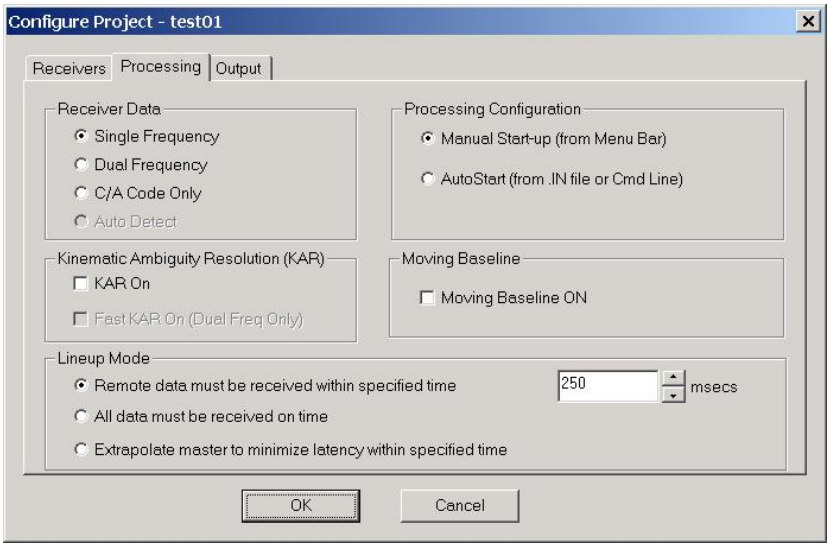


Figure 2.19: Processing Options

It may be worthwhile to explore each of the above processing options, given that they can be extremely important for some applications.

Receiver Data

Dual frequency measurements help KAR considerably, and permit the minimization of ionospheric effects**.** Therefore, if dual frequency receivers were used, it is beneficial to ensure this radio button is selected. Similarly, select **C/A Code Only** if a code-only solution is desired.

Kinematic Ambiguity Resolution

Check this box if you wish to resolve phase ambiguities on the fly. This is very important for users who require centimetre accuracy. This can be done for single or dual frequency receivers. Baselines should be as short as possible for optimal reliability; less than 4 km for single frequency and less than 10 km for dual frequency. More related options are available under *Processing | Options.*

Line-Up Mode

This setting has to do with the availability of the serial or network data coming from the remote GPS receivers. By default, the option **Remote data must be received within specified time** is selected and contains 250 msec by default. This means that RTKNav will wait up to 250 milliseconds to see if all the baselines are sending data. If any baselines fail to send their measurements in this time frame, RTKNav will compute positions for the baselines that did send data, and ignore the baselines for the remote receivers that failed to send data. Note that for users who are computing at 10Hz, this value must be 100 msec at most. For long-term projects, the default option should be selected.

The option **All data must be received on time** has a major disadvantage if you are in a project and one GPS receiver fails to send data. In this case, RTKNav

will not compute data for any baselines. If you expect some remote GPS receiver to go off-line for any reason, then use the default option.

For projects where the base station data arrives either very latent or at a lower interval, the **Extrapolate master to minimize latency within specified time** setting may be used. In such cases, the master station data will be extrapolated using time history information. For this option, the user defined option EXTRAPOL_EPOCHS may need to be added (see Section 2.3.7).

Processing Configuration By default, **Manual Start-up** is selected and should not be changed unless the user wished to run RTKNav from a DOS prompt. In such a case, select this option and run RTKNav from the command line like this: **RTKNav myfile.in**

Moving Baseline Ensure **Moving Baseline ON** is checked if you have a moving baseline application such as a ship-to-buoy(s) or airplane-to-airplane(s). In addition, moving baseline users should ensure that they have define their base station data as kinematic, not static.

2.3.2 Additional GPS Processing Options

The GPS processing engine RtGpsx.dll can be configured with a wide variety of commands. Some of these are very useful or even essential for some applications. Some applications that might require additional processing commands are:

- **Moving Baseline applications** – any ship to buoy(s) or airplane-to-airplane(s) applications will require the moving baseline option to be turned ON. In addition, moving baseline users should define their base station data as kinematic, not static.
- **Deformation analysis** – perform Kinematic Ambiguity Resolution (KAR) at given time intervals. New to version 3.11 is RtStatic, which computes fixed static solutions in near real-time.
- **Orthometric heights** can be computed real-time using a Waypoint Geoid file (WPG) using the geoid32.dll. The user can enter the base station coordinates in ellipsoidal height or orthometric height and have the output as ellipsoidal height or orthometric height.
- **Bad pseudoranges** can be rejected with the user command REJECT_PSR (see Appendix A Summary of Commands)

It should be noted that although the RtGpsx.dll Kalman filter can be commanded with a large number of options, most applications will be able to use the default options as set internally by RTKNav.

Moving baseline users are an important exception to this, as RTKNav must be told that you intend to use it in Moving Baseline mode. Please remember that once a IN and a CFG file have been created and saved, RTKNav will read and adopt all values in these files upon opening an existing project**.**

Step 12: Choose Your Processing Options
Go to *Processing* | *Options…* The dialog box shown in Figure 2.20 will appear.

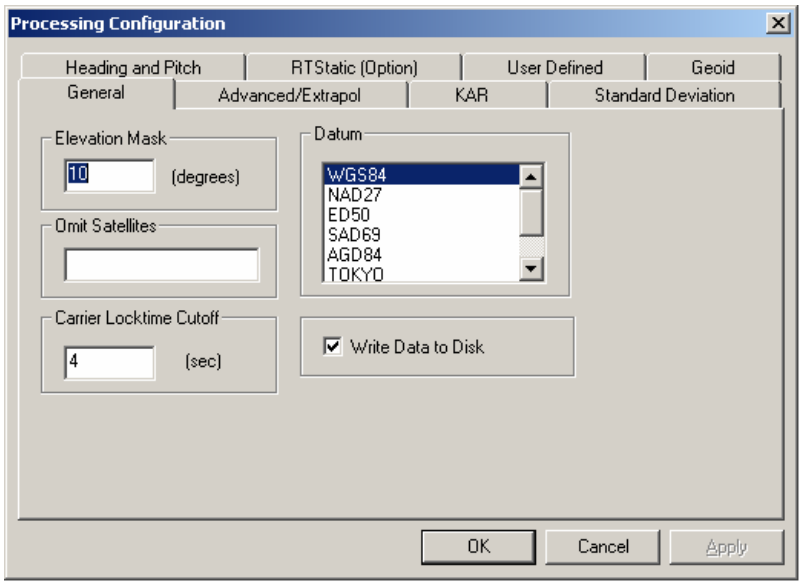


Figure 2.20: General Options

2.3.3 General Options

Elevation Mask — Satellites below this mask angle will be ignored. A 10-degree elevation mask is suitable for most kinematic applications. However, as baseline lengths increase, a 15-degree mask becomes more suitable, especially for monitoring applications.

Omit Satellites — This is a list of satellite PRN numbers to ignore. Multiple satellite PRNs must be separated by spaces. This option, while sometimes useful in post-processing for eliminating problematic satellites, is of little use here.

Datum — By default, the processing datum is WGS84. This processing datum also works well if base station coordinates are entered in NAD83. Otherwise, it is important to enter the base station coordinates in the selected datum.

Write Data to Disk — Only check this option if you wish to write an ASCII output file to hard disk. This file contains information about every epoch of data processed for each baseline. A more detailed explanation of this is given in a later section.

Carrier Locktime Cutoff — This value indicates the number of seconds of continuous carrier lock before the receiver's phase measurements are actually used by RTKNav. Most receivers, even those of reputable high quality, put out unreliable phase measurements for

the first few seconds after acquiring lock. Users who require very high accuracy may wish to raise this to 10 seconds.

2.3.4 Advanced/Extrapol Options

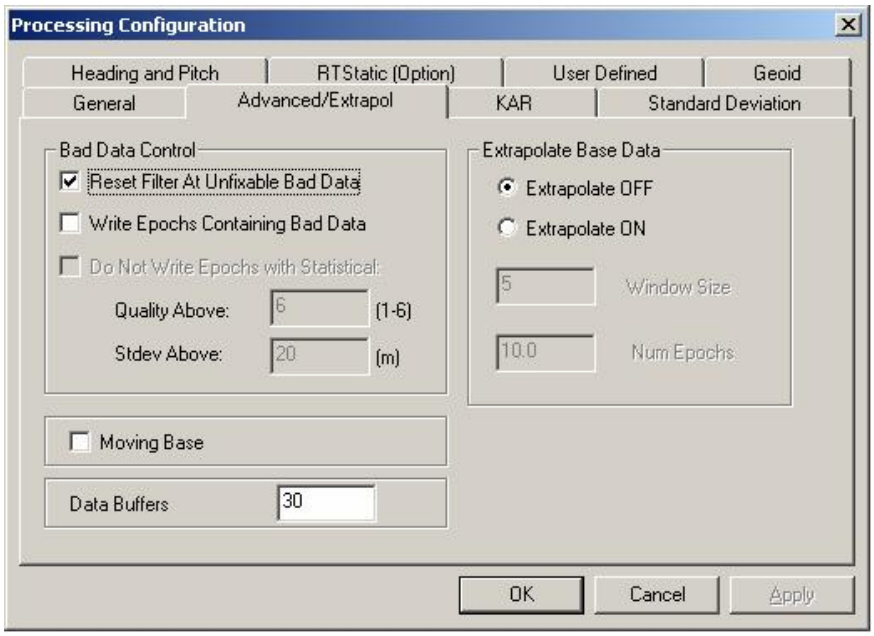


Figure 2.21: Advanced Options

Bad Data Control

Reset Filter At Unfixable Bad Data forces a Kalman filter reset if RTKNav is unable to fix bad phase or code measurements or loss of lock. It should be left on for most applications.

Write Epochs Containing Bad Data writes measurement epochs with bad DOPs to the OUT file. Normally, these outliers are just ignored by RTKNav. Some quality filters are adjustable via the **Stdev Above** and **Quality Above** boxes. This option can normally be ignored unless data analysis is required post-mission.

Moving Base Check this ON for moving baseline mode**.** If this box was selected previously in the *Configure Project* window, it will already be checked here.

Data Buffers This is the number of epochs of data that will be searched in order to line up base and remote receiver measurement epochs. It can normally be ignored. For most applications, 30 epochs is sufficient. However, if data rates and latencies are high, this number may need to be increased. For users replaying GPB files, this number must be increased, depending on how much data is being replayed. If the replayed data stops unexpectedly, the user must increase this number to allocate more buffers to be read.

2.3.5 KAR Options

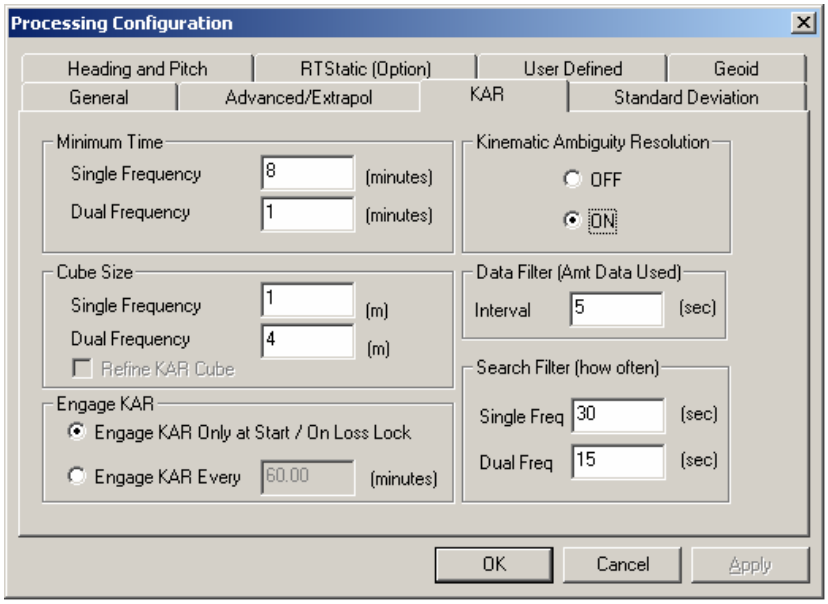


Figure 2.22: Kinematic Ambiguity Options

Minimum Time These are the length of times which RTKNav will perform float code/phase solutions before attempting to resolve ambiguities on the fly. Users in poor GPS environments may want to increase these times. The time needed for a dual frequency receiver to resolve ambiguities can often be lowered in good GPS conditions.

Cube Size These are the regions of space that will be searched for the correct combination of phase ambiguities. Decreasing these sizes reduces the likelihood of finding the correct intersection. However, increasing them will significantly increase KAR computation times. Normally, these options do not need changing.

Engage KAR Should the **Engage KAR Every *n* (minutes)** be selected, RTKNav will also engage upon loss of lock and at the start of the data. This option is preferable to many users in that it provides some level of protection against a bad KAR fix. If KAR calculates the wrong solution, it will be completely independently recomputed *n* minutes later. This is in contrast to the default option, in which it is only recalculated upon loss of lock.

Search Filter These are considered advanced options, and only need to be changed by users with experience using KAR. The KAR search interval controls how often KAR performs a search. By default, this is every 30 seconds for single frequency and 15 seconds for dual frequency. For specialized applications that need very fast ambiguity resolution, these values can be lowered.

Data Filter This data interval is how often KAR stores an epoch in memory. KAR will store up to the Maximum Time (e.g. 30 minutes) in memory for both the master and remote. Therefore, lowering this number will cause more memory to be used. It will also slow down processing. However, KAR solution times and reliabilities can be improved by lowering this value. The default value is 5 seconds, but users can see improvements by lowering the value to 1 second. Data sets that are improved tend to be those with "white noise" carrier phase characteristics. Carrier data sets that have very systematic errors tend not to see any improvements.

2.3.6 Standard Deviation Options

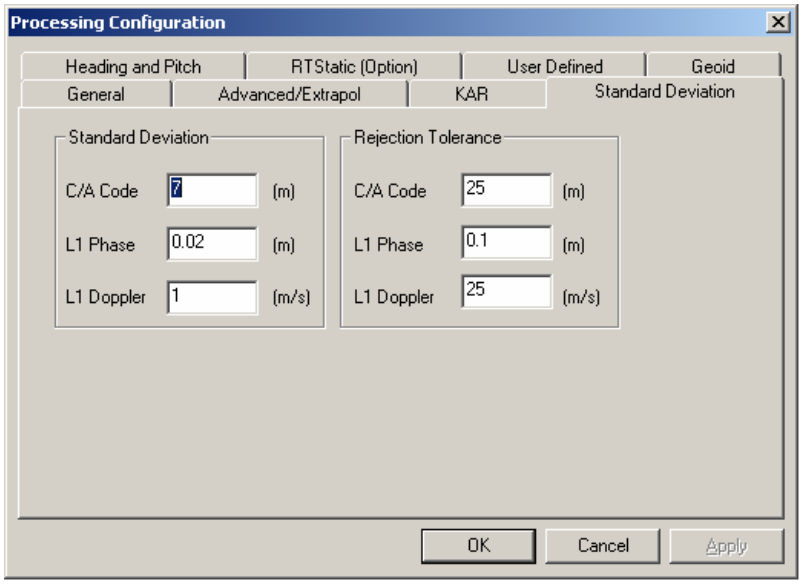


Figure 2.23: Standard Deviation Options

These indicate the a priori standard deviations applied that give weights to the various measurements used in the Kalman filter. The rejection tolerance values are used to determine when the filter should reset itself if it is not able to fix measurements that have post-filtering errors above the given tolerances.

Using realistic values for the code and carrier standard deviations will improve float solution convergence. For instance, many narrow correlator receivers have a C/A code measurement of 1 to 3 metres, which is much lower than the default value of 7 metres.

Normally, users do not have to change these values. In extreme GPS environments, it may be useful to give more weight to the code measurements and less weight to the phase measurements. Tracking sounding rockets is an example of this. These carry single frequency receivers to heights of 1000 km. Changing the phase to 0.20 m and the code to 2.0 m dampens the effects of uncorrected atmosphere on the phase measurements. Note that raising the L1 phase standard

deviation also requires a raising of the rejection tolerance (ratios of 4-to-1 or 5-to-1 normally work well.)

2.3.7 Heading and Pitch

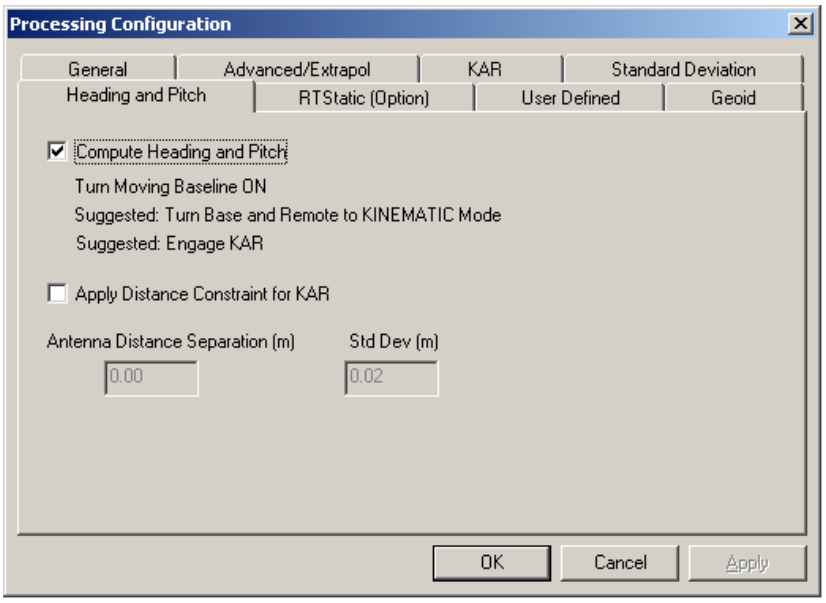


Figure 2.24: Heading and Pitch

Given a three GPS receiver configuration, RTKNav has the ability to compute roll, pitch and azimuth. If this option is selected, the following suggestions are listed:

- Turn Moving Baseline ON (via the *Advanced/Extrapol* tab)
- Turn Base and Remote to KINEMATIC Mode (via *View* | *Project Configuration…*)
- Engage KAR (via the *KAR* tab)

KAR needs to be engaged because successful ambiguity determination is essential in heading and pitch determination. KAR cannot engage unless the data is set to KINEMATIC, and the moving baseline option must be engaged, as typically the entire GPS antenna configuration will be moving simultaneously.

2.3.8 RTStatic Options

Aimed at near real-time deformation monitoring applications, RtStatic uses Waypoint's GrafNav processing engine to provide Fixed Static solutions in near real-time. Millimeter coordinate changes on slow moving features such as slopes or dams are obtained by filtering of the time history of the Fixed Static solutions.

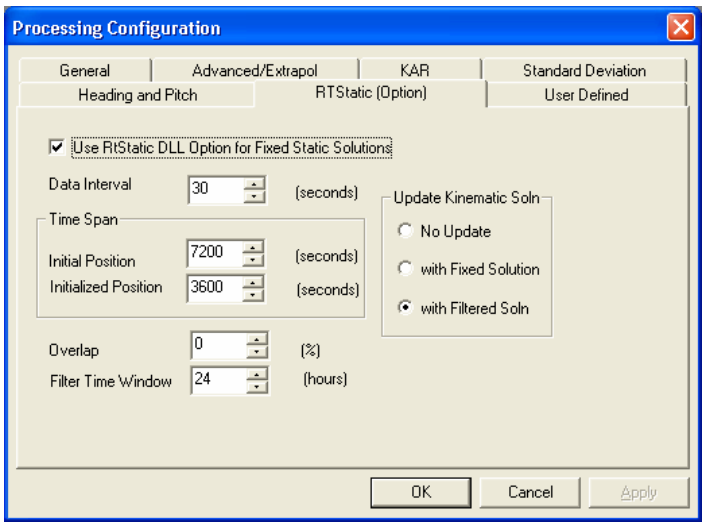


Figure 2.25: RtStatic Option

Data Interval This value indicates the processing interval used to calculate the fixed static solution. Thirty seconds is a good value, as it is not generally beneficial to process static data at a higher rate than this. Processing static data at a higher interval will often produce over-confident statistics, or cause an incorrect solution to pass when it would have otherwise failed.

Time Span The **Initial Position** time is the time that RtStatic will use to calculate the first fixed static solution. This solution is used as the benchmark from which all subsequent solutions are compared. Generally, this time should not be lowered, as the initial position should be computed as accurately as possible. Alternatively, if the coordinates of the remote receiver are initially known they can be directly entered when adding the remote receiver to the project (see Figure 2.9). All other fixed static solutions will be subtracted from this one to determine if slow movement is present. Therefore, it is imperative that the initial solution is correct.

The **Initialized Position** time is the amount of data that will be used to compute fixed solutions after the initial position. The default value is 60 minutes. Lowering this value too much can potentially cause erroneous fixes. Single frequency users may wish to raise this value under questionable GPS conditions.

Overlap This is the percentage of epochs that RtStatic will re-use from its previous solution in the solution of the next fixed static solution. This should generally be left at zero.

Filter Time Window This constant is the amount of time used in the low pass filter to smooth the results. Reasonable filter time constant values range from 12 to 24 hours.

2.3.9 User Defined Options

There are numerous commands that can be sent to RtGPsx.dll. The *User Defined* options are all listed in the dialog box below, along with help in the *Command Information* box. Review the attached Appendix for a description of the commands that be added. These are generally used to modify commands that are not normally used. See Figure 2.26.

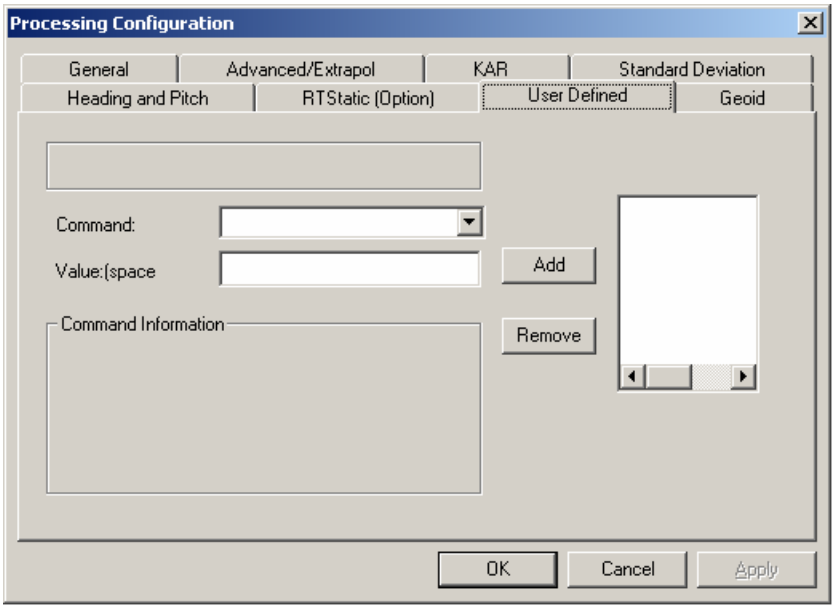


Figure 2.26: User Defined Options

ISSUE_KAR_TIME is an example of a user-defined command. This particular command is very useful in deformation analysis, where a static or near-static baseline must be continuously determined to high accuracy. This command forces RTKNav to re-do kinematic ambiguity resolution every *n* minutes. It is recommended for any users who wish to retain high precision for very long periods of time.

2.3.10 Geoid Options

This feature will allow the user to compute orthometric heights while processing real-time or when replaying a GPB file. It is important that the user has a valid WPG file that spans the area of interest so that the geoid height can be computed. See Figure 2.27.

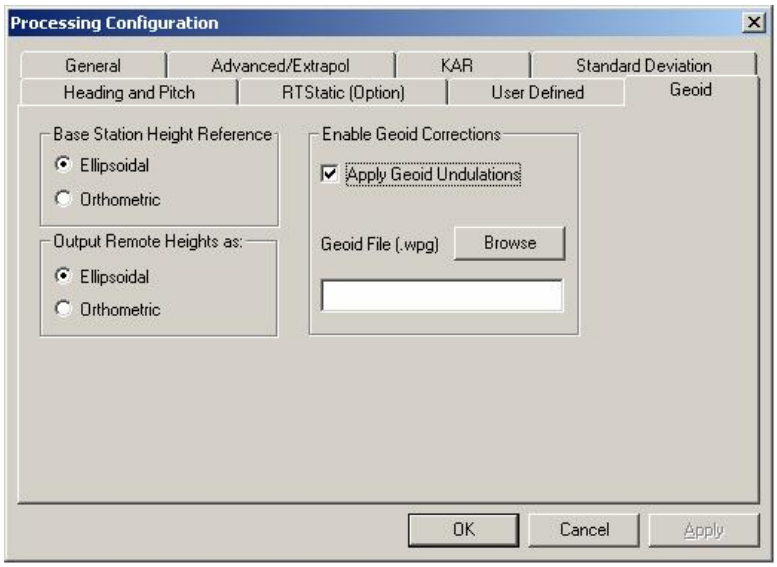


Figure 2.27: Geoid Options

Enable Geoid Corrections Enabling **Apply Geoid Undulations** will prompt RTKNav to calculate orthometric heights when processing. Click **Browse** to locate the path of the WPG file that RTKNav will use as a source of geoidal undulations. The file must span the area of interest. Otherwise, RTKNav will return an error.

Base Station Height Reference The user may select whether their base station coordinates entered were ellipsoidal height or orthometric height. See Figure 2.8.

Output Remote Height as The user can also specify the output for all the remotes as either ellipsoidal height or orthometric height.

Section 4 Real-Time Graphical Output

RTKNav provides a number of text and graphical displays which indicate the state of the program's communication parameters, the coordinates of the baselines and the state of the measurements with respect to each baseline. In addition, there are a variety of waypoint calculations and plots available for real-time high precision navigation to pre-determined points and boundaries.

2.4.1 Start Processing Real-Time Data

Assuming all of your serial and network connections have been made properly, RTKNav will start processing on *Processing* | *Start Processing* or click on the icon with the green circle, as shown below in Figure 2.28.

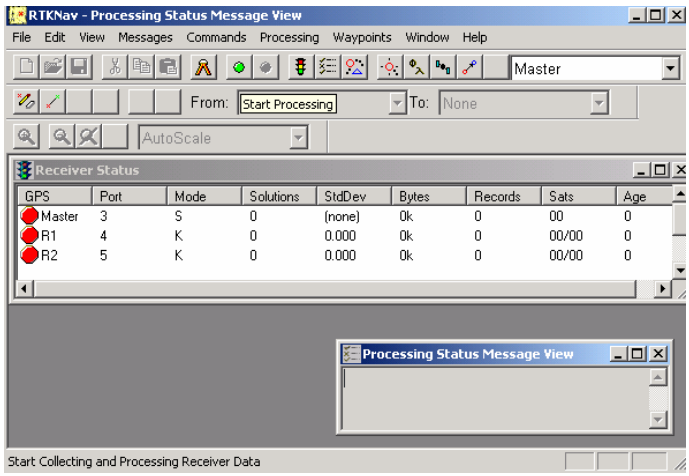


Figure 2.28: Start Processing Data

Note that prior to processing, the receiver icons are RED to indicate no data is being logged.

RTKNav will now send configuration commands to each GPS receiver at the baud rates you have chosen**.** If the GPS receivers respond to these configuration messages, the icons will turn YELLOW.

If RTKNav receives measurement data from all of the receivers and ephemeris data from at least one receiver, baseline solutions will begin to be computed. If a baseline solution has been successfully computed, the icons will turn GREEN as shown in Figure 2.29.

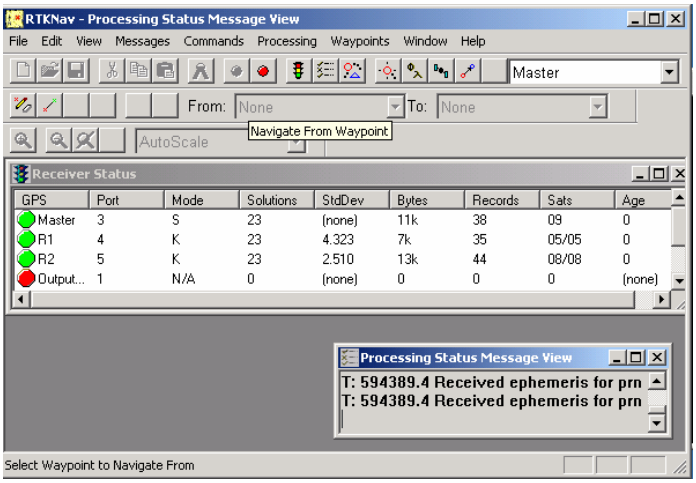


Figure 2.29: Successful Start-Up

2.4.2 Display Remote Coordinates and Satellite Info

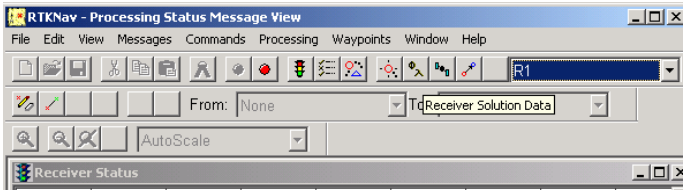


Figure 2.30: Prepare to Display Data for Remote #1

Note that in the toolbar image in Figure 2.30, we have selected **R1** in the list box. We then hit the **Receiver Solution** tool button. The resulting text box is displayed in Figure 2.31.

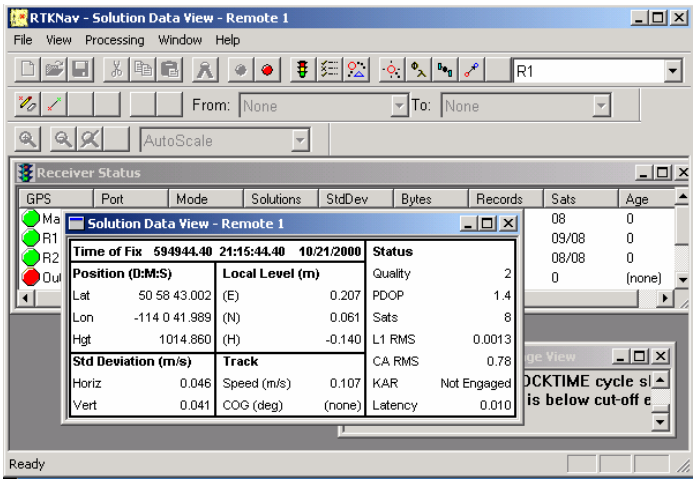


Figure 2.31: Coordinates Remote baseline #1

Coordinates of the above include latitude, longitude and height of the remote antenna, as well as delta east, north and up with respect to the base station. In Moving Baseline mode, only the Local Level coordinates are meaningful and of high accuracy due to the nature of relative positioning.

We can also display locktime, azimuth and elevation information for each baseline as depicted in the next set of images.

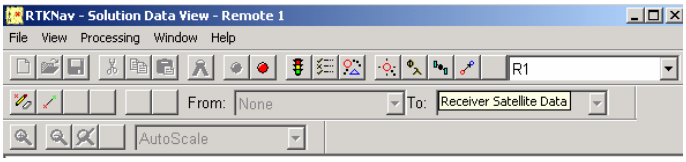


Figure 2.32: Prepare to Display Satellite Info on Remote Baseline #1

Again, note that R1 has been selected in the list box and the **Receiver Satellite** tool button. These choices add the following text display to the screen, seen in Figure 2.33.

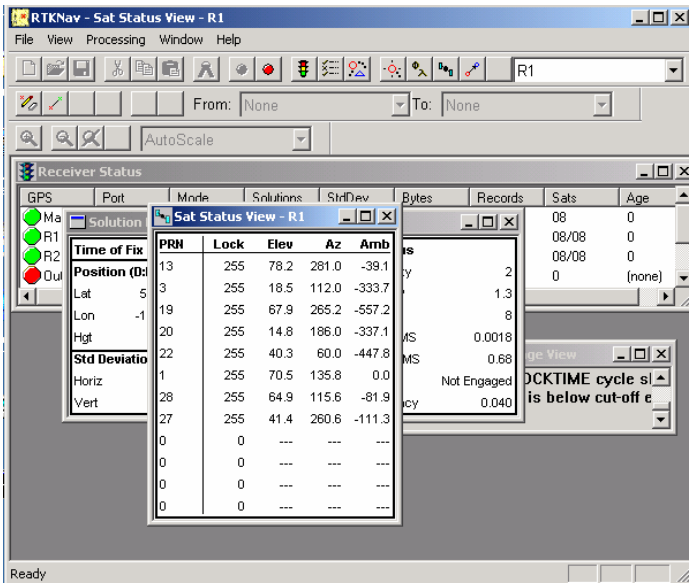


Figure 2.33: Satellite Info Display

In the list box seen above, the azimuth and elevation of the satellites are shown. Of importance in kinematic surveys are the lock values**.** Here, the lock number goes to 255 and stays at this value until phase lock is lost. If lock is lost on any satellite, the lock value goes back to zero and begins to count up with time. In dynamic surveys, the lock values are an important quantity to observe as accuracy depends on continuous phase lock being maintained.

2.4.3 Position Plots of Base and Remotes

Activate the *Plot View* window via *View* | *Plot* or clicking on the **Position Plot** tool button**.**

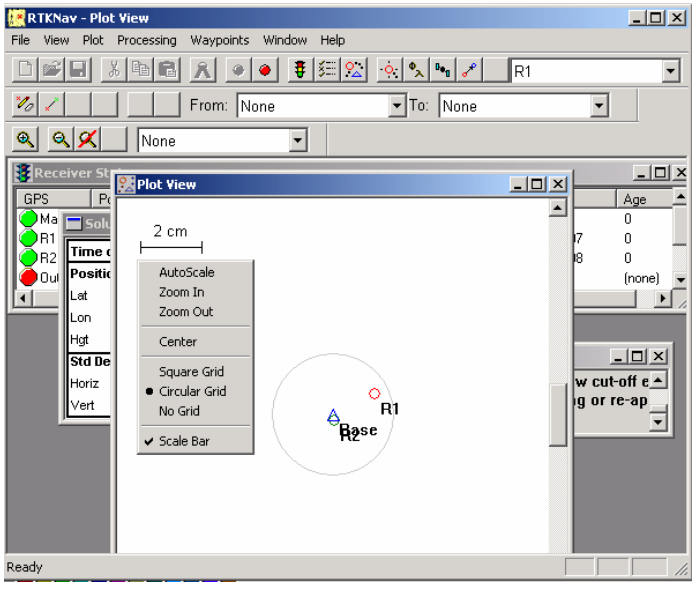


Figure 2.34: Zoomed In Plot View of Base, R1 and R2

To bring up the floating menu**,** right-click on the *Plot View* window. You will note that the above is really a zero baseline, with a scale of 2 cm. The base, R1 and R2 are really computing data from the same antenna. The variation in coordinates is just receiver noise.

Right-clicking with the mouse on the symbols in the plot window brings up a menu that allows you to edit the properties of the symbols as seen in the two images below.

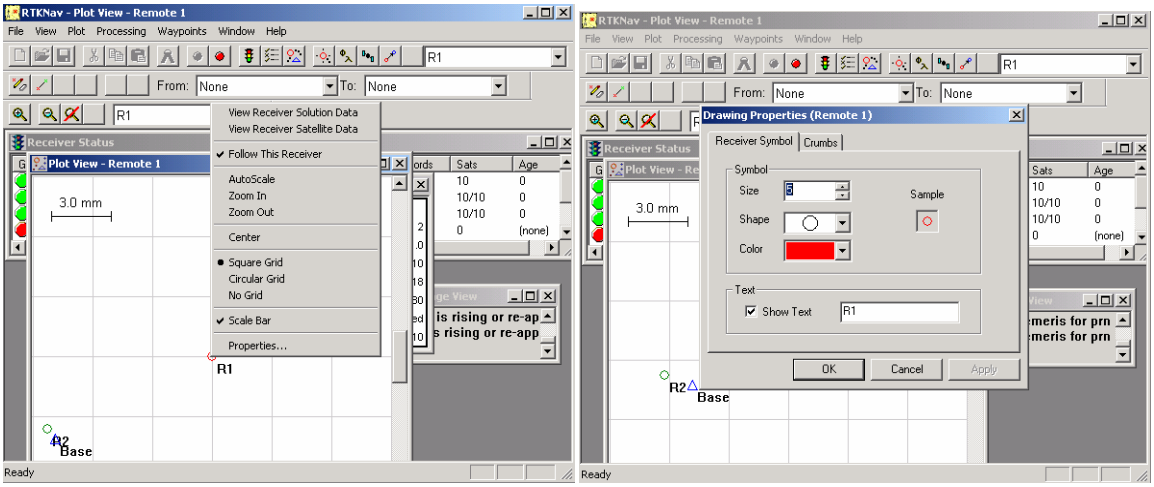


Figure 2.35: Changing Properties of the Plot Symbols

Section 5 Waypoint Navigation

2.5.1 Defining Waypoints and Boundary Plots

RTKNav allows you to load a list of waypoints and/or enter and edit waypoints interactively. These are pre-determined points that you may wish to navigate to or alternately avoid in real-time. Another use in deformation monitoring might be to inspect visually the movement of an antenna in real-time with respect to the a priori coordinates of an object.

Boundaries can be defined by choosing certain waypoints as vertices of a polygon**.** Waypoints can be:

- Loaded from a simple ASCII text file
- Edited interactively
- Marked in real-time

2.5.2 Loading Waypoints from the Menu

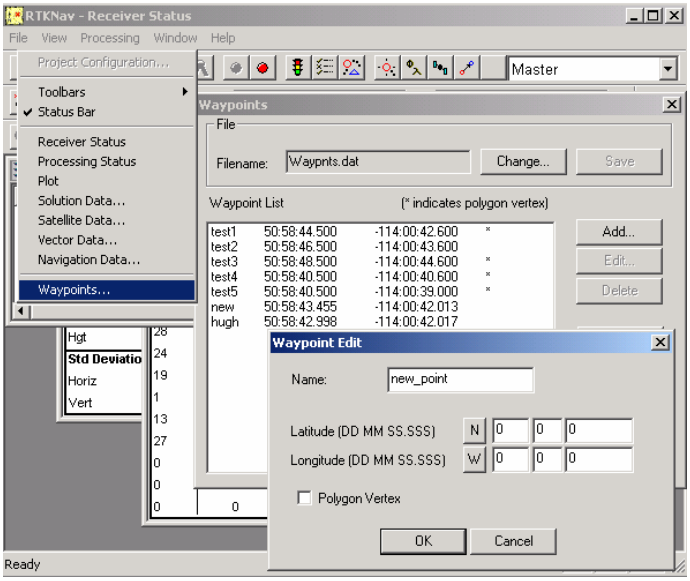


Figure 2.36: Waypoints Loaded from the Menu

Figure 2.36 shows what occurs on selecting the *View* | *Waypoints…*. In this case, a simple waypoint file called WAYPNT.DAT has been loaded from the hard disk.

Waypoint files have the following format (WAYPNT.DAT is used as an example):

Name latitude (degrees minutes seconds) longitude (degrees minutes seconds) *(optional)

test1 50 58 44.500000000009 -114 0 42.599999999982,*
test2 50 58 46.500000000016 -114 0 43.599999999998
test3 50 58 48.499999999997 -114 0 44.600000000065,*
test4 50 58 40.499999999996 -114 0 40.600000000001,*
new 50 58 43.455012698966 -114 0 42.012714166015
hugh 50 58 42.998050950986 -114 0 42.017246776385

Note that the ***** is used to designate the vertex of some point defining a boundary**.** RTKNav will join these points with lines to indicate boundary limits, provided the waypoints are actually points on the boundary that you are interest in. An example might be the limits of an airplane test range. This boundary could be used for range safety purposes.

2.5.3 Displaying Waypoints

To display the waypoints that you have loaded or added, select *View* | *Plot* or click on the **Plot Position** tool button, as shown below in Figure 2.37.

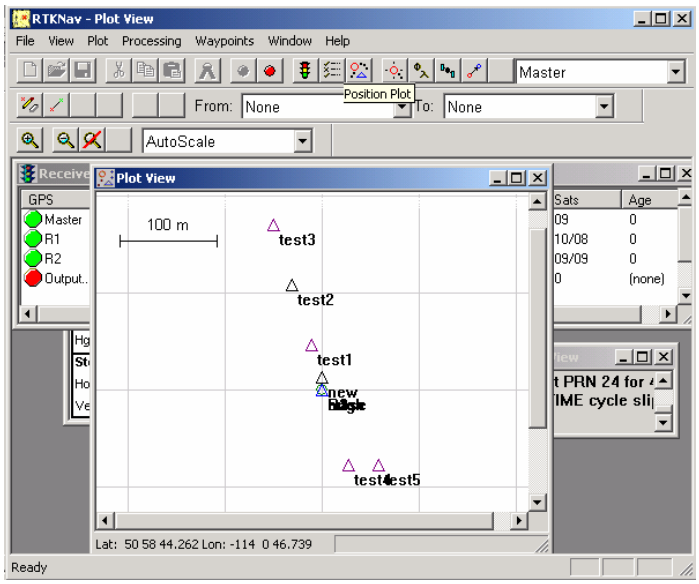


Figure 2.37: Displaying Waypoints in the Plot Window

After displaying your waypoint list in the *Plot View* window, you can also join any two lines in the above plot or you can define boundary vertices and join any polygon defining the boundary. Be sure to enter your polygon vertices in order to define the boundary plot correctly**.** To define a boundary plot make sure that a * follows the longitude entry in the waypoint file. See Section 2.5.1 .

2.5.4 Displaying Boundary Lines in the Waypoint Plot Window

Displaying a boundary consists of joining the points defined as polygon vertices in the waypoint list. This can be done via *Waypoints* | *Connect Polygon Points*. See Figure 2.38**.**

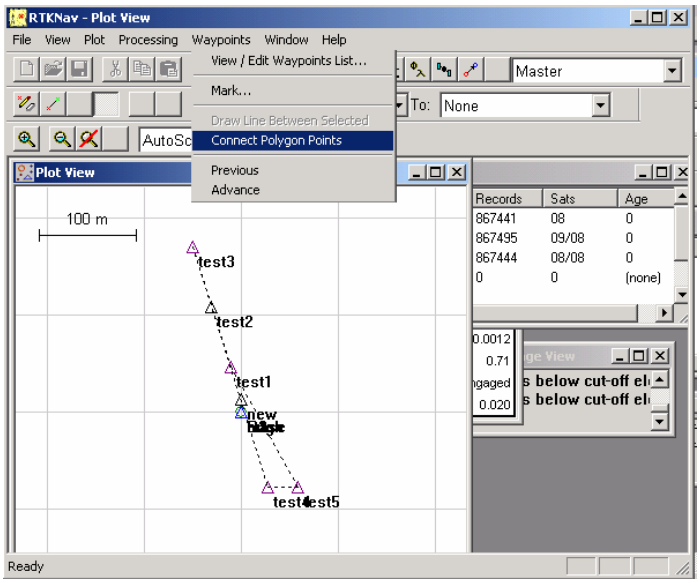


Figure 2.38: Joining Polygon Vertex Points in the Waypoint List

You now have defined a boundary using your current waypoint list. Similarly, any two points can be joined via *Waypoints | Draw Line Between Selected***.**

2.5.5 Marking the Current Remote Point as a Waypoint

If you are interested in marking points as you go, you may mark the current remote receiver position as a new waypoint. This may be useful, if you want to save the coordinates of any particular point for some reason. Again, use the *Waypoints | Mark…* as shown in Figure 2.39.

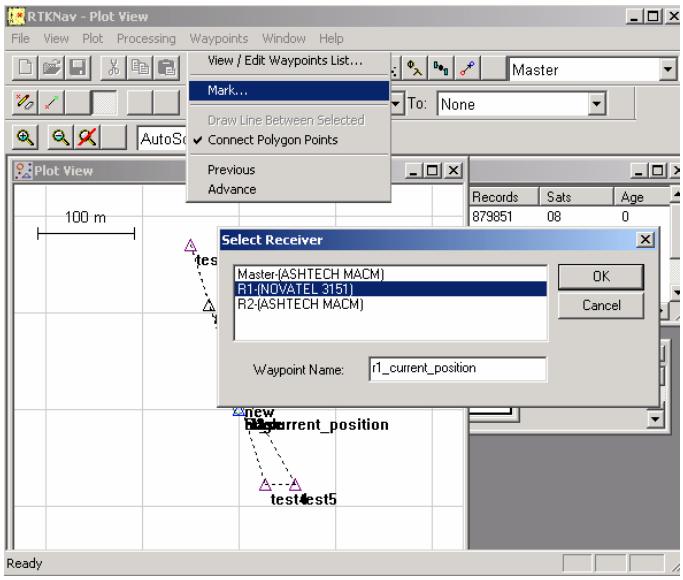


Figure 2.39: Marking a Point

In the figure above, it can be seen that R1_CURRENT_POSITION is now defined as a waypoint and plotted.

Section 6 RTKNav - FAQ

The following FAQ (Frequently Asked Questions) describes some problems or questions a typical user may encounter while learning how to use RTKNav for data collection and real-time processing.

Q: How do I toggle the static/kinematic flag for receivers when processing in real-time?
A: In the Receiver Status window, right-click on the desired receiver and select static or kinematic from the pop-up menu.

Q: How do I change the project so that the master station is moving?
A: To use the moving baseline option for processing your GPS Data, go into the Processing > Options menu and into the Advanced tab options. The moving baseline option is the second option in this window.

Q: How do I know if my receivers are collecting data?
A: The red lights in the receiver status window should turn from red to yellow to green when everything is working properly, and you should also be able to see that the receivers have locked onto satellites in the Satellite Data View windows. If in doubt, you can always use wlog.exe and test to see if your receivers and serial cables/COM ports are connected properly.

Q: I chose the wrong settings in the project and/or processing configuration. Is there any way to change the options while processing?
A: At this time, changing the configuration options while processing has been disabled.

Q: Should I be modifying the standard deviation and KAR (Kinematic Ambiguity Resolution) options and tolerances?
A: In general, it is not recommended that you change the default options for these two groups of options since RTKNav is designed to reset the filter when data is really bad. It is suggested that these options only be changed during post-processing in software like GrafNav, unless you have a-priori information about your data.(e.g. you know your C/A code measurements will be good)

Q: What happens if I start processing, stop, and then start again? Will my files be appended or overwritten?
A: Upon restarting processing, your raw GPS data files (in .gpb format) will be overwritten. Unfortunately, the Receiver Status will show that the total number of epochs recorded is the amount from the previous processing plus the current number of records if you start, stop, and restart processing. It is definitely not recommended to try this since RTKNav has and might crash if you restart processing.

Q: Why am I getting the following error message, "Error: Hardware key not found, check printer port"?

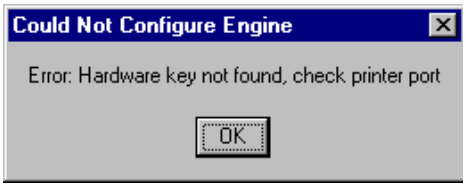


Figure 2.40: Hardware key not found error

A: A number of things can cause this error message. It cold be that your hardware lock is not in the printer port, your hardware key is loose and not properly connected in the printer port, the hardware key has not been burned properly, the hardware lock drivers are not installed, or the hardware lock is faulty. If you are getting the error message and your hardware key is properly connected to the printer port with the proper drivers installed, please contact the Waypoint Products Group, NovAtel Inc. for information.

CHAPTER 3 RTSTATIC

Section 1 What is RtStatic?

Waypoint has added a major new feature called RtStatic to its RTKNav real-time kinematic processing package. This option is aimed at near real-time deformation monitoring applications.

RtStatic uses Waypoint's GrafNav processing engine to provide Fixed Static solutions in near real-time, while the standard RTK engine produces kinematic real-time solutions on a per epoch basis. Filtering of the time history of the Fixed Static solutions produces millimetre level coordinate changes on slow moving features such as slopes or dams.

Simultaneously, the standard kinematic engine processes the same data in real-time to monitor fast moving events in standard kinematic fashion. On short baselines, single or dual frequency receivers can be used with similar precision. Up to 20 base/remote combinations can be processed on the same computer platform. Raw input or processed output data can be transferred in real-time over serial or network connections.

Additionally, users have the ability to rebroadcast data collected in real time over a network or over the Internet, thus allowing other instances of RtStatic on other computers to process all, or a subset of the data that you are processing. Additionally, data can be rebroadcast so that other instances of RtStatic on the same computer can be used to process a subset of the data.

Section 2 Getting Started

To use RtStatic in your RTKNav project, simply ensure the following box is checked in the processing options:

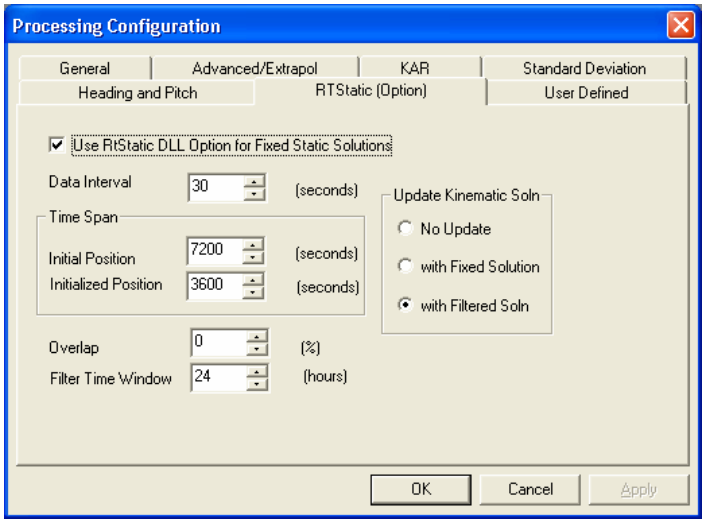


Figure 3.1: RtStatic Option

It is *essential* to the proper functioning of RtStatic that a correct fixed solution is initially obtained. This is important as all subsequent fixed static solutions are differenced with the initial position in order to determine if gradual motion is present in the remote antenna. This is why be default two hours of data is used to compute the first fixed solution, and one hour of data is used to determine all subsequent solutions.

Depending on the length of baseline, the type of processing used (single or dual frequency) and the surrounding GPS conditions (presence of large treed sections, buildings, or other obstructions) users may wish to increase or decrease the initial position time, however decreasing this time is generally not recommended.

RtStatic filters the hourly fixed static solutions with a 24-hour filter time window in order to graphically display the apparent movement of the remote receiver relative to the base. Only the fixed static solutions that pass the statistic tests (RMS and reliability) are used in the filter. The kinematic solution is updated with the filtered solution in order to increase the accuracy of the kinematic solution. This will help to show very accurate kinematic results in the event of sudden movement in the roving receiver. This feature especially useful in relatively long (> 3 km) single frequency data sets in which KAR may have difficulty reliably resolving ambiguities on the fly.

If known a priori to the survey, the coordinates of the remote receiver can be directly entered when adding the remote receiver, as shown below. This dialog first appears after selecting **Add GPS Unit** after creating a new project.

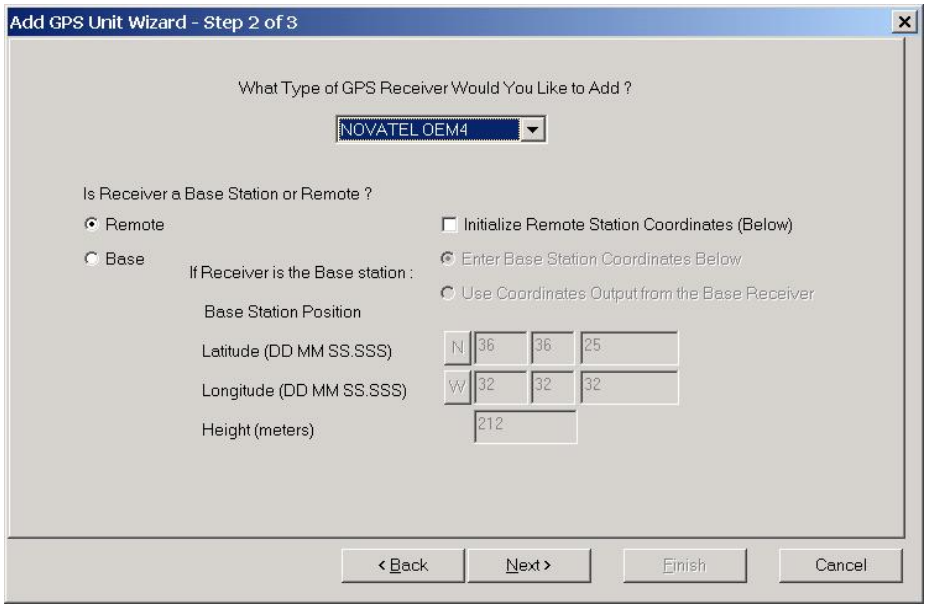


Figure 3.2: Initializing Remote Coordinates

For more information on the options shown in Figure 3.1, refer to section 2.3.8 .

Section 3 Using RtStatic within your RTKNav project

Provided the RtStatic option has been correctly selected as shown in Figure 3.1, there are three main windows of interest, all found in the *View* menu:

- Static Plot…
- Static Solution Status
- Static Diagnostics

A description of each of these windows follows.

3.3.1 Static Plot

When *View* | *Static Plot* is selected, you are first prompted for which remote you want to plot. Upon choosing your desired remote, the following dialog appears:

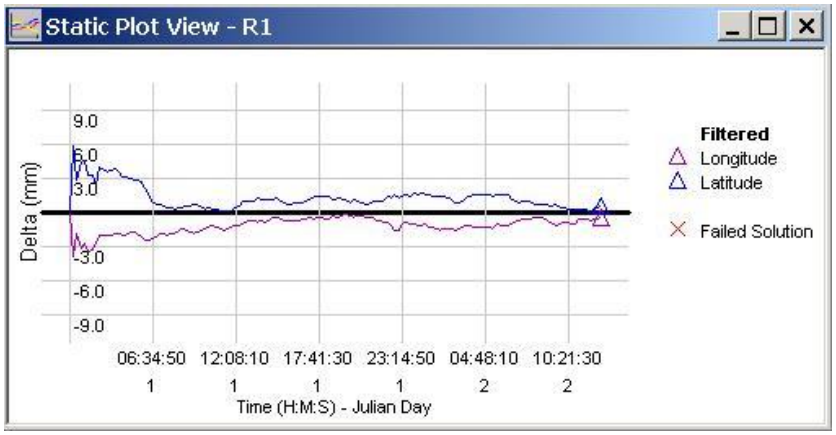


Figure 3.3: Static plot of R1

The values from this graph are obtained from differencing fixed static solutions at 15-minute intervals (by default) from the initially computed solution. This graph therefore shows the *difference*, or apparent movement in the remote antenna over time with respect to it's initial position.

In addition to the failed fixed static solutions, this plot shows (by default) filtered east and north coordinates. For analysis purposes these are the best indicators of movement in the antenna, as the height coordinate is typically determined with less accuracy than the horizontal coordinates.

The filtered coordinates are obtained after a low pass filter is applied to the passed fixed static solutions. The failed fixed static solutions are immediately rejected and are not used in this filter. This serves to "smooth" solutions that do not follow the trend of neighboring points, thus providing a better indication of overall receiver movement.

The user can plot a variety of other values by right clicking on the graph shown in Figure 3.3. After doing this, a properties dialog box appears with two tabs:

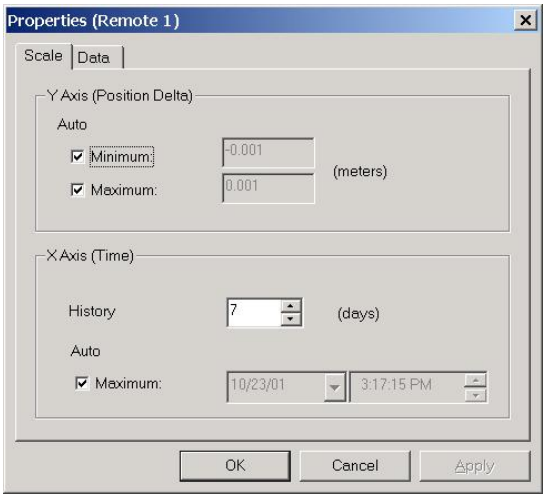


Figure 3.4: Scale Tab

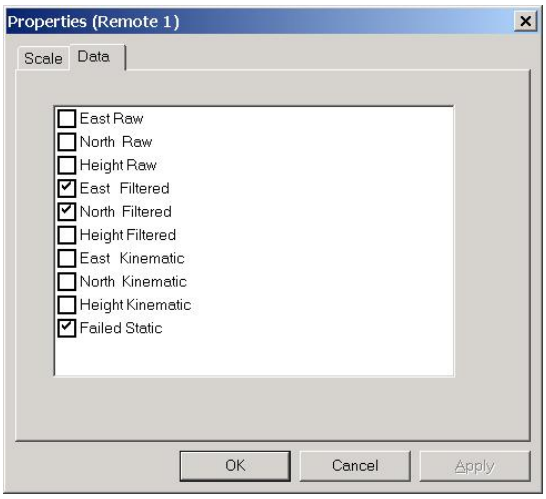


Figure 3.5: Data Tab

The above two Figures show the default values of both tabs. As shown, the X and Y scales of the graph can be adjusted on the scale tab, and the plotted data can be changed in the data tab. Plotting the raw data simply shows the data before the low pass filter is applied. This plot will be much nosier and thus much harder to interpret, especially in height. Plotting the kinematic solutions will simply show the current kinematic solution, obtained by the standard RTKNav processor. This solution, while unreliable to determine very gradual movement over extended periods of time, will show relatively fast movement (or apparent movement) in real time. However due to the nature of this solution it is subject to much more noise and residuals from epoch to epoch can be large.

As an example of the effectiveness of the low pass filter at removing noise from the plot, look at the following plot that shows both the unfiltered height (rough line) and the filtered height (smooth line) on the same graph:

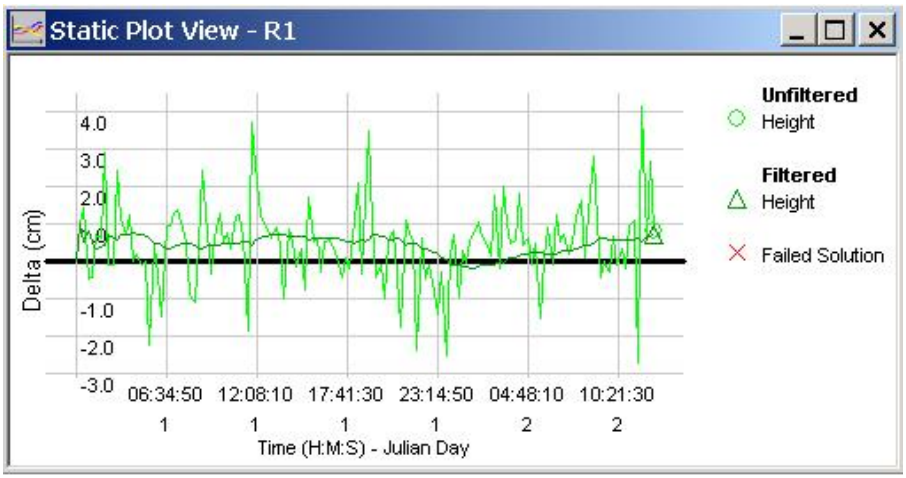


Figure 3.6: Filtered and Unfiltered data

The filtered value removes large spikes and better shows the general trend of the data.

3.3.2 Static Solution Status

This window simply provides a summary of the last fixed static solution for each remote. The fields shown in the summary are:

- Time/Date
- Latitude
- Longitude
- Height
- Horizontal Standard Deviation
- Vertical Standard Deviation
- RMS
- Reliability
- Status

As a rule of thumb, standard deviation values are typically over-optimistic by about a factor of 3 to 5. The RMS value indicates how well the solution "fits". The maximum allowable RMS value is 0.025m + 1PPM for dual frequency and 0.015 + 1PPM for single frequency. The reliability is obtained by dividing the second best RMS solution by the best RMS solution. This in effect tells you how much better it is than the next likely solution. It is therefore desirable for this number to be as high as possible. In GrafNav, the minimum allowable reliability is 1.35. The status field simply indicates if the solution passed or failed. Longer baselines typically fail because of RMS rejection and shorter baselines because of reliability failures.

3.3.3 Static Diagnostics View

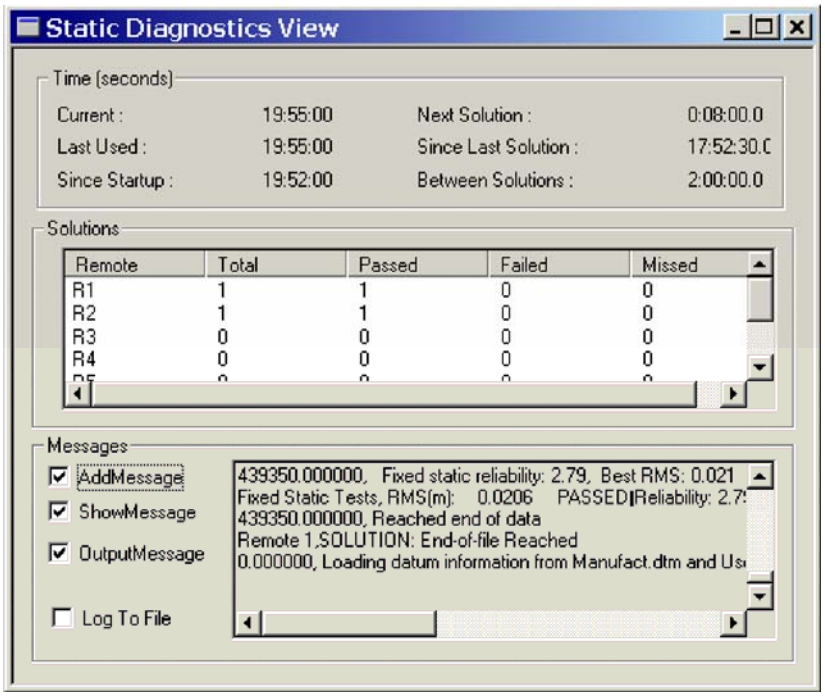


Figure 3.7: Static Diagnostics View

This above dialog summarizes some important information about the status of RtStatic. *Current time* is the current GMT time as read from the raw GPS data. *Last Used* indicates the last epoch used by RtStatic in computing a fixed static solution. For example, if the raw data is collected at 1 Hz, the current time will increment by 1s, however the *Last Used* field will only increment on 30 second intervals as the fixed static solution uses a processing interval of 30 seconds (default).

Since Startup indicates the length of time since RtStatic has been engaged. *Next Solution* is a timer that counts down to when the next fixed solution will be calculated. *Since Last Solution* counts up from the time of the last successful fixed static solution. *Between Solutions* is the interval between fixed static solutions (15 minutes by default).

The solutions box in Figure 3.7 summarizes the number of total, passed and failed solutions. There are three kinds of messages that can be displayed to the screen, and if desired logged to a file. These are *Add*, *Show*, and *Output* messages.

Selecting *Add* messages will display information regarding base satellite selection, tropospheric model used, number of ephemeris files used, type of processing (GPS only or GPS+GLONASS) etc. Selecting *Show* messages will display the fixed static solution statistics such as the RMS, reliability, and the status (passed/failed). Selecting *Output* messages will display any error messages that can be helpful in determining the cause of a processing failure, should it occur. *Log To File* will log the error messages displayed on the screen to an ASCII file with the same name as your project name and a SLG extension.

CHAPTER 4 UTILITIES

Section 1 GPS Data Logger (Windows)

Waypoint provides a WIN95/98/2000/NT data logger that currently supports NovAtel, Trimble, Ashtech, Parthus, Javad, Ublox, Rockwell, CSI and Marconi receivers. The data logger configures the GPS receivers, logs the measurement data and converts it into Waypoint's GPB/EPP (measurement/ephemeris) format. Adjunct features include waypoint navigation as well as satellite and scatter plot capabilities. In addition, stations and events can be marked and written to STA files compatible for post-processing by GrafNav/GrafNet.

The data logger is shipped with it's own device driver for WIN95/98 users. This driver is called WPCOMM.VXD and should be placed in your WIN95 System Directory or in the current directory from which the data logger runs. On Windows 2000/NT machines, the data logger uses the 2000/NT device driver.

4.1.1 Getting Started

To begin collecting data with WLOG, simply use the *New Project Wizard* by selecting *File* | *New Project*. Setting up a new project with the *Wizard* consists of the following steps:

1) Choose *File* | *New Project*.

2) Type in a project name, if you wish to store data to disk. The project file stores information on the various settings used for logging data. Click **Next**.

3) Select the appropriate receiver type.

4) Select a data interval at which to record data.

5) Select the appropriate Receiver COM Port.

6) Check the **Request Camera Marks** box if you want camera marks. Note this option is only available for certain NovAtel and Ashtech receivers.

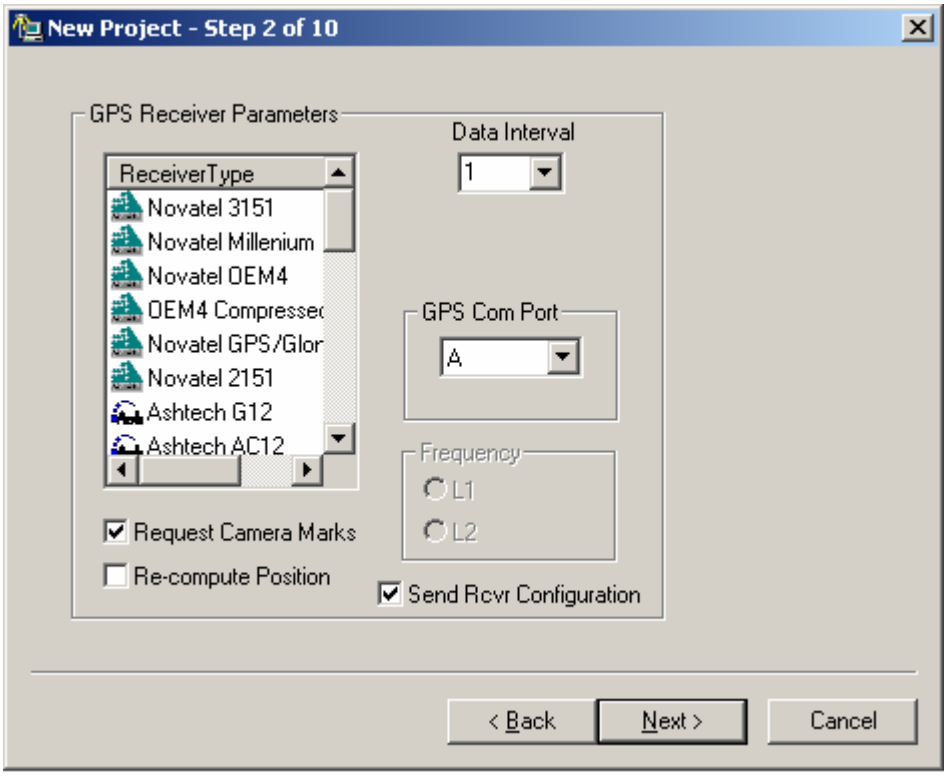


Figure 4.1: Selecting Receiver Options

7) NovAtel and Ashtech receiver users have the option to send ASCII Commands to the receiver. This can be used to shut off commands or over-ride various receiver commands. Refer to your receiver manual for information on these commands.

8) Select the Computer COM Port that the receiver is connected to.

9) Choose a Baud rate. Refer to your receiver manual if you are unsure.

10) Select the Parity. Parity for most receivers is none.

11) Select the bits for the receiver. Bits is 8 for most receivers.

The next steps are of concern mainly to WIN95/98 users. The program can call on its device driver WPCOMM.VXD to install (temporarily) COM 1 or COM2 on any PCI or ISA bus card. That is you can configure and use a non-standard COM port “on the fly”.

12) If you are not using a standard serial device then you will have to select an IRQ and Port Address. The data logger defaults to the standard IRQ and Port Address for COM1 and COM2. Win95/98 users can re-configure COM1 and COM2 to any non-standard port available on the computer. **Note**: Windows 2000, NT users can’t change the device driver, IRQ or Port Address.

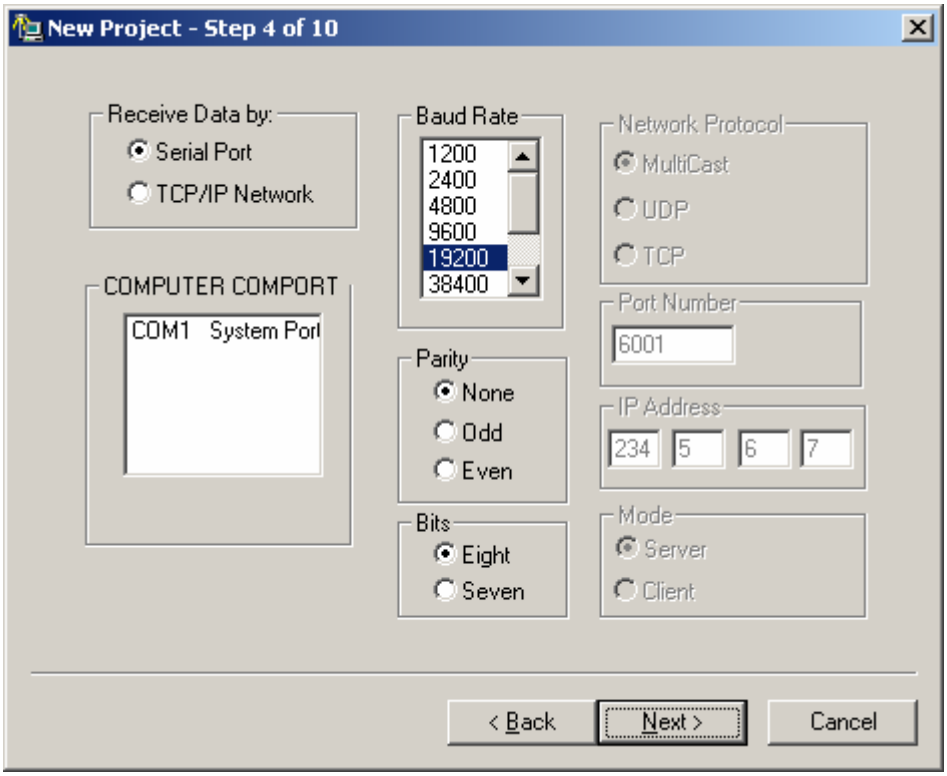


Figure 4.2: Computer/Receiver Configurations

13) Select the radio button indicating how you would like the data to be saved.

14) If you want the data to be saved to disk then enter the file name.

15) Select if you want all the data to be logged or if you want data within a certain time to be logged. Note if you are using defined start time, then you will have to enter the GMT offset.

16) RTCM-104 corrections are the updated differential corrections. Check the **Output RTCM–104 Corrections** box if you want RTCM corrections to be displayed. Otherwise, you are finished the setup and can click on the **Finish** button.

17) Select the type of RTCM output you would like and the interval for each.
    - **Type 1**: includes time, PRN, δρ and δρ rate.
    - **Type 2**: has the last IODE (issue of data ephemeris).
    - **Type 3**: gives position.

18) Select the Comport you would like to use for the RTCM output.

19) Enter the base station coordinates for the antenna.

20) Select the Baud Rate and then click **Finish**.

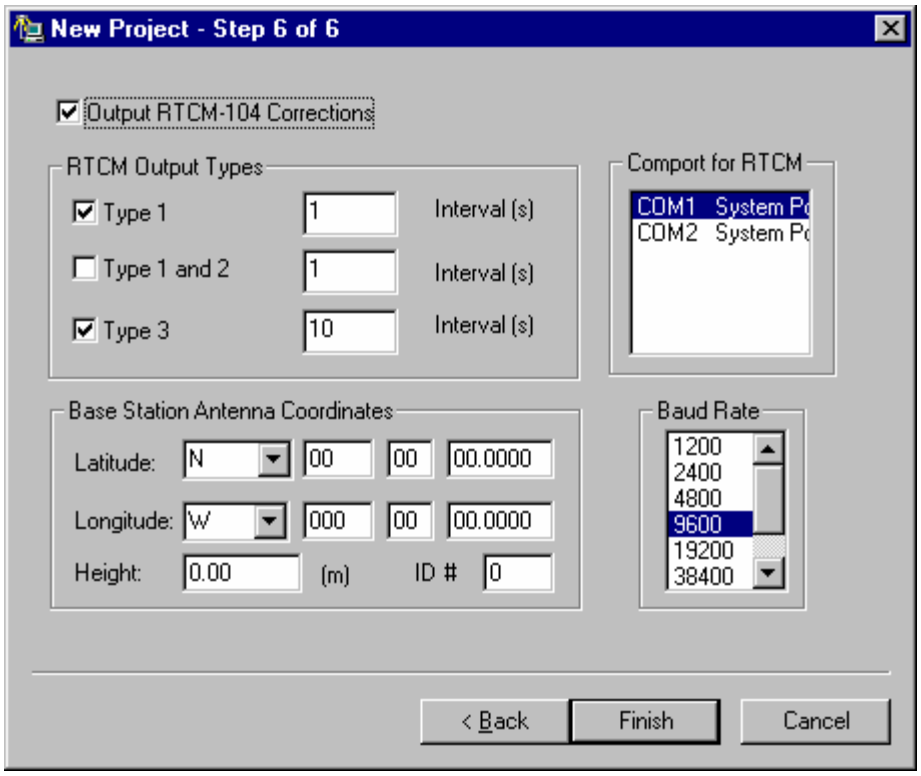


Figure 4.3: RTCM Corrections

4.1.2 Logging Data

Once a project has been opened and the COM port has been initialized, the GPS receiver will send binary data to your computer to be logged. The screen as shown in Figure 4.4 should appear.

4.1.3 Basic Logging Display

The text appearing in Figure 4.4 below should be fairly self-explanatory. It should be noted that GPS time is out of synch with UTC currently by 13 seconds. The **Mode** item appears as **Static** by default. This can be changed to **Kinematic** by hitting the *F3* key or using the *Events* menu option. If the data will be post-processed by our GrafNav/GrafNet modules, this is important.

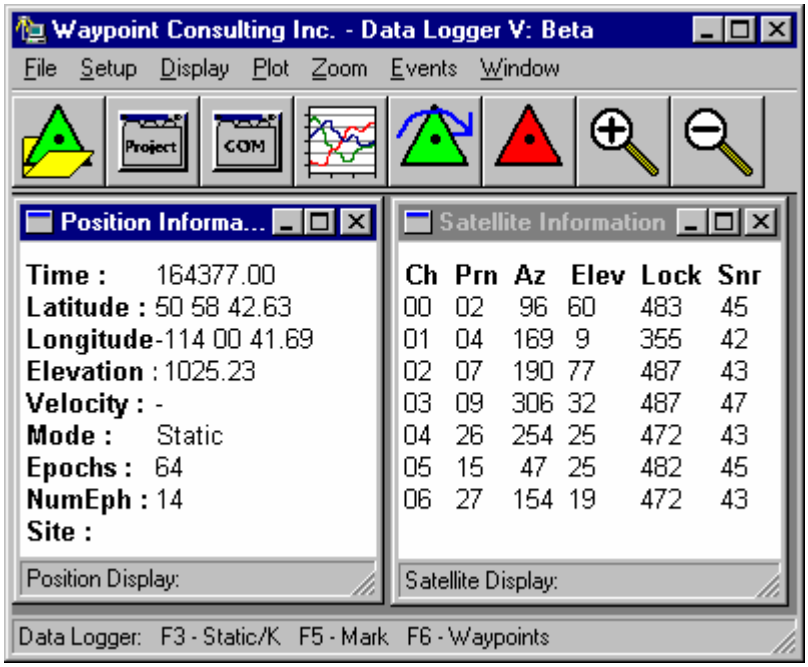


Figure 4.4: WLOG Logging Data

An extended logging display including waypoint navigation features can be invoked from the *Plot* menu option.

4.1.4 Extended Logging Display

The extended display has two functions. The first is to display the azimuth and elevation of the satellites being tracked by the receiver and the second is to plot the current track of the static or kinematic antenna. The scatter plot of a static antenna will basically be an indication of Selective Availability. A more useful feature of the Scatter Plot window is that it allows the user to follow the track of a vehicle to waypoints read from a simple text file. In Figure 4.5 below, the waypoints are indicated by triangles while the current position of the GPS receiver is shown as a dot. The *Zoom* menu option or tool buttons allows you to set a scale, which is congruent with the situation that you are in. The W*aypoint Information* box is invoked from the *Display* menu option.

4.1.5 Using Waypoints

An ASCII waypoint file must be loaded in order to plot waypoints on the screen. To load an ASCII waypoint file, you must first build the file with any text editor. Each line in the waypoint file must look like:

Station_name latitude(deg min sec) longitude (deg min sec)

For instance, part of the file read in for Figure 4.5 below is simply:

```
NW    51 05 47.1005    -114 22 24.0872
100   51 01 56.07954   -113 54 21.34525
```

```
101   51 05 45.48627   -113 54 43.28268
```
and so on…….

To actually load the waypoint file, look under the *File* menu option or click on the **Load Waypoints** tool button.

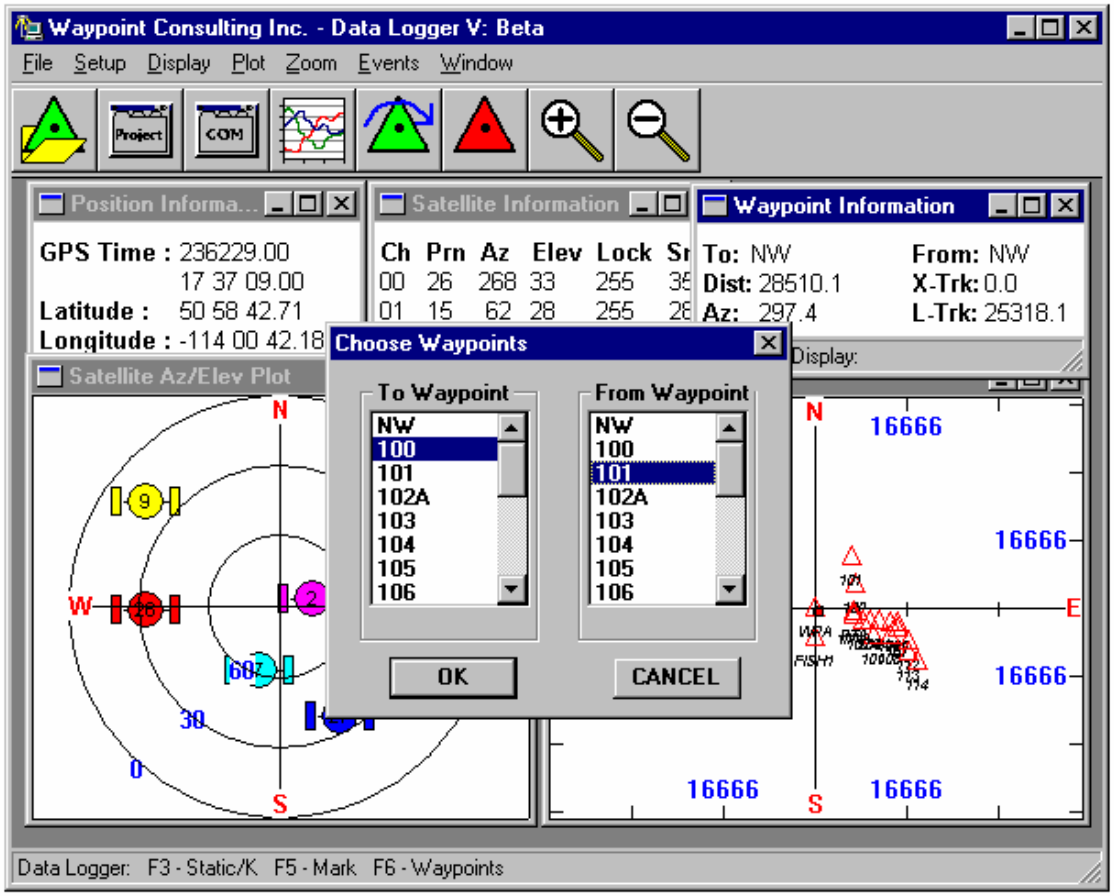


Figure 4.5: Loading Waypoints

It can be seen from the *Waypoint Information* box that the current **To Waypoint** is station 100, while the current **From Waypoint** is station 101. The distance and bearing that must be traveled from the current receiver position to station 100 is 9533 m at an azimuth of 50.9 degrees. If one was to attempt to drive in a straight line from station 100 to 101, it can be seen that the current dot on the screen is 7746 m left of line. The along track distance indicates that there are 12656 m left to travel along the line.

To dynamically choose **To** and **From Waypoints** from the ASCII waypoint file, choose the *Events* | *Next Waypoint* menu option or hit the *F6* key.

4.1.6 Marking Events

Currently, two kinds of events can be marked. The first event is the static/kinematic mode sequence**,** which indicates that the antenna is either motionless or static. The second is the station mark event,

which allows the user to mark the GPS time at which the antenna was over some significant point. The static/kinematic marks are placed both in an ASCII STA file, and in the binary GPB measurements file**.** The data logger creates these files for each project you have. The station marks are placed in the ASCII STA file. GrafNav/GrafNet will read the station marks in the STA file and plot these in the GrafNav environment.

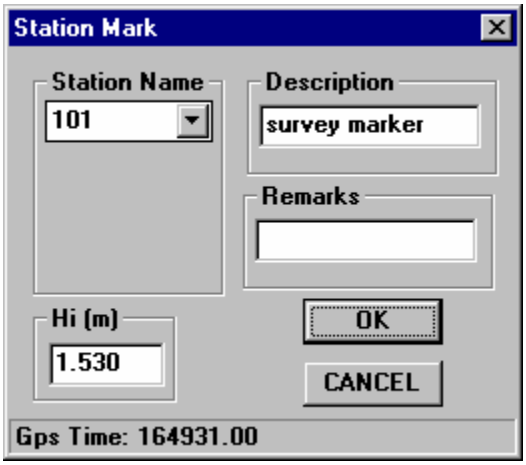


Figure 4.6: Station Marks

The information in the dialog box shown above is stored in the ASCII STA file. Note that the GPS time in the status bar of the dialog box is the GPS time current at the time that the dialog box has been invoked by hitting the *F5* key or using the *Events* menu option. The **Mode** has been toggled to kinematic by hitting the *F3* key or using the *Events* | *Static/Kinematic* menu option.

4.1.7 Output Files

If a project name has been entered into the *Log Data?* dialog box, the data logger will output measurement files in Waypoint's binary GPB format, ephemeris files in an ASCII EPP format and STA files which are ASCII files associated with event marks.

Section 2 ViewGPB

GPB files are in a binary format, and so cannot be viewed with a normal text editor. *ViewGPB* allows you to both view your data and edit it in limited ways. A picture of the program is shown below in Figure 4.7.

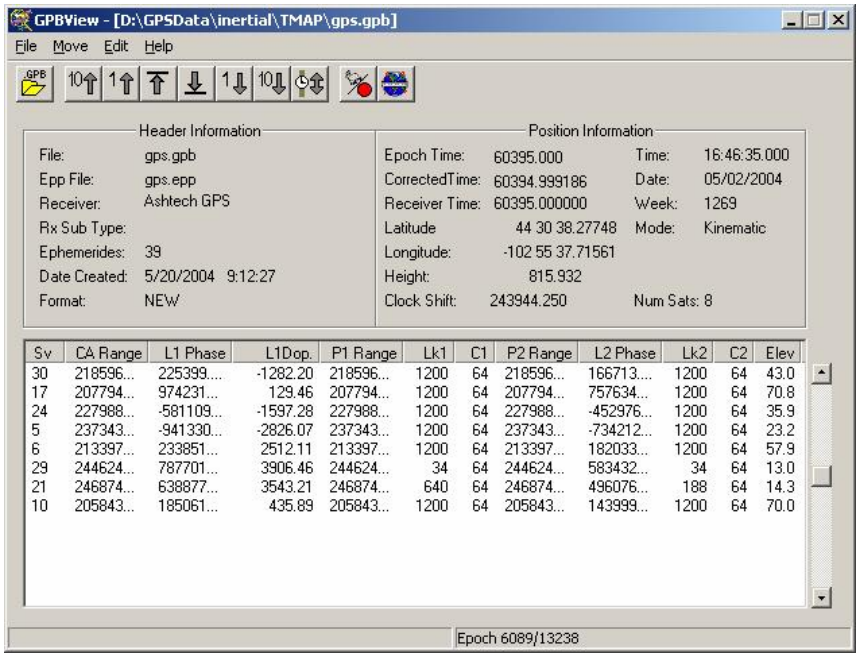


Figure 4.7: GPB Viewer

4.2.1 Why Use ViewGPB?

1. If you were unable to switch the remote data from KINEMATIC to STATIC or vice-versa while collecting data, you can change the kinematic marker in the binary file. This is also useful if you did not use the real-time logging software provided, such as logging internally in the receiver. This is important if you wish to process kinematic data. Go to the epoch where the kinematic/static is to start. To change the process mode, go to *Edit* | *Switch Static/Kinematic* and enter the number of epochs that you want switched. Choose whether the data will be switched to static or kinematic.

2. If you have cycle slip problems, you can go to the epoch with the problem by using the Search option, which allows you to search by Second, Epoch or H.M.S. By examining the phase and phase rate (Doppler measurement) at the previous epoch, you can compute what the phase measurement at the present epoch should be.

   $Phase_t = phase_{t-1} + phase\_rate_{t-1} * time\_interval + \Delta + clockcorrection$

3. If a data record is corrupt, simply because the serial data was bad or the receiver clock jumped for one epoch, you can eliminate this record. Go to *Edit* | *Disable Satellite(s)*. This will zero pseudoranges for one or more epoch(s) for a given satellite and will remove this/these epoch(s) from processing.

4. Viewing and editing locktime cycle slips on the receiver. These cycle slips can be edited using *Edit* | *Add/Remove Cycle Slips*. That is cycle slips can be removed by making the new locktime 255 for 255/recording_interval epochs. The cycle slip can be added by making the new locktime 1 for 255/recording_interval epochs.

5. Recompute position and clock correction records. This is useful for:
   - computing a position where one did not exist
   - correcting erroneous or bad clock shift data causing processing data errors. Note that ephemerides must exist; use *File | Load Alternate Ephemeris…* to specify another file containing the proper ephemeris.

4.2.2 How to Use View GPB?

The *File* menu allows you to open or close a GPB file. The *Load Ephemeris* command is useful to print proper GMT H:M:S times or to recalculate position and clock shift. Also, the ephemeris file must be loaded in order to search for H:M:S.

The *Move* menu is used to move or search through the list of epochs. To move through the GPB file, you can either use the options under the *Move* menu or use your keyboard. To scroll one epoch, use the *Up* and *Down* keys. To scroll 10 epochs, use the *Page Up* and *Page Down* keys. If you wish to find the start or end of the GPB file, use the *Home* and *End* keys.

The *Edit* menu edits the GPB file. This includes switching from static to kinematic and vice-versa. Furthermore, the user can change the locktime to add or remove a cycle slip. *Disable Satellite(s)…* will zero the pseudoranges for one or more epochs for a given satellite. *Recalculate Position* recalculates receiver position values using a single point GPS solution.

Before any changes are made to the GPB file, *ViewGPB* will confirm that you want to make the changes. These changes are PERMANENT, so it is advisable to keep a backup copy of the original observation file.

Section 3 Concatenate, Slice, Resample Utility

This utility can be called from the *GPB Utilities* sub-menu under the *File* menu in either GrafNav or GrafNet. As its name suggests, this utility can be used to concatenate multiple files into one new file, take a small portion of one file and make a new file with that portion, or create a new file from data sampled at a different data rate from the original file.

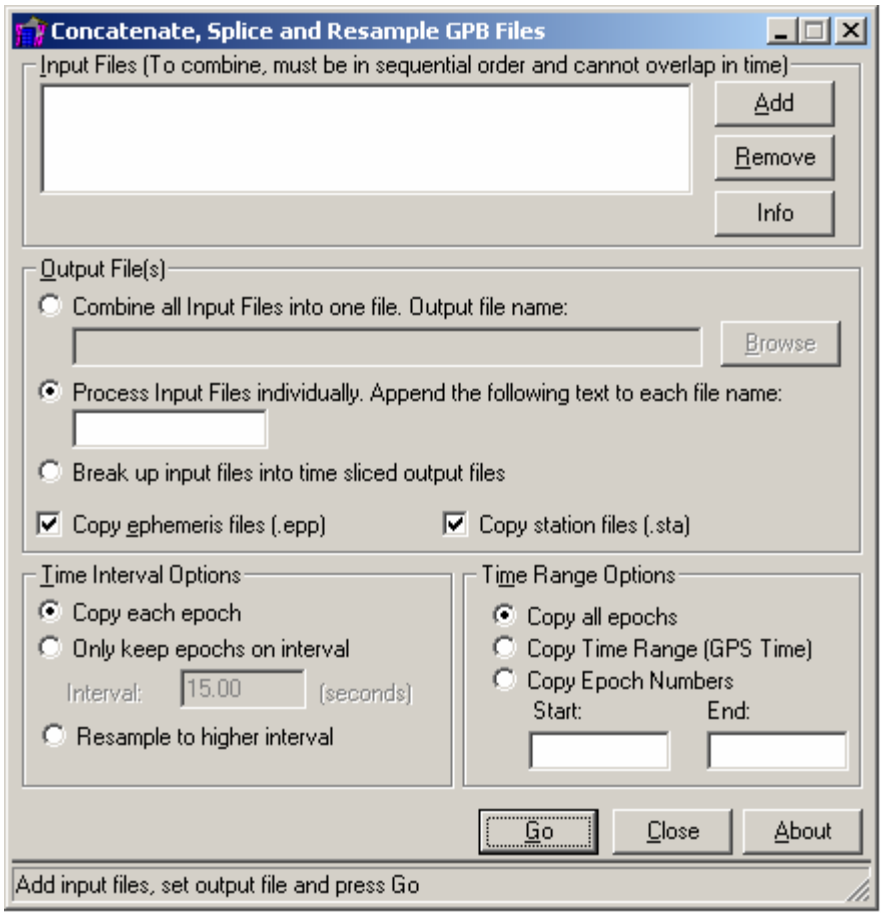


Figure 4.8: The Concatenate, Splice and Resample GPB Utility

Use the **Add** and **Remove** buttons to select the files that you wish to use as original files. From the *Time Interval Options* box, select the **Copy each epoch** radio button to simply splice a file, or select the **Only keep epochs on interval** to resample the file. If you wish to concatenate two or more files, either radio button may be selected depending on whether you want to resample the data as well as concatenating it. Use the *Time Range Options* to set the times that will be used to create the new file.

This utility also allows for a resampling of GPB data to a higher data interval. This is best performed on static data since doing so on kinematic data will also attempt to interpolation vehicle motion, which is not very well characterized by the polynomials used.

An additional dialog box appears with the following options:

- The data mode defines what measurement quantities are to be interpolated. It is important to set this properly.
- For kinematic data, results will be unreliable. However, if the user wishes to try it, make sure that the kinematic box is selected.
- Window size in epochs is the range of data used for interpolation. The window size should normally be set between 4 and 6. Very large windows will have problems, especially with data files that have large data intervals.

- The data interval is the interval that will be resampled to. It should be finer than the original input interval.
- The number of polynomial coefficients is the number of Chebychev polynomial coefficients used for the interpolation. Normally a value close to the Window size is acceptable. This value cannot be larger than the window size.
- The maximum time span prevents the interpolator from using data across a too high of an interval. Currently, 3 minutes is the default. However, larger values are required for large interpolation windows with coarse input data rates.
- Cycle slips can cause the interpolation to have problems. Therefore, a coarse detector is implemented. This value cannot be lowered too much, since then pseudorange noise will be mixed up with carrier phase errors (a minimum value of 50 cycles should be used).
- The GPB resampling utility needs GPS ephemeris data. Normally, the ephemeris from the input files is used. If these ephemeredes do either not exist, or they are incomplete, then use the alternate ephemeris option.

There will be accuracy degradation for interpolated data. This is especially the case for 30-second input data, where interpolated carrier phase is accurate to approximately 20 cm. Therefore, it is often good to *de-weight* the carrier under GrafNav's standard deviation options (e.g. 0.2 m). The L1 rejection tolerance should also be increased (e.g. to 0.5 m).

Section 4 GPB to RINEX Converter

This program will convert a GPB file into a standard format RINEX version 2.0 or 2.1 file. You can convert multiple files in succession by simply adding them all to *Files to Convert* list. Each time you add a file, you will be prompted for a station name, an antenna height, and whether an alternate ephemeris should be used.

The type of data that will be written to the RINEX files can be selected with the radio buttons in the *Data Types to Export* box. If **Auto-Detect** from this box is selected, then the program will export all available data. Regardless of what button you press, only data that exists will be exported (columns of zeroes will not be created for missing data).

*GPB to RINEX Converte*r allows you to set the week number the observations were made on. If the **Auto-Detect Week** button in the *GPS Week* box is chosen, then the week that the observations were made will stay the same. You can also set the week by choosing the **Set Week** button. Occasionally, decoded data is given an incorrect week when it is converted from a receiver format to a GPB file. These errors can be corrected by converting the GPB data into RINEX data with the correct week, and then back to GPB data.

CHAPTER 5 COMMAND PORT INTERFACE

This chapter describes the command port interface, which allows users to monitor the operation of RTKNav. It uses an ASCII based command structure. Normally, communication is via TCP/IP, but a serial connection can also be used. Provided the user's local network has a gateway to the outside, a user can connect to RTKNav anywhere in the world using TCP/IP. The command port interface is designed so that there are no commands than can permanently harm the computer running the software (i.e. disk cannot be reformatted and files cannot be displayed or deleted).

Section 1 Configuring a Command Port

Configuring the command port is necessary for proper communication. There may be more than one command port assigned (up to 16 can be assigned for a single RTK session). This can be useful by allowing multiple users the ability to check the activity of RTKNav.

5.1.1 RTKNav Command Port

In RTKNav, a command port must be added before navigating is allowed (i.e. before the green button is pressed). This is performed as follows:

a) From the RTKNav interface, select *View* | *Project Configuration…*
b) Select the *Output* tab.
c) Click on **Add Port…**
d) Check **Use this port as a Command Port**. THIS IS VERY IMPORTANT.
e) Set the port settings.
   - For TCP/IP:
     i) Enable **TCP/IP Network**.
     ii) Select **TCP** as the *NetWork Protocol*. This is highly suggested because our TCP utilizes has a special server mode that allows it to better reconnect.
     iii) Enter a port number that does not conflict with the other ports employed. Normally port numbers above 1023 are used. However, port 23 is also available. This is the default port number for Telnet. Please note that port 23 can only be used once. If multiple command ports are desired, then the second, third, etc… ports will need to be assigned to values higher than 1023.
   - For serial ports:
     i) Enter the comport number.
     ii) Enter the baud rate. Higher baud rates are usually better to prevent the port from being overloaded.

5.1.2 RtEngine Command Port

In RtEngine, the command port needs to be assigned in the IN file. A complete description of this file format is given in Chapter 8 . In RTKNav, the command port can be connected via TCP/IP or a serial port. RtEngine supports these two modes as well. In addition, users can setup

a CONSOLE command port interface in RtEngine. This turns the DOS Prompt screen into a command port.

a) For a TCP/IP command port, add the following to the IN file:

```
; Adds NETWORK TCP port to RtEngine
Port {
        PortNum: 101
        Type: NETWORK
        IP: 0.0.0.0
        NetPort: 6000
        Protocol: TCP NORMAL
        NetMode: SERVER
}
; Tells RtEngine that port 101 is a command port
Command {
        PortNum: 101
        Status: ON
}
```

This adds a TCP command port to network port 6000. The PortNum (i.e. 101) is arbitrary and must be unique for each port in use by RtEngine. Valid PortNums are 1-1023.

b) To add a serial command port, use the following in your .IN file

```
; Adds serial port (COM7) to RtEngine.
Port {
        PortNum: 102
        Type: SERIAL
        comport: 7
        baudrate: 19200
}
Command {
        PortNum: 102
        Status: ON
}
```

Note again that the PortNum assignment is completely arbitrary.

c) To add a CONSOLE command port, use the following in your .IN file

```
; Adds CONSOLE port to RtEngine.
Port {
        PortNum: 103
        Type: CONSOLE
```

```
}
Command {
        PortNum: 103
        Status: ON
}
```

Section 2 Connecting to the Command Port

This section covers how to connect to a command port once it has been configured. Currently, RTKNav will open a command port once **Start Processing** has been engaged. When processing is stopped, the port will be closed. Future versions may be able to connect right after the port has been added or an existing project has been opened (i.e. command port will remain open even after **Stop Processing** is selected)

5.2.1 TCP/IP (Network) Connection

For TCP/IP (TCP mode only), the easiest way to connect to the command port is via the Telnet program. Telnet is available on all Windows and UNIX machines.

a) For Windows NT/2000/XP users, access telnet from a command prompt as follows:
telnet *IPAddress NetPort*
For example,
telnet 192.166.99.200 6000
If the NetPort is dropped, then the default port is 23 (i.e. telnet port).

b) For Windows 9x users, telnet has an easier to use interface. It can be used as follows:
   i) Open a DOS Prompt
   ii) Type in "telnet".
   This should bring up a Windows program. If telnet cannot be located, then you may not have your path set to include the Windows and Windows System directories.
   iii) From the main menu, select *Connect* | *Remote System* …
   iv) The following dialog box should appear:

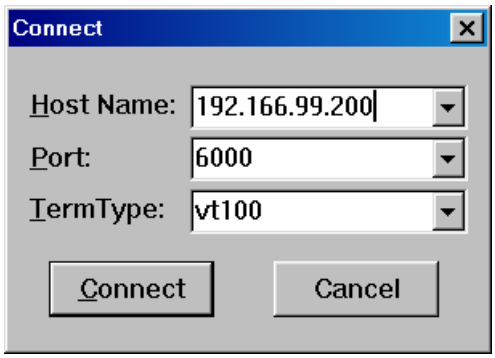


Figure 5.1: Telnet Login

v) Enter the IP address in the Host Name and the NetPort in the **Port** box.
vi) Click on **Connect**.

c) For UNIX users, the same procedure as (a) can be used.

5.2.2 Serial connection

For a serial port connection, one of the many serial terminal program can be used. For example: Procomm, HyperTerminal, … The Waypoint Group, NovAtel Inc. also has a program available for users that are having difficulties locating one.

5.2.3 Once Connected

Once connected, the following message should appear:

```
RtEngine - Real-Time Kinematic processing software
           Version 2.00
           Copyright NovAtel Inc., 2000

Type HELP for a list of available commands

Port103>
```

Note that the Port103> prompt refers to the PortNum assigned by RTKNav (via the .IN file). This does not refer to the network or COM port number.

To find out what port you are connected to, type the WHOAMI command:

WHOAMI

The result will be:

Port 103 (TCP IP192.166.99.200 P6000)

To get a list of all the commands available, type

HELP

The result is:

```
CLEAR                Clears the screen
CONFIGRX             Configure GPS receiver (ask for
ephemeris)
DIR                  Lists directory contents for a given
path
DISABLE              Disable port operation for problem
receiver
DISKSPACE            Shows the available space for a drive
DYNAMICMODE          Set STATIC/KINEMATIC mode for a given
receiver
ECHO                 Echo character input
ENABLE               Will enable port operation
ENGAGEKAR            Start KAR for a particular remote
```

```
EXIT!                   Quit RtEngine or RtkNav now
FILTERRESET             Caused Kalman filter to be restarted
HELP                    Display list of all commands or help
just one
LISTPORTS               List all ports available
LOGREC                  Log a given record to an output port
MASTERPOS               Set position of master station
MESSAGE                 Send all messages to this command port
REPEAT                  Repeat set of commands every 'n'
seconds
SETCOM                  Change settings for a serial port
SLEEP                   Set sleep time for a given command
port
SOLUTION                Shows last solution for a given remote
receiver
START                   Start navigating
STATUS                  Show status of RTK operation
STOP                    Stop navigating
TIME                    Displays GPS time
UNLOGALL                Stop logging all records on given port
UNLOGREC                Stop/disable logging of a given record
VERSION                 Show program name, version number and
project name
WHOAMI                  Show current port and information
about it
```

To get additional info about a given command, type

HELP *command*

The most commonly used commands are:

LISTPORTS	Lists the available ports and their status
STATUS	Shows the status of the RTK operation
SOLUTION	Shows the last solution for a given remote
LOGREC	Starts logging of a given record type (these records are described in Chapter 6).
UNLOGALL	Stops logging all records in this port. Use LOGREC to just stop logging one record.
MESSAGE	Enables/disables output of scrolling messages to this display
VERSION	Shows the current version, remotes connected, maximum remotes and copyright information.
REPEAT	Continuously repeats a given command

A complete description for all of the commands is given in the next section.

Section 3 Available Commands

This section gives an alphabetical listing of each of the commands and how to use them.

5.3.1 Introductory Concepts

Command Format

The commands accept space, command or tab separated arguments. For example:

Command arg1 arg2 arg3 …

Followed by a carriage return and/or line-feed character (i.e. Enter/Return Key). Character case is not important.

For arguments that have a space within (this happens commonly with the REPEAT command), then quotation mark must be used. For example:

repeat 0.25 "solution r1"

In the command usage listings, some arguments are encased by "[" and "]". This indicates that this argument is optional. The brackets should not be typed.

Port/Receiver References

Many of the commands are specific for given port, receiver (i.e. master or remote), and command port or assigned port name. Assigning port names is a future feature of RTKNav.

To reference an assigned port number, use

P#

Where # refers to the assigned port number (not the network or comport number!). For example, P600 refers to port 600. Valid port assigned numbers range from 1 to 1023.

To reference the master receiver, use

M

To reference a certain remote receiver, use

R#

Where # refers to the remote number (1,2,3…). For example, R3 refers to remote # 3

Finally, you may wish to refer to the current command port that you are connected to. In this case, use

THIS

Again, case is not important.

When a command usage shows:

P#/M/R#

This means that any one of these can be used. More than one port definition may NOT be used.

Command Results/Outputs

Some of the commands have an argument REC *or [REC] to show that it is optional.* When used, the result of this command will be encased in a NMEA style record. This makes for easy ready

by your software program. For a command that outputs multiple records (e.g. DIR or LISTPORTS command), then the first record will be:

$RESULT,DIR,BEGIN*11

While the last will be:

$RESULT,DIR,END*19

Each command will either output the requested data or give one of the following NMEA style outputs:

- $SUCCESS,*CommandName* *XX
  This indicates that the command has been accepted properly and no errors were detected.

- $RESULT,*CommandName,data…*XX
  This allows the user to easily (and reliably) read the results of the command in their own software program.

- $ERROR,*CommandName,Error message* …*XX
  This indicates that an error was detected. A message describing the error is given as part of the message. It may be possible that the error message may have commas. Therefore, any commas after the "*CommandName,*" should be ignored.

Checksums

Commands can also be transmitted in a NMEA style wrapper (see Chapter 6 Section 2 for more details on NMEA records). This greatly diminishes the chanced of a command being altered via the transmission medium. For example, the STATUS command could be transmitted as follows:

$STATUS*14

5.3.2 CLEAR Command

Clear issues a "clear screen" to the current terminal. It uses the ANSI definition which is:

ESC[2J (note that ESC refers to the ESC character (hex 1B)

Usage:

CLEAR

5.3.3 CONFIGRX Command

The CONFIGRX command allows the user to re-configure one of the GPS receivers. This will re-send the commands to that receiver. This command is normally used if a receiver stops responding, or you wish to request ephemeredes because another session of RTKNav has connected to the rebroadcast ports. CONFIGRX currently only works for receivers connected via serial ports.

Usage:

CONFIGRX P#/M/R#

Example:
configrx r3

5.3.4 DIR Command

This command lists the directory contents for a given folder (or path). It operates very similarly to the DOS DIR command, except that it does not have all of the options.

Usage:
DIR [*path* [REC]]

The *path* refers to a path name as would be used in windows. REC forms a NMEA style output.

Example:
dir c:\data*.cfg

Result:

```
Directory information for c:\data\*.cfg:
File Name                       Date(m/d/y)  Time   Size
test.cfg ......................  08/22/2000 10:25 3.007k
testfile.cfg ..................  08/21/2000 17:33 3.072k
rtkreb1.cfg ...................  08/25/2000 15:03 1.318k
rtknetwork.cfg ................  09/14/2000 18:50 1.424k
     4 file(s) and 0 directories use 8.821k
```

5.3.5 DISABLE Command

See ENABLE command

5.3.6 DISKSPACE Command

DISKSPACE can be used to find out how much disk space is available on a certain drive.

Usage:
DISKSPACE [*drive* [REC]]

Where *drive* is a drive definition (e.g. C:) or a network path (e.g. \\user\c\)

Example:
Diskspace e:

Result:

```
E: has 134.8M out of 1.991G free (6.6 %)
```

5.3.7 DYNAMICMODE Command

This command allows users to switch the STATIC/KINEMATIC mode for a given master or remote receiver. Switching a master to kinematic only has meaning in the moving baseline mode (See 0).

Usage:

DYNAMICMODE P#/M/R# STATIC/KINEMATIC

Only the first three characters of the STATIC/KINEMATIC really need to be used.

Example:

Dynamicmode r3 kin

5.3.8 ECHO Command

This command enables or disables echoing of characters to the current command port. By default when a new command port is opened echoing is ON, but if your terminal also performs the echo, you may wish to turn this feature off. You may also wish to disable echoing to avoid confusing your own software.

Usage:

ECHO ON/OFF

Example:

Echo on

5.3.9 ENABLE/DISABLE Commands

These two allow users to enable or disable a port or receiver. In the case of GPS receivers, there are two portions of the disabling process:

a) Receiver data decoding may be disabled.
b) Receiver processing in the engine (RtDLL) may be disabled.

Under normal circumstances, it is desired that both be disabled. In such a case, the R# port definition should be used. If it is desired to just disable data logging (seldom the case), then the P# can be listed. The master cannot be disabled other than data logging via the port definition.

Usage:

ENABLE/DISABLE P#/R#

Example:

Disable r3

5.3.10 ENGAGEKAR Command

This command can be used to engage Kinematic Ambiguity Resolution (KAR) for a certain receiver. This forces KAR to start searching for a new solution. If it is already searching, then nothing happens unless the RESET option is used. In this case, KAR will start from scratch and ignore any previous data. In order for this command to take effect, KAR must be enabled in the Process Configuration.

Usage:

ENGAGEKAR P#/R# [RESET]

Example:

Engagekar r1 reset

5.3.11 EXIT! Command

The EXIT! Command can be used to stop RTKNav. It will close all ports and perform an orderly shutdown of the current process. Unless there is a loop back style program that calls RTKNav, it may not be possible to recover from this process remotely. Therefore, caution should be used with the EXIT! Command.

Usage:

EXIT!

5.3.12 FILTERRESET Command

This command resets the Kalman filter for one or all remotes. This will bring the accuracy back to DGPS levels. KAR will also be engaged (if it is enabled). This command is useful if it is noticed that the solution has become corrupted. If the command (MESSAGE ON) is used before, it is easy to tell if this command has taken effect.

Usage:

FILTERRESET P#/R#/ALL

Example:

filterreset r3

5.3.13 FIXREMOTE Command

This command can be used to fix the initial position of one remote receiver. The latitude and longitude are entered in decimal degrees, and the height in meters.

Usages:

FIXREMOTE R1 latitude longitude height

Example:

r1 52.1848796 –114.12459657 1110.235

5.3.14 HELP Command

The help command can either be used to list the available commands or the usage of a particular command.

Usage:

HELP [*command*/*x-y*/COMMON]

Where *command* would be the command name. *x-y* would be a range of letters to display available commands over (e.g. a-m). Use COMMON to only show commonly used commands.

Example:

help repeat

Result:

```
HelpFor: REPEAT - Repeat set of commands every 'n' seconds

Format:  REPEAT interval(s)/STOP/LIST/COUNT ["cmd1 v1 v2..." ["cmd2 v1 v2..."]]
Usage:   Can be used at any time
Remarks: STOP quits repeating. LIST shows commands repeated. Count shows # times
used. Use just interval to change interval
```

For help on a particular command (see result above), usage refers to when the command can be used. Currently, command ports are only active during processing (navigation). In the future, some command will be usable before processing has been engaged.

5.3.15 LISTPORTS Command

This command lists the available ports and some information about each port. Like the DIR command, the REC option can be used to form NMEA style output records.

Usage:

LISTPORTS [REC]

Example:

listports

Result:

```
Port Description              Name/Type    Rx/Info               Read  Write
   2 MUL 234.5.6.7 5002       Master       ASHTECH MACM i0.10    5.01M 0000
   4 MUL 234.5.6.7 5004       Remote#1     NOVATEL 3151 i0.10    5.54M 0000
   6 MUL 234.5.6.7 5006       Remote#2     ASHTECH MACM i0.10    5.01M 0000
 100 Console                  Command      Connected             0000  0055
 101 TCP 0.0.0.0 6000         Command      Not connected         0000  0187
 102 TCP 0.0.0.0 6001         Command      Not connected         0000  0187
 103 TCP 0.0.0.0 6002         Command      (cx) 192.166.99.200   0280  5.22k
```

Where:

Port	Refers to the assigned port number
Description	Gives particulars about the actual port (i.e. Network or serial settings)

Name/Type	Defines if the port is a Master, Remote, Rebroadcast, Output or Command Port.
Rx/Info	Information about device connected to port (i.e. GPS receiver or IP address of user connected to command port).
Read/Write	Number bytes, kilobytes, and megabytes read/written by port.

5.3.16 LOGREC Command

This command is used to start logging of a particular output record to a given command or output port. A list of available commands and their format is given in Chapter 6 . Each record can only be requested once for a given output/command port. If requested again, this request is used to change the interval or other settings for that record. This is NOT recommended for MULTIENGINE due to the large number of records which will arrive at the port. If used, the UNLOGREC command MUST be use to stop the data flow. It is recommended to simply use an out port instead.

Usage:

LOGREC P#/THIS *RecName* [*interval*]

Where *RecName* would be one of:

NMEA standard records:

GPGGA	DGPS position record (one per remote)
GPVTG	NMEA velocity record (not implemented yet)

Waypoint custom records:

RTSOL	Geographic position + solution status record (one per remote)
RTSLE	RTSOL with some addition status information.
RTUTM	UTM remote position record (one per remote)
RTVEC	Base-to-remote local level vector record (one per remote)
RTSAT	Satellite information record (one per remote)
RTKAR	KAR information record (each time KAR is resolved).
RTKDC	Can be ignored for most applications (KAR distance constraint record)
RTSIO	Status record of datalogging. An interval must be requested for this record (one a specified interval)
RTBIN	Output of binary solution structure from RtDLL (see gps_epsol_type structure in engine.h). You may need to request this structure from the Waypoint Products Group, NovAtel Inc. This record is only suitable for software programmers.

The *interval* is in seconds. It is necessary for the RTSIO record and optional for the reset. If it is not used, the specified record will be outputted each time a new record becomes available (i.e. on remote data input interval).

Example:

logrec this rtvec 5.0

Result:

```
$RTVEC,67345.00,R1,0.006,0.001,0.002,0.018,0.023,K,6,2,3*5B
$RTVEC,67345.00,R2,0.000,0.002,0.002,0.018,0.023,K,6,2,3*5D
$RTVEC,67350.00,R1,0.006,0.000,0.002,0.018,0.023,K,6,2,3*5E
$RTVEC,67350.00,R2,0.001,0.001,0.001,0.018,0.023,K,6,2,3*58
$RTVEC,67355.00,R1,0.006,0.000,-
0.001,0.018,0.023,K,6,2,3*75
$RTVEC,67355.00,R2,0.000,0.000,0.000,0.018,0.023,K,6,2,3*5C
```

5.3.17 MASTERPOS Command

Allows user to enter the position of the master station. The latitude and longitude values can be inputted in either decimal degrees or "degrees minutes seconds". This command will only take effect if the master position has not been set. The master position can also be defined in the .IN file, .CFG file and the RTKNav interface. If a position has been set, this command will be ignored. RTKNav must re-start processing in order to change the master position. For moving baseline processing, the master position will be re-computed within the program if the master station is set to kinematic mode.

Usage:

MASTERPOS DEC *latitude longitude height*

or

MASTERPOS DMS *lat_deg lat_min lat_sec lon_deg lon_min lon_sec height*

Latitude values must be negative for the southern hemisphere, while *longitude* values must be negative for the western hemisphere (i.e. North America).

The *height* must be in metres. The output remote coordinates will be relative to this height system. For example, if ellipsoidal heights are entered, then the resulting remote heights will be ellipsoidal as well. If the height is entered in orthometric (i.e. mean-sea-level), then the remote heights will be relative-ellipsoidal to this value. If distances are short, then errors are minimal. If this becomes a problem, please contact the Waypoint Products Group, as we have our own Geoid modeling routines than can be easily inserted into the software.

Example:

MASTERPOS DMS 51 04 12.2949 –114 00 14.3921 1021.121

5.3.18 MESSAGE Command

This command can be used to start and stop status messages from being transmitted to the current command port. Enabling such messages can be very helpful in diagnosing a problem. Using the REC option allows for NMEA style record output. If this is used, please note that there may be commas in the message. These should not be confused with item separators normally used in NMEA records.

Usage:

MESSAGE ON/OFF/REC

Example:

message on rec

Result (after a while):

```
68208.5: Ephemeris received on PRN 4
68208.5: Ephemeris received on PRN 13
68244.8: Satellite drop-out PRN 13 for 4.1 seconds (BL 1)
68244.8: Warning: LOCKTIME cycle slip on 13 (BL 1)
68252.9: Satellite drop-out PRN 13 for 4.1 seconds (BL 1)
68252.9: Warning: LOCKTIME cycle slip on 13 (BL 1)
68283.4: Satellite drop-out PRN 13 for 4.1 seconds (BL 1)
68283.4: Warning: LOCKTIME cycle slip on 13 (BL 1)
```

5.3.19 REPEAT Command

This is a very powerful command as it allows users to continually send one or more commands. Its most common usage is to produce a text based display that is shows the status of the RTK operation. However, it can also be used to send KAR commands, reset the Kalman filter (FILTERRESET) or configure the receiver. Each command port is limited to having one sequence of repeat commands. Therefore, if multiple repeats are desired at different intervals, they must be requested on separate command ports (which is easy with TCP/IP).

Usage:

REPEAT *interval*/STOP/COUNT/LIST [*cmd1 "cmd2 arg1 arg2" cmd3* …]

The *interval* is specified in seconds. If a user wishes to change the interval of the current repeat operation, then type

REPEAT *new_interval*

STOP is used to stop the repeat operation. COUNT will display how many times the current repeat commands have been issued. LIST shows a list of the commands currently in the repeat list.

cmd1, cmd2, … refer to the commands that are to be placed in the repeat buffer. Be careful to encase commands with arguments with quotations. Without this a command will be incorrectly interpreted. A command list cannot be changed. If you wish to add another command, the list must be re-typed (or use cut and paste).

Example:

Repeat 5 clear time "repeat count" listports "solution r1" "solution r2" status

Result (every 5 seconds):

```
GPS time 68998.845 seconds, Time 19:09:58.845, Date 10/22/2000
CPU time 186069.372 seconds, CPU usage N/A
Repeat count is 2
Port Description              Name/Type    Rx/Info               Read  Write
   2 MUL 234.5.6.7 5002       Master       ASHTECH MACM i0.10     11.1M 0000
```

```
   4 MUL 234.5.6.7 5004        Remote#1     NOVATEL 3151 i0.10     12.5M 0000
   6 MUL 234.5.6.7 5006        Remote#2     ASHTECH MACM i0.10     11.1M 0000
 100 Console                   Command      Connected              0000  0055
 101 TCP 0.0.0.0 6000          Command      Not connected          0000  0187
 102 TCP 0.0.0.0 6001          Command      Not connected          0000  0187
 103 TCP 0.0.0.0 6002          Command      Connect 192.166.99.9   0511  19.5k
Solution for R1: [VALID]
  Time: 68998.70 (19:09:58.70 10/22/2000)   NSats: 7
  Lat:    50 58 43.00005                    Latency: 0.055 s
  Lon:  -114 00 41.99981                    CaRms: 1.03 m
  Hgt:  1014.996 m                          L1Rms: 0.0015 m
  Vec:  0.004, 0.001, -0.004 m              Speed: 0.041 m/s
  SD-H: 0.018        SD-V: 0.022 m          DDDop: 1.63
  KAR:  OFF          Amb: FLOAT             Qfact: 2
Solution for R2: [VALID]
  Time: 68998.70 (19:09:58.70 10/22/2000)   NSats: 7
  Lat:    50 58 43.00007                    Latency: 0.055 s
  Lon:  -114 00 41.99997                    CaRms: 0.38 m
  Hgt:  1014.998 m                          L1Rms: 0.0024 m
  Vec:  0.001, 0.002, -0.002 m              Speed: 0.090 m/s
  SD-H: 0.017        SD-V: 0.022 m          DDDop: 1.63
  KAR:  OFF          Amb: FLOAT             Qfact: 2
Processing Status Information:
NavMode:    Navigating
NumEph:     20
Latency:    0.055 s        CpuUsage: N/A
MasterPos:  OK (50.978611, -114.011667, 1015.000)

COLOR PORT NAME         DY    #SOL   STDEV A    DATAIN    RECIN   NSV AGE
GREEN    2 Master       S    41579   (N/A) L    11376k    48908    07   0
GREEN    4 Remote#1     K    40143   0.028 L    12816k    48917 07/08   0
GREEN    6 Remote#2     K    41575   0.028 L    11351k    48910 07/07   0
```

A $SUCCESS,REPEAT*78 is sent every time the repeat operation succeeds.

5.3.20 SETCOM Command

This command allows the user to change the comport settings for a certain serial port. Normally, only the baud rate is changed, but other port settings can also be altered.

Usage:

SETCOM P#/M/R#/THIS *baud* [*databits* [*stopbits*]]

The *baud* refers to the baud rate, which can be one of: 1200, 2400, 4800, 9600, 19200, 38400, 57600 and 115200. *Databits* may either be 7 or 8, but 8 normally used (8 is the default). *Stopbits* may either be 1 or 2. 1 is normally used (1 is the default).

Example:

setcom P101 19200

5.3.21 SLEEP Command

This command is used to dictate how often the command port checks for keyboard input or repeated operation. The default sleep time is 250 milliseconds, which is why the command port may appear somewhat sluggish. The purpose of such a large value is to conserve CPU time for

processing. However, users may wish to make a port more responsive, which is the main reason for using this command. If the REPEAT command is used with a very fast repetition rate, the sleep value should be lowered as well. Note that output records (requested by LOGREC) are unaffected by the sleep value. For users sending a burst of commands in a very short time period, lowering the sleep value may also be very beneficial.

Usage:

SLEEP P#/THIS [*SleepValue*]

SleepValue is the time in milliseconds the port "goes to sleep" between checking for input or command repeats. Leaving the *SleepValue* off will display the current *SleepValue* for that port. The minimum allowed value is 1 ms, while *SleepValues* above 1 second (i.e. 1000 ms) can cause a command port to be non-responsive.

Example:

sleep this 50

This sets the sleep value to 50 milliseconds.

5.3.22 SOLUTION Command

This command reports the last solution for a given remote.

Usage:

SOLUTION R#/P# [SAT]

The optional SAT parameter shows information about each of the satellites currently being processed.

Example:

solution r1 sat

Result:

```
Solution for R1: [VALID]
  Time: 71036.20 (19:43:56.20 10/22/2000)   NSats: 8
  Lat:    50 58 42.99999                    Latency: 0.040 s
  Lon:  -114 00 42.00002                    CaRms: 0.58 m
  Hgt:  1015.000 m                          L1Rms: 0.0008 m
  Vec:  0.000, 0.000, 0.000 m               Speed: 0.095 m/s
  SD-H: 0.015        SD-V: 0.028 m          DDDop: 2.23
  KAR:  OFF          Amb: FLOAT             Qfact: 2

  CH SV Elev Azim  Lock Ambiguity
  01 25   38   64  BASE
  02 19   27  239   255 -636.0
  03 28   29  162   255 -158.0
  04 01   64  292   255 -587.0
  05 22   48  123   255 -608.0
  06 04   19  307   255 -763.0
  07 20   59  205   255 -490.0
  08 13   36  288   255 -263.0
```

Where:

Time	GPS time in GMT time zone.
Latency	Is the estimated latency. It may not be very accurate (i.e. 100+ ms) since RTKNav does not accept a PPS input. For re-broadcasted data inputs accuracy is even poorer. This is because it is difficult to estimate network delays.
SD-H	Horizontal (1-sigma) height standard deviation estimated by the Kalman filter.
SD-V	Vertical (1-sigma) height standard deviation estimated by the Kalman filter.
Amb	This is either FLOAT or FIXED and indicates if the ambiguities have been fixed or not.
Qfact	Quality factor (1=best, 6-worste). Normally, 1-fixed integer solution, 2-stable float, 3 & 4-converging float, 5&6 DGPS. These are only guidelines and actual accuracies may vary.
Lock	Seconds that a satellite has been locked on for.

5.3.23 START/STOP Commands

In the current versions of RTKNav these two commands have little meaning. In RTKNav, STOP will shut down the command port. In future versions, START=Start Processing, while STOP=Stop Processing. This will allow a user to bring RTKNav in and out of navigation mode.

Usage:

STOP

or

START

5.3.24 STATUS Command

This command displays a report showing the overall status of the RTK operation. It is similar to the Status Window in RTKNav.

Usage:

STATUS

Result:

```
Processing Status Information:
NavMode:    Navigating
NumEph:     24
Latency:    0.215 s        CpuUsage: N/A
MasterPos:  OK (50.978611, -114.011667, 1015.000)

COLOR PORT NAME         DY    #SOL   STDEV A    DATAIN    RECIN   NSV AGE
GREEN    2 Master       S    69537   (N/A) L    18802k    76867    09   0
YELLO    4 Remote#1     K    64322   0.000 U    20555k    76876 00/09   0
GREEN    6 Remote#2     K    69533   0.029 L    18786k    76869 09/09   0
```

Where:

NavMode	Indicates whether the user has selected Start Processing or not. It does not indicate if the receiver/RTK is working properly. Use the color settings below for that.

NumEph Number of unique ephemeris records that have been decoded. If this number is less than 4, RTK operation will continually fail until enough ephemeris records have been received.

Latency Is the estimated latency. It may not be very accurate (i.e. 100+ ms) since RTKNav does not accept a PPS input. For re-broadcasted data inputs accuracy is even poorer. This is because it is difficult to estimate network delays.

MasterPos Current position of master station. Will indicate if no position has been received.

COLOR This is a status indicator where RED indicates that no valid data is incoming on a port. Reasons for this are:

i) Continual checksum failures
ii) Radio link has been broken (ByteCount will not increment)
iii) Receiver is set incorrectly in setup (i.e. selected receiver type does not correspond to that type connected to the port)
iv) Baud rates are set incorrectly
v) Receiver has stopped operating
vi) Port has become dead.

YELLOW indicates that records are arriving but they cannot be processed. Generally, records cannot be processed for one of the following reasons:

i) No master data
ii) Missing remote data and *Line-Up* mode is set to **ALL**
iii) Not enough ephemerides have arrived
iv) Not enough satellites on either master or remote
v) Data intervals do not line up
vi) Master position set incorrectly

DY Indicates if DYNAMICMODE for this receiver is STATIC or KINEMATIC

#SOL Number of solutions that have been processed (using RTK)

STDEV Current standard deviation in metres. This is combined for X, Y and Z and is 1-sigma.

A Indicates if the ambiguities have been fixed (F), are floating (L) or unknown (U)

DATAIN Number of kilobytes of data that has arrived. Should increment if port is connected.

RECIN Number of measurement records that have been decoded.

NSV Number of satellites. First value is number processed, while second value is number tracked. Differences between the two are normally due to a different elevation angle used for processing and tracking. However, missing ephemerides can also cause fewer satellites to be processed.

AGE Seconds since the last valid record was received.

5.3.25 STOP Command

See START command.

5.3.26 TIME Command

This command displays the estimated current GPS time. Due to inaccuracies in receiver and input record latency, this value is only accurate to 50-500 ms. If no valid GPS data is incoming, this value will only display the current CPU time.

Usage:

TIME [REC]

Example:

time

Result:

```
GPS time 72828.970 seconds, Time 20:13:48.970, Date 10/22/2000
CPU time 189900.162 seconds, CPU usage N/A
```

Where:

GPS time	Seconds since the beginning of the week (0-604800)
Time	Current HH:MM:SS.SSS
Date	Current MM/DD/YYYY
CPU time	Result of GetTickCount() windows API function. Seconds since computer startup.
CPU usage	Percentage of CPU that RTKNav is using. Only available for Windows NT or 2000.

5.3.27 UNLOGALL Command

Stops logging all records for a given port. Can also stop logging all records on all ports. The UNLOGREC command is used to stop logging individual records.

Usage:

UNLOGALL P#/THIS/ALL

Example:

unlogall this

5.3.28 UNLOGREC Command

Stops logging a certain record on a given port. Record logging is started via the LOGREC command, RTKNav interface or defined in the .IN file. Use the UNLOGALL command to stop logging all records for a port.

Usage:

UNLOGREC P#/THIS *RecName*

RecName is the name of the record that you wish to stop logging (see LOGREC command or Chapter 6 for a list).

Example:
unlogrec this rtvec

5.3.29 VERSION Command

Shows the current version running. It also shows the current number and maximum number of remotes.

Usage:
VERSION [REC]

Example:
version

Result:
```
RtEngine, Version 2.00, Navigating Mode, 2 Remotes, 3 Maximum Remotes
Copyright NovAtel Inc., 2000
```

5.3.30 WHOAMI Command

This command gives information about the current port that you are connected to. For instance, it can be used to determine the Network Port or comport number

Usage:
WHOAMI [REC]

Example:
Whoami

Result:
```
Port 103 (TCP IP192.166.99.200 P6002)
```

CHAPTER 6 OUTPUT RECORDS

RTKNav can output a number of ASCII NMEA style records. For applications employing more than one remote, the NMEA record(s) are not suggested. This is because they have no identifiers for the remote number. The Waypoint custom records are more suitable since they identify the remote in the record. A summary of the possible records is given as follows:

Record	**Description**	**When written** *	**Interval****
GPGGA	NMEA standard DGPS position record	On Remote	Optional
RTSOL	Geographic position + solution status record	On Remote	Optional
GPAVL	Outputs ECEF position and velocity, as well as local level East, North, and Up among other things.	On Remote	Optional
RTVEC	Base-to-remote local level vector record	On Remote	Optional
RTSLE	RTSOL with some addition status information	On Remote	Optional
RTUTM	UTM remote position record.	On Remote	Optional
RTSIO	Status record of data logging. An interval must be requested for this record	On Interval	Required
RTSAT	Satellite information record	On Remote	Optional
RTATT	Heading or roll, pitch and heading information	On Solution	Optional
RTKAR	KAR information record	On Remote (KAR)	Not suggested
RTKDC	Can be ignored for most applications (KAR distance constraint record)	On Solution	Optional
RTBIN	Output of binary solution structure from RtDLL (see gps_epsol_type structure in engine.h). You may need to request this structure from Waypoint. This record is suitable for C/C++ software programmers.	On Solution	Optional
GPVTG	NMEA standard velocity record	On Remote	Optional
RTSTC	Geographic position and fixes for rtstatic	On Remote	Optional
FUGTAR	Fugawi Network Message	On Remote	Optional
RTVECEX	Delta position and velocity and stats	On Remote	Optional

** This indicates when the results for a record are triggered, where:

On Remote For each remote being processed.

On Solution One record for each epoch (i.e. each time a solution is computed for all remotes).

On Interval This record is only triggered on a specified interval.

* Handling of the data interval field in the LOGREC command or RTKNav dialog boxes.

Section 1 Record Format

The format of records follows the NMEA standard. This is an ASCII record protocol using the following definition:

$*RecName,v1,v2,v3…*XX*

RecName is normally a 5-character record text identifier. Waypoint uses RT to precede its custom records. GP indicates a NMEA GPS record. The items are comma separated. The number of decimals for floating point values is not fixed. Nor is the width of any field fixed. Only the commas should be used to identify separate items. Fields may also be blank (e.g. ",,") if that value is not available for whatever reason. The end of the data is signaled by an asterix ('*'), which is followed by a two character HEX checksum value. The checksum is a bitwise XOR of each of the characters between (but not including) the '$' and the '*'. Finally, there is a carriage return and line feed at the end.

Section 2 Record Descriptions

This section gives a description of each type of record supported by RTKNav. The most commonly used records are RTSOL, RTVEC, RTUTM and GPGGA. See also NMEA-0183 document for the NMEA records (i.e. GPGGA and GPVTG).

6.2.1 GPGGA Record

This is the NMEA geographic position record (NMEA 0183, Global Positioning System Fix)

Format:

$GPGGA,*hhmmss.ss,lat,N/S,long,E/W,qf,nsats,pdop,ht,M,,,age,# *XX*

Where:

hhmmss.ss	Solution time in UTC HMS. May be GPS time if UTC correction not available.
lat	Latitude in (*ddmm.mmmmmm*)
long	Longitude in (*ddmm.mmmmmm*)
qf	GGA quality factor: 0 NO solution 1 Single point solution (SPS) 2 DGPS solution 3 PPS DGPS solution 4 RTK with fixed integers (KAR valid) 5 Float RTK
nsats	Number of satellites
pdop	Position dilution of precistion
ht	Ellipsoidal height in metres (may be pseudo-orthometric if base height entered as orthometric).
age	Age of differential solution in seconds.
#	This indicates the remote number (i.e. R1, R2 …).
XX	Checksum (hex).

Example:

```
$GPGGA,171747.00,5058.7165714,N,11400.6999986,W,5,6,1.53,1015.065,M,,,0.1,2*03
```

6.2.2 RTSOL Record

This record outputs the geographic position, velocity and status information for each remote solution. It is one of the most often used records.

Format:

$RTSOL,*gpstime*,R*#*,*phi*,*lamda*,*ht*,*sdh*,*sdv*,*ve*,*vn*,*vh*,*nsats*,S/K,*qf*,*dd_dop*,*status*, *latency***XX*

Where:

gpstime	Solution time in GPS seconds of the week. This position may be latent by the time estimated in the RTSIO records (*latency*).
R*#*	This indicates the remote number (i.e. R1, R2 …).
phi	Latitude in decimal degrees.
lamda	Longitude in decimal degrees.
ht	Height in metres.
sdh	Horizontal standard deviation (1 sigma) in metres.
sdv	Vertical standard deviation in metres.
ve,*vn*,*vh*	East, north and vertical velocity in m/s. Vehicle track can be computed from the *ve* and *vn* quantities (e.g. atan2(ve,vn)).
nsats	Number of satellites used in the solution.
S/K	Mode: static (S), kinematic (K).
qf	Quality factor: best (1), worst (6), no RTK solution (7).
dd_dop	Double difference DOP ≈ $PDOP^2$.
status	No solution (0), single point (1), DGPS (2), RTK (3), RTK(errors) (4)
latency	Estimated latency of the last solution (how far behind). This value does not take into account the latency within the GPS receiver and the transmission time of this record.
XX	Checksum (hex). Same definition as NMEA (bitwise XOR between and not including the $ and *).

Example:

$RTSOL,150210.00,R1,50.97861102,-114.01166575,1015.056,0.082,0.113,-0.06,0.00,-0.12,6,K,3,1.94,3,0.040*4C

6.2.3 GPAVL Record

The format of the GPAVL record is as follows:

R#,*utc*,*lat*,*lon*,*ht*,*veast*,*vnorth*,*vup*,*gpstime*,*xecef*,*yecef*,*zecef*,*vxecef*,*vyecef*,*vzecef*,*checksum*

Where,

R#	Remote number (R1, R2…)
Utc	UTC milliseconds of the day
Lat	latitude – degrees
Lon	longitude – degrees
Ht	Height – meters
Veast	Velocity East

Vnorth	Velocity North
Vup	Velocity Up
Gpstime	seconds of the week
Xecef	X ECEF coordinate
Yecef	Y ECEF coordinate
Zecef	Z ECEF coordinate
Vxecef	X ECEF velocity
Vyecef	Y ECEF velocity
Vzecef	Z ECEF velocity
Checksum	Checksum[cr][lf]

6.2.4 RTVEC Record

The RTVEC record outputs the local level vector between the master and remote. This vector is computed as follows:

X,Y	Rotate ECEF master->remote vector to local level using geographic position of master
Z	Difference between remote and master elevation.

This record can be useful for range and bearing applications.

Format:

$RTVEC,*gpstime*,R#,*east*,*north*,*up*,*sdhz*,*sdv*,S/K,*nsats*,*qf*,*status***XX*

Where:

gpstime	Solution time in GPS seconds of the week. This position may be latent by the time estimated in the RTSIO records (*latency*).
R#	This indicates the remote number (i.e. R1, R2 …).
east	East coordinate value with respect to master station (metres).
north	North coordinate value with respect to master station (metres).
up	Vertical coordinate value with respect to master station (metres).
sdh	Horizontal standard deviation (1 sigma) in metres.
sdv	Vertical standard deviation in metres.
nsats	Number of satellites used in the solution.
S/K	Mode: static (S), kinematic (K).
qf	Quality factor: best (1), worst (6), no RTK solution (7)
status	No solution (0), single point (1), DGPS (2), RTK (3), RTK(errors) (4)
XX	Checksum (hex).

Example:

```
$RTVEC,151180.00,R1,0.000,-0.002,0.001,0.019,0.024,K,6,1,3*4A
```

6.2.5 RTSLE Record

The RTSLE record contains everything that the RTSOL record has, and it has additional quality control variables inserted at the end.

Format:

$RTSLE,*gpstime*,R*#*,*phi*,*lamda*,*ht*,*sdh*,*sdv*,*ve*,*vn*,*vh*,*nsats*,S/K,*qf*,*dd_dop*,*status*,F/L/U,*CaRms*,*L1Rms***XX*

Where:

gpstime	Solution time in GPS seconds of the week. This position may be latent by the time estimated in the RTSIO records (*latency*).
R#	This indicates the remote number (i.e. R1, R2 …).
phi	Latitude in decimal degrees.
lamda	Longitude in decimal degrees.
ht	Height in metres.
sdh	Horizontal standard deviation (1 sigma) in metres.
sdv	Vertical standard deviation in metres.
ve,vn,vh	East, north and vertical velocity in m/s. Vehicle track can be computed from the *ve* and *vn* quantities (e.g. atan2(ve,vn)).
nsats	Number of satellites used in the solution.
S/K	Mode: static (S), kinematic (K).
qf	Quality factor: best (1), worst (6), no RTK solution (7)
dd_dop	Double difference DOP ≈ $PDOP^2$.
status	No solution (0), single point (1), DGPS (2), RTK (3), RTK(errors) (4)
F/L/U	Fixed integer ambiguity status: fixed (F), float (L), unknown (U)
L1Rms	L1 carrier RMS (m)
CaRms	C/A code RMS (m)
XX	Checksum (hex). Same definition as NMEA (bitwise XOR between and not including the $ and *).

Example:

$RTSLE,150390.00,R1,51.0,-114.0,1014.9991,0.020,0.026,-0.02,-0.05,-0.03,6,K,1,1.83,3,F,0.77,0.0020*3E

6.2.6 RTUTM Record

This record contains the position expressed in the Universal Transverse Mercator projection. Currently, the zone is picked automatically for each remote. Therefore, position near the zone boundary may result in different zones for different remotes. In the future, a SETZONE command may be added to the command port interface.

Format:

$RTUTM,*gpstime*,R*#*,*east*,*north*,*ht*,*zone*,*sdh*,*sdv*,*nsats*,S/K,*qf*,*dd_dop*,*status*,*F/L/U***XX*

Where:

gpstime	Solution time in GPS seconds of the week. This position may be latent by the time estimated in the RTSIO records (*latency*).
R#	This indicates the remote number (i.e. R1, R2 …).
east,north	UTM easting and northing (m)
ht	Height in metres.

zone	UTM zone number 1-60
sdh	Horizontal standard deviation (1 sigma) in metres.
sdv	Vertical standard deviation in metres.
S/K	Mode: static (S), kinematic (K).
qf	Quality factor: best (1), worst (6), no RTK solution (7).
dd_dop	Double difference DOP ≈ $PDOP^2$.
F/L/U	Fixed integer ambiguity status: fixed (F), float (L), unknown (U)
XX	Checksum

Example:
$RTUTM,151200.00,R2,709766.8985,5651698.0642,1014.9992,11,0.0189,0.0242,6,K,1,146,3,F*37

6.2.7 RTSIO Record

This record is used to obtain the age of the last solution and latency of the remote solutions. Since solutions for multiple remotes are solved simultaneously, the latency will be the same for all. This record can also be used to determine the GPS time of the last incoming record. The STATUS command is usually better suited for this, but RTSIO can be used as well.

Format:

$RTSIO,*gpstime*,*age*,*latency*,*num*,M,*time*,*nsats*,R1,*time*,*nsats*,R2, *time*,*nsats*…**XX*

Where:

gpstime	Solution time in GPS seconds of the week. This position may be latent by the time estimated in the RTSIO records (*latency*). May not be on the whole interval.
age	Seconds since last solution computed. Will increase if base or one of the remotes is not tracking or receiving.
latency	Estimated latency of the last solution (how far behind). This value does not take into account the latency within the GPS receiver and the transmission time of this record.
num	Number of stations to follow.
XX	Checksum (hex).

For each station:

M or *R#*	Master or Remote Number.
time	Time of last incoming record (GPS seconds of the week).
nsats	Number of satellites tracked.

Example:
```
$RTSIO,149935.9,0.155,0.040,3,M,149935.8,5,R1,149935.8,7,R2,149935.8,5*31
```

6.2.8 RTSAT Record

This record lists the available satellites for a remote. It indicates the number of satellites used for processing and the elevation, azimuth, locktime and ambiguity for each.

Format:

$RTSAT,*gpstime*,R*#*,*nsats*,*prn*1,*elev*1,*az*1,*amb*1,*lock*1,*prn*2,*elev*2,*az*2,*amb*2,*lock*2…**XX*

Where:

gpstime	Solution time in GPS seconds of the week. This position may be latent by the time estimated in the RTSIO records (*latency*).
R#	This indicates the remote number (i.e. R1, R2 …).
nsats	Number of satellites used in the solution (4 values per satellite to follow)
XX	Checksum (hex).

For each satellite:

prn	Satellite PRN number
elev	Satellite elevation in degrees
az	Satellite azimuth in degrees
amb	Satellite ambiguity in cycles (only shows last one thousand cycles e.g. –1000.0 to 1000.0)
lock	Seconds since the last cycle slip (may be 255 max).

Example:

$RTSAT,149580.00,R2,5,25,67,148,0.0,255,29,30,77,350.3,255,21,11,129,706.4,255,11,35,227,474.9,255,30,21,58,-666.4,255*31

6.2.9 RTATT Record

This record is used to output the roll, pitch and heading in 3-D attitude determination mode or the heading in moving baseline heading determination mode. In heading mode, future versions may also include a pseudo-pitch value.

Format:

$RTATT,*gpstime*,*roll*,*pitch*,*heading*,*roll_sd*,*pitch_sd*,*heading_sd*XX*

Where:

gpstime	Solution time in GPS seconds of the week. This position may be latent by the time estimated in the RTSIO records (*latency*).
roll	Roll value (right handed system—left wing up=positive) (degrees)
pitch	Pitch value (right handed system—nose up=positive) (degrees)
heading	Heading value=-*yaw* (left handed—CW turn=positive) (degrees)
roll_sd	Estimated roll standard deviation (degrees)
pitchl_sd	Estimated pitch standard deviation (degrees)
heading_sd	Estimated heading standard deviation (degrees)
XX	Checksum (hex).

Note that if unavailable, a blank will be displayed for the value.

Example:

```
$RTATT,453921.0,,,179.92,,,1.21*FF
```

6.2.10 RTKAR Record

Gives KAR status after a solution has been tried. The frequency of KAR solutions can be controlled with the KAR_EPOCH_SIZE command in the .CFG file.

Format:

$RTKAR,*gpstime*,R#,*rms*,*rel*,P/F,*fltfixed*,*sec_used*,*sec_engaged*,*avg_sats*,S/D**XX*

Where:

gpstime	Solution time in GPS seconds of the week. This position may be latent by the time estimated in the RTSIO records (*latency*).
R#	This indicates the remote number (i.e. R1, R2 …).
rms	RMS of best intersection (cycles). Should be 0.07 or less.
rel	Second best RMS divided by the best RMS. Should be 1.5 or better.
P/F	Indicates whether this solution has passed (P) or failed (F).
fltfixed	Separation between float and fixed integer solution. This number may vary greatly depending on how accurate the float solution is.
sec_used	Number of seconds used for the KAR solution.
sec_engaged	Number of seconds since KAR was engaged.
avg_sats	Average number of satellites used.
S/D	Single (S) or dual (D) frequency KAR solution.
XX	Checksum (hex).

Example:

```
$RTKAR,150135.60,R2,0.008,1.63,F,0.04,57.599998,571.099976,5.0,S*39
```

6.2.11 RTKDC Record

Distance constraint KAR solution info. This indicates how well the distance constraints worked.

Format:

$RTKDC,*gpstime*,*All*P/F,*amb*P/F,*reliability*,*rel*P/F,*NumInt*XX*

Where:

gpstime	Solution time in GPS seconds of the week. This position may be latent by the time estimated in the RTSIO records (*latency*).
*All*P/F	Indicates if all tests passed (P) or failed (F).
*amb*P/F	Indicates if the ambiguity constraint passed (P) or failed (F).
reliability	Reliability number (should be 1.5 or greater).
*rel*P/F	Indicates if the reliability passed (P) or failed (F).
NumInt	Number of intersections found passing distance constraints.
XX	Checksum (hex).

6.2.12 RTBIN Record

This record delivers to the user the complete binary solution structure for a given epoch. This structure contains the solutions for all of the remotes. Because this structure is quite large (especially for 20 remotes), RTBIN is mainly suitable for TCP/IP communications. The

definition of this structure (called gps_epsol_type) is given in engine.h, which comes as part of the developer's kit. However, users may request access to this structure without purchasing the kit. The structure is packed using a simple algorithm to minimize bandwidth. Therefore, this record is only suitable for software developers. Note that the gps_epsol_type structure is packed on the one byte boundary (/Zp1).

Format:

$RTBIN,*NumRemotes,MaxRemotes,StructSize,DataSum,Data…*XX*

Where:

NumRemotes	Current number of remotes in use. Value is in HEX.
MaxRemotes	Maximum number of remotes allowed with this version of RTKNav. Value is in HEX.
StructSize	Number of bytes in unpacked structure. This can be used as a check against your structure size and the unpacked buffer should also be this size. Value is in HEX.
DataSum	This is a 16 bit unsigned value stored in HEX. It is a sum of all of the data bytes in the buffer before packing. It can be used as a check to in addition to the NMEA 8 bit checksum.
Data…	See Unpacking Data below
XX	Checksum (hex).

Example:

```
$RTBIN,2,3,13F0,1069,ð13##03<0030C<007L;0241=<00311<0031D<009+@0A<00317<003Ð07{
001E03<00308<007"1A{002601<003:íþ43}I@5Bò‹%¿€\À#À}44WGS3834<00E@¦TX41¿}1D14Ä?X4
1[001C4L;0241<00608@qÖý!43}I@ÝäÙ%¿€\À#àm07Ð· @§®1Cõ11`¨?Ÿ]¤ùT|¦?ô®01è+
²?âô§08³È|¿07~ Y¯1D ?0F04È':14 ?V nkæ14Ö?þ-
wd¬35Û?×.>i10Oæ?IK&Èât¿;ˆÎi„0C‹?<003`]ý—¿02<006`1Ayø?õ¢ö¹08ù„?ü0A¨›`éS?£÷—
òÉ43ð?{003CèÖ<006èÖ<00601[0010306<00319™05„4214V1743
<00Dào@{00381DP45#42²¥˜42?"ôu¿€À<005ào@{0038153723J41æ`#43€‹¸àš?,À<005ào@{00380
B30b1442432Ce43À,m‰ ? À<005ào@{00381Eý0Aª4124žr42€)õ±24¯ŒÀ<005ào@{003814ßî"42l0
2–
43@^…131CoŠÀ<005ào@[0021E®þFFFFK;0241<00608@¿°'"43}I@Y©u24¿€\À#@Íµõ· @l‹01ý06ð¥
?0CµN—ûW¤?Ê,09õ08—
°?h1C^Ÿ\7BS¿§¢o«Hè ?Ëô± ±š§?3945#14ËxÕ?ä÷31 M34Ú?†ò›žú23å?³0D-
1D;¤'?l,Œ10|~ ?<003À¶˜t¿02<006`1Ayø?ñÝÐ«l•‹?1C>Þv453C5B?"31˜¤ø—
á?{003CíÖ<006íÖ<00601[0010306<00319™05„4214V1743<00Dào@{00381DP45#42²¥˜42#240C3
5Úáu@<005ào@{0038153723J41æ`#43#36K0F€10†@<005ào@{00380B30b1442432Ce43ÀY0E37ßž}
@<005ào@{00381Eþ0Aª4124žr42#ã(NÝÖ„À<005ào@{003814ßî"42l02–
43#11À13 @À<005ào@[007EAøSã%©36104135^ºÉ¨361041*F7
```

Unpacking Data:

To pack the data, the following rules are used:

Character Encountered	What to do
Translated characters (expand to one byte):	
0-9,A-F	Hex nibble (always in pairs). Decode hex byte
#	Byte 00
Repeat characters (expand to many bytes):	

<CCR	Up to 15-character repeat. '<' character followed by 3 hex values. First two values (CC) refer to the hex byte value. R is the number of repetitions (0-15)
{CCRR	Up to 255-character repeat. '{' character followed by 4 hex values. First two values (CC) refer to hex byte value. RR refers to repeat count (16-255)
[CCRRR	Up to 4095 character repeat. '[' character followed by 5 hex values. First two values (CC) refer to hex byte value. RRR refers to repeat count (256-4095)

Finished:

*	Decoding complete. End of NMEA data identifier.

Otherwise (expand to one byte):

Ch	Read byte directly. For example, character 'u' would translate to a byte value of 117, etc… Use the ASCII table for your computer+character set.

6.2.13 GPVTG Record

This is the NMEA velocity record (NMEA 0183, Global Positioning System Fix)

Format:

$GPVTG,*COG,T,MCOG,M,SpeedKnots,N,SpeedKmh,K,CRLF*XX*

Where:

COG	True course over ground, 000 – 359 degrees
MCOG	Magnetic course over ground, 000 – 359 degrees
SpeedKnots	Speed over ground, 00.0 to 999.9 knots
SpeedKmh	00.0 to 1851.8 ko/hr
**XX*	Checksum

Example:

$GPVTG,240.81,T,,M,8.12,N,15.03,K*63

6.2.14 RTSTC Record

This record gives geographic information with the time in seconds since 1980 as well as statistics. This is suited for RTStatic applications. Output occurs after every fixed solution.

Format:

$RTSTC,*1980sec,R#,PassFail,lat,lon,ht,fixed_lat,fixed_lon,fixed_ht,sdhz,sdv,rms,rel*XX*

Where:

1980sec	Seconds since 1980
R#	Remote baseline number
PassFail	Passed or Failed String
lat	Latitude in dms (filtered)
lon	Longitude in dms (filtered)

ht	Height in meters
fixed_lat	Latest fixed latitude (dms, unfiltered)
fixed_lon	Latest fixed longitude (dms, unfiltered)
fixed_ht	Latest fixed height (meters, unfiltered)
sdhz	Standard deviation in east + north (meters)
sdv	Standard deviation height (meters)
rms	Fixed solution RMS in meters
rel	Fixed solution reliability in meters
**XX*	checksum (hex)

Example:
$RTSTC,735883290.00,R4,PASSED,34 20 00.31919,-118 01 33.59092,1567.935,34 20 00.31919,-118 01 33.59092,1567.935,0.003,0.005,0.017*0D

6.2.15 FUGTAR Record

This is the Fugawi Network Message – Fugtar for Tracker 3

Format:

$PFUGTAR,*latdegmin,N_S,londegmin,E_W,R#,R#,speed,COG,CCCCCCCC*

Where:

Latdegmin	Latitude in degrees decimal minutes
N_S	North (N) or South (S) hemisphere for latitude
Londegmin	Longitude in degrees decimal minutes
E_W	East (E) or West (W) flag for longitude
R#	Remote baseline number
Speed	speed in m/s
COG	Course-over-ground
CCCCCCCC	default

Example:
$PFUGTAR,3420.0905,N,11823.8120,W,R5,R5,000.0,167.0,CCCCCCCC

6.2.16 RTVECEX Record

This record contains delta position and velocity information. The deltas are always with respect to the base station coordinates.

Format:

$RTVECEX,*GPSTime,R#,DelEast,DelNorth,DelHt,SDevHoriz,SDevVert,VelEast,VelNorth,VelHt,SDevHorizVel,SDevVertVel,SK,NumSats,qf,status,*XX*

Where:

GPSTime	GPSTime in seconds of the week
R#	Remote baseline number

DelEast	Delta Easting in meters
DelNorth	Delta Northing in meters
DelHt	Delta Height in meters
SDevHoriz	Standard Deviation of horizontal position
SDevVert	Standard Deviation of vertical position
VelEast	East Velocity (m/s)
VelNorth	North Velocity (m/s)
VelHt	Height Velocity (m/s)
SDevHorizVel	Standard Deviation of horizontal velocity (m/s)
SDevVertVel	Standard Deviation of vertical velocity (m/s)
SK	Mode: static (S), kinematic (K).
NumSats	Number of Satellites
qf	Quality factor: best (1), worst (6), no RTK solution (7)
status	No solution (0), single point (1), DGPS (2), RTK (3), RTK(errors) (4)
**XX*	Checksum (hex)

Example:
$RTVECEX,432120.00,R8,10067.421,-28873.794,-253.255,5.733,10.867,0.004,-0.000,-0.007,7.755,5.503,K,7,3,3*42

CHAPTER 7 RTDLL

Section 1 RtDLL – Getting Started

The RtDLL is a Windows 95/NT Dynamic Link Library (DLL) that encompasses the Waypoint Group's processing engine. This engine facilitates combined GPS code and carrier phase processing, which attains accuracies much higher than conventional DGPS. The purpose of this product is to give GPS integrators the ability to add Real-Time Kinematic (RTK) capabilities to their own application. Accuracies as high as a few centimetres can be attained.

The DLL is called RtGps#.dll, where # refers to the maximum number of remotes supported by the DLL version. The header files Engine.h, Engproto.h, Eph.h and Gps_io.h are required to call the DLL.

1. Sample source and copying files

Create the following directories:

.\Sample	Holds sample source (Sample.zip)
.\RtDll3	Holds 3 remote DLL and header files (RtDll3.zip)
.\Data	Holds test data (Data.zip)
.\Hardlock	Hardware lock files (Hardlock.zip)

The 'C' source file Testeng.c located in the .\Sample directory is an example how to use the DLL. This example reads data files from the disk, and it is important that the master and remote data files start within a few seconds of each other. It processes two remotes with one base.

This example can be compiled using the Makefile provided. It may have to be modified slightly to conform to your compiler.

Run the example as follows:

```
TestRt ..\data\test.in
```

This processes the two remotes and sends data to the following files:

test.out	Complete ASCII output record originating form the DLL
test.ann	Warning and status messages originating from the DLL
test.sio	Simulation of serial records originating from testeng.c

For processing, the hardware lock is also required. This lock must be placed on the LPT1 port of the computer doing the processing. If a parallel port lock is inconvenient, then a PCMCIA variant is also available. For Windows 95, copy the file hardlock.vxd to your Win95 system directory. For Windows NT, run the program hl_inst from the directory containing the device driver (hlvdd.dll). This is done as follows:

```
hl_inst .
```

2. Programming for the DLL

When developing your application for use with the RtDLL, there are a few important considerations:

- The user must open and log data from the serial ports
- Use the Win32 LoadLibrary() and GetProcAddress() functions to allow usage of the DLL functions.
- They must also decode the raw GPS data originating in the GPS receiver's format and fill GPB structures (See Section 3). In many cases, there may be a library of our source available from the Waypoint Products Group, NovAtel Inc. for doing this.
- The user must either:
  a) Wait for all data records to arrive and process an epoch using the ProcessEpochData() function

  or

  b) Add the data to the buffers as it arrives, and use the ProcessEpochBuf() function to line the data up internally. This is an easier approach, since much of the difficult programming is performed within the DLL

The entire process described above should be at least its own thread. This ensures that data will not be lost as other portions of your program are performing complex tasks. The decoding of the data for each of the GPS receivers (Master and *n* remotes) and the processing could be their own thread. However, if this is done, then it is vital the Functions AddDataToBuf() and ProcessEpochBuf() are not used simultaneously from different threads.

An easier approach is to make the entire process one thread. An example employing two remotes is shown in Figure 7.1. In such an implementation, it is important that the serial port buffers can contain at 1-2 seconds of data. The RtEngine program uses 8K buffers. The black boxes indicate Win32 functions. The grey boxes indicate your own functions, while the while boxes are RtDLL functions.

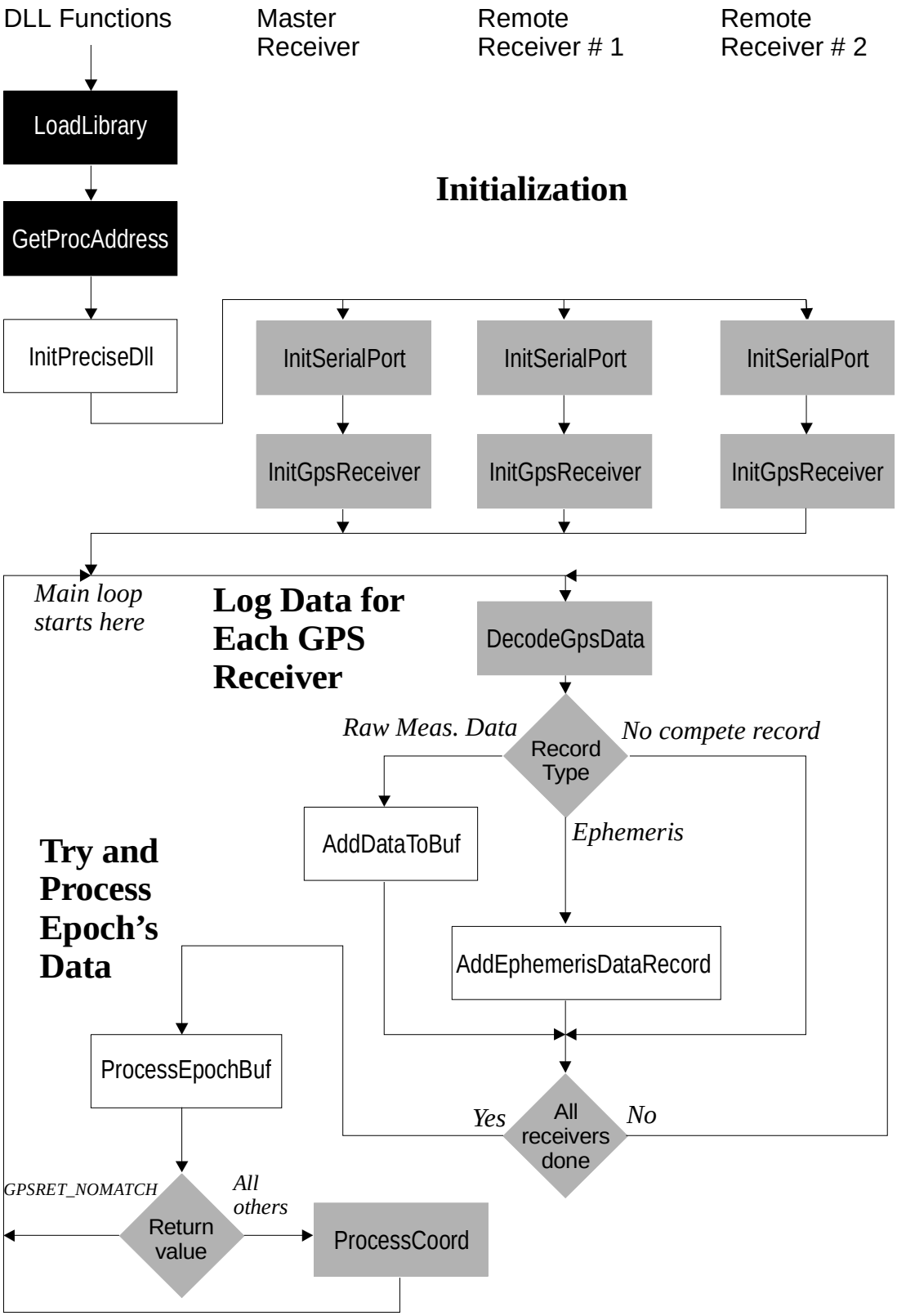


Figure 7.1: Single thread buffered RtDll implementation

A description of each of the grey boxes is given as follows:

InitSerialPort This opens the serial device driver that you are using. You may use your own, that of Windows 95 or NT or from an external provider (e.g. Greenleaf).

InitGpsReceiver This routine should send the commands to initialize the GPS receiver and start logging.

- **For NovAtel**: The RGEC or RGEC and REPB records must be logged. The CLKB can also be logged to obtain the clock bias (which is normally very small).
- **For Ashtech (G12)**: The SNV, MBN and PBN records are required
- **For CMC**: Records 22 and 23 are required.
- **For Motorola**: The @@Eg and @@Bf records are required.
- **For the Rockwell Jupiter**: The 1102 record is required
- **For NavSymm**: The Output Format #2 is required

DecodeGpsData This routine will take the raw binary records from a particular GPS receiver, and convert to the GPB structures (pben_bin_type & mben_bin_type), which are passed on to the DLL. It is important that there are no while loops in this routine and it should return if not enough bytes have been decoded for a particular record. Once complete, the record (in Waypoint's format) should be passed on to the DLL using the AddDataToBuf() or AddEphemerisDataRecord() functions.

ProcessCoord This function would take the gps_epsol_type output of ProcessEpochBuf() and pass the position etc… onto another program area.

Some other important issues to consider are described in parts 3 onwards:

3. Static/Kinematic

The RtDll makes an important distinction whether the antenna is stationary (static) or moving (kinematic), and it can be detrimental to process kinematic data while set to static. Therefore, bit 1 of the *status* variable must be set properly in the pben_bin_type structure (see Section 3). The user must set this. If the user is not sure whether the antenna will be static or kinematic, then using kinematic is always safer.

4. Decoding the data

Decoding the data involves taking the stream of serial bytes originating from the GPS receiver, and extracting important formation. It is important to check any checksums. Once the record has been completely obtained, then useful information (times, pseudoranges, carrier phase, etc…) must be extracted into the GPB file structures (see Section 3). Unless each decoder is on its own thread, it is not very good to use while loops in the decoding process.

5. Lining up the data

If the ProcessEpochData() function is used, then the user must externally line up the data. This means that records for the Master and all Remotes must be accumulated for a given epoch before processing can continue. This function also requires that data from all remotes

be present. Another function will soon be added that facilitates computations for individual remotes. However, the easiest method is to use the function described in 6, which is an internal data buffering scheme.

6. Data Buffering

Data buffering allows *N* epochs of data to be stored internally by the DLL for the Master and all Remotes. This makes it easy to find matching data records for all of the stations. It also allows for more flexibility if the CPU for some reason falls behind.

To enable buffering, bit 11 of the ProcessMode parameter passed to InitPreciseDll() function must be set (use the PROCESS_DATABUFR to AND with other process options). The number of data buffers (i.e. number of epochs) can be controlled with the NUM_DATA_BUFFERS command in the .CFG file (passed with the InitPreciseDll() function).

The AddDataToBuf() function is used to add a measurement record to the buffers, while the ProcessEpochBuf() function will process using data from the buffers. This function will select the oldest match of records for which data from master and all remotes can be found.

7. Ephemeris

The ephemeris is the functional specification of the satellite path. For GPS, each satellite has a set of parameters that change every hour. RtDll cannot make any computations until at least one ephemeris has been obtained for 4 or more satellites. Therefore, when starting your application, it is important to ask for all of the ephemeredes form at least one GPS receiver. After that, ephemeredes should be requested as they change (on change) or every 10 minutes or so. Normally, the on change method is used.

8. Master Station Position

Before computations can be made, the position of the master station is required. This can either be set in the .CFG file or using the SetMasterCoord() function. In either case, the position should be in the same datum as that defined in the .CFG file (normally WGS84).

If the master station position is erroneously defined (more than a few 100 metres in error), then it can cause the program to develop numerical instabilities. If the master station is on the wrong part of the earth (i.e. wrong sign on the latitude or longitude), then error (GPSRET_TOOFEWSATS may be continually returned from ProcessEpochData() or ProcessEpochBuf(). If not defined, then GPSRET_NOMASTER will be returned from these functions.

Section 2 RtDLL – List of Functions

This chapter lists the functions that can be used within the DLL. Each function's purpose is given along with input output and return variables. Use the Win32 load Library and GetProc Address routines to gain access to these functions.

1. InitPreciseDll

```
DLL_INT InitPreciseDll( char *cfgfile, char *cfgstr, int
num_remote,
                        int ProcessMode )
```

Purpose: This function must be called after loading the DLL and before any other functions are used. It allocates all memory structures and loads configuration information.

Input: cfgfile - .CFG file name (char *) *or*
cfgstr – Null terminated string containing configuration commands (char *)
Each command is "/n" separated,
eg: "DATUM = WGS84\nELEV_MASK = 10.0\n…"
num_remotes – Number of remotes to process (int)
ProcessMode – Mode of processing (use PROCESS_??? in engine.h): (int)
Bits 0-5: frequency
Bits 6-8: static process mode
Bits 9-10: kar mode
Bit 11: enable data buffering

Return: (int)
0 – success
1 – failure (use GetLastGpsError())

2. ProcessEpochData

```
DLL_INT ProcessEpochData( gps_epoch_type *MasterData, int
num_remote,
                          gps_epoch_type *RemoteData,
                          gps_epsol_type *Solution )
```

Purpose: Processes an epoch of raw data from the master and remotes. Data from master and all remotes must be present and be from the same epoch. The user must line the times up prior to calling this function. If this is too cumbersome, use the ProcessEpochBuf() function.

Input: MasterData – GPS raw data for master station (epoch_data_type *)
num_remote – Number of remotes to follow (must be same as that passed to InitPreciseDLL() (int).
RemoteData – Array of raw data structures for remote station (epoch_data_type *)

Output: Solution – Solution structure (see Section 3) (gps_epsol_type *)

Return: (int) see GPSRET_???
Use GetLastGpsError() to retrieve error messages for return values other than GPSRET_SUCCESS

Possible return values:

```
#define GPSRET_SUCCESS    0   // solution ok
#define GPSRET_LSQSUCCESS 10  // Successful Least Squares solution
(ProcessEpochMsBufEx only)
#define GPSRET_FAILURE    -1  // serious failure (further problems may be encountered)
#define GPSRET_DATAPROB   1   // data error, unable to decode data
#define GPSRET_TOOFEWSATS 2   // Not enough satellites or similar effect
#define GPSRET_DGPS       3   // C/A code solution obtained (1-5 m)
#define GPSRET_KARFAILED  4   // Filtered solution, but KAR failed
#define GPSRET_BADSOL     5   // Solution structure may contain errors
#define GPSRET_DATAERRORS 6   // Raw data contained errors, solution could be out
#define GPSRET_NOKEY      7   // No hardware key found
#define GPSRET_NOMASTER   8   // No coordinates on master station
#define GPSRET_NOMATCH    -2  // ProcessEpochBuf() only, no data lined up, try again
#define GPSRET_BUFERROR   -3  // Error occurred during data buffer reading
```

3. ProcessEpochBuf

```
DLL_INT ProcessEpochBuf( gps_epsol_type *Solution )
```

Purpose: This function is similar to ProcessEpochData(), except that the data is obtained from the internal data buffers. Use the function AddDataToBuf() to add data to buffers. This function requires that data be present for Master and all Remotes for a solution to be computed for a given epoch. Otherwise, the GPSRET_NOMATCH is returned. The oldest unprocessed data will be selected.

Output: Solution – Solution structure (see Section 3 , Structure 2)
(gps_epsol_type *)

Return: (int) see GPSRET_???
Use GetLastGpsError() to retrieve error messages for return values other than GPSRET_SUCCESS

4. ProcessEpochMsBuf

```
DLL_INT ProcessEpochMsBuf( gps_epsol_type *Solution,
                           long Milliseconds )
```

Purpose: The function acts like ProcessEpochBuf, but it does not require that all of the data exist in the data buffers. It will pick the use any remotes arriving within a window of ‘n’ milliseconds. All remotes must be present for the first epoch to initiate the Kalman filter.

Input: Milliconds – Window time after which remote records will not be processed

Output: Solution – Solution structure (see Section 3 , Structure 2)
(gps_epsol_type *)

Return: (int) see GPSRET_???

Use GetLastGpsError() to retrieve error messages for return values other than GPSRET_SUCCESS

5. ProcessEpochsMsBufEx

Purpose: The function is similar to ProcessEpochBuf. However, it also extrapolates the master station data in order to minimize latency. This is a very new function, and is still considered BETA. It currently also only works with two or more remotes (i.e. not with one). This function would be used when the master data is arriving much later than the remotes. A least squares solution is computed for remotes arriving within a 'n' millisecond window. When the master data arrives, then another solution will be produced. This is the Kalman filter solution. KAR would also computed at this time. This methodology can also be used to output solutions at a higher data rate than the base arrives. For example, remote data could arrive at 10 Hz, while master data could arrive at 1 Hz. Using the previous 3 lining up methods, solution output would only be available at 1 Hz. For the ProcessEpochMsBufEx function, data could be output at 10 Hz. The command EXTRAPOL_EPOCHS must be used with this function (see Section 3).

Input: Milliconds – Window time after which remote records will not be processed

Output: Solution – Solution structure (see Section 3 , Structure 2) (gps_epsol_type *)

Return: (int) see GPSRET_???
Use GetLastGpsError() to retrieve error messages for return values other than GPSRET_SUCCESS or GPSRET_LSQSUCCESS

6. AddDataToBuf

```
DLL_INT AddDataToBuf( int station, int remote_number,
                      gps_epoch_type *RawData )
```

Purpose: This function adds an epoch of data to the buffers. Raw GPS data can be added either for the MASTER or REMOTE # *n*. Data should be added as it is decoded from the GPS receiver. Use the .CFG parameter NUM_DATA_BUFFERS to control how many epochs of data are to be buffered. Normally 10-15 seconds of data are sufficient.

Input: station – This is either MASTER (1) or REMOTE (0) (int)
remote_number – For the REMOTE station, this is remote number starting from zero this parameter is ignored for the MASTER (int).
RawData – Raw GPS measurement data (gps_data_type *)

Return: 0 – success
1 – Data could not be added to buffers (see GetLastGpsError())

7. AddEphemerisDataRecord

```
DLL_INT AddEphemerisDataRecord( eph_type *EphData )
```

Purpose: This function is used to add an ephemeris structure (see eph.h) to the DLL. These will change every hour for each satellite. A satellite cannot be used until an ephemeris record has been added. Duplicate ephemeris records will be ignored. Currently there are no purging capabilities in the DLL and memory will continually be used as new ephemeris records are added.

Input: EphData – Ephemeris data (eph_type *)

Return: Number of unique ephemeris records received

8. AddEphemerisEppFile

```
DLL_INT AddEphemerisEppFile( char *EppFile )
```

Purpose: This function can be used to add ephemeris data stored in an .EPP file. This is a Waypoint format that can be obtained by contacting the Waypoint Products Group, NovAtel Inc.

Input: EppFile – File name (char *)

Return: -1 on error (see GetLastGpsError())
or
Number of unique ephemeris records received

9. GetLastGpsError

```
DLL_VOID GetLastGpsError( char *ErrStr )
```

Purpose: This function retrieves the last error message

Output: ErrStr – String to contain error message. Should be at least 256 character long (char *)

Return: (void)

10. ClosePreciseDll

```
DLL_VOID ClosePreciseDll()
```

Purpose: Frees all memory structures. The windows CloseLibrary() function will also free memory.

Return: (void)

11. WhatIsInDataBuffers

```
DLL_INT WhatIsInDataBuffers( buf_list_type *BufList )
```

Purpose: This function can be used to interrogate what data currently exists in the memory buffers. If ProcessEpochBuf() continually returns a GPSRET_NOMATCH, then this function can be used to determine which station is not receiving data.

Output: BufList – array of buf_list_type structures
BufList[0] = master
BufList[1] = remote#1
BufList[2] = remote#2
:
This array must be allocated num_remotes+1

Return: (int) Number of records filled

12. SetMasterCoord

```
DLL_VOID SetMasterCoord( double phi, double lamda, double
height,
                         double ant_ht )
```

Purpose: This function can be used to define the position of the Master station. This must be set before processing can start. If the master position is set in the .CFG file, calling this function will be ignored. It will also be ignored if this function has already been called (i.e. the master station position cannot be changed once defined). It is important that this position be in the same datum as defined in the .CFG file. Normally this is WGS84.

Input: phi – Latitude in degrees, +ve north, -ve south (double)
lamda – Longitude in degrees, +ve east, -ve west (double)
ht – elevation in metres (double)
ant_ht – Height of the antenna in metres (double)

Return: (void)

Section 3 RtDLL – Data Structures

The following structures are used for input and output into DLL functions.

1. Input Structures

a) GPB structures (gps_io.h)

These structures hold the raw GPS measurement data. There are three structures used:

header_bin_type	Header information (first record in a .GPB file)
pben_bin_type	Position record (contains time, position and clock info)
mben_bin_type	Raw measurement record (1 per channel tracked)

i) header_bin_type (header information)

```
typedef struct                  /* Header & structure for binary gpb files */
                                /* (202 bytes) */
{
        short size;             /* structure size in bytes */
        float version;          /* version number (see above) (usually 1.01) */
        char receiver;          /* receiver type (see above) */
        char max_channels;      /* maximum number of channels (for safety) */
        time_type time;                 /* time of file open */
        float interval;         /* data interval in seconds */
        char extra1[64];
        char fname[80];                 /* variables used by software */
        FILE *f;                        /* file pointer */
        short vbufsize;         /* size of file buffer (internal) */
        void *vbuf;             /* pointer to vbuf (allocated in open) */
        char extra2[24];

}       header_bin_type;
```

For this structure, only the receiver type needs to be filled in. The following receiver types are possible:

```
#define B_GENERIC 0     /* generic receiver (ranges, phase, phase rate) */
#define B_MX4200  1     /* magnavox 4200 */
#define B_ASHP12  2     /* ashtech pcode */
#define TRIM_4000 3     /* trimble ca-code */
#define B_NOVATEL       4       /* novatel rx. */
#define B_MOTOROLA      5       /* Motorola receivers */
#define B_RINEX   6     /* rinex format */
#define B_FURUNO  7     /* Furuno */
#define B_NAVSTAR       8       /* Navstar/NavSymm receiver */
#define B_ROCKWELL      9       /* Rockwell PLGR */
#define B_MARCONI       10      /* Canadian Marconi */
```

```
#define B_AOA           11      /* Allen Osborne */
#define B_RTCM      12  /* RTCM types 18/19 */
#define B_LEICASR   13  /* leica SR 9500 */
#define B_JUPITER   14  /* Rockwell Jupiter */
#define B_SV6           15      /* sv6, not yet added, but maybe later */
#define B_RESAMPLE      16      /* resampled data with GPB_CAT */
#define B_ASHGLN    17  /* ASHTECH GPS-GLONASS */
```

ii) pben_bin_type (positive/time information)

```
typedef struct              /* position record (68 bytes) */
{
        short size;         /* size of structure */

        char num_sats;              /* number of satellites to follow */
        char status;        /* bit 0: position valie (1 = valid)
                               bit 1: 0 - static mode 1 - kinematic */
        float ant_ht;       /* antenna height (HT) in meters */

        double phi, lamda;  /* position dec deg */
        float ht;

        double rcv_time;            /* receive time in seconds since sunday */
        double corr_time;           /* corrected receive time */
        double clock_shift; /* clock_shift in meters */
        double clock_drift;

        short week_num;             /* week number */

        char extra[6];

}       pben_bin_type;              /* binary position record */
```

Important! The rcv_time is the time of measurement referenced in the GPS receiver's time frame. The DLL requires that the rcv_time from master and remotes be equal. Therefore, it is best to ensure that this time is on the whole interval. The corr_time is the measurement time referenced in the GPS time frame (i.e. the rcv_time corrected by the clock bias). It is important to fill in the rcv_time and corr_time.

The clock_shift is the difference between the rcv_time and the corr) time, but is not used. The clock_drift is not used either. Both rcv_time and corr_time range from 0 to 604800. The ant_ht should be set to zero. The week_num can be ignored.

The position (phi, lamda and ht) need only be filled in for moving baseline processing since this will be the base position in kinematic mode. Note that latitude (phi) is in degrees and positive for the Northern Hemisphere and is negative in the Southern

Hemisphere. Longitude (lamda) is positive for the Eastern Hemisphere and negative for the Western Hemisphere.

Important! The num_sats variable indicates the number of valid mben_bin_type structures that contain data. It is very important that this variable be filled in.

Important! Bit 1 in the status variable should reflect if the vehicle is moving (1) or stationary (0). This is required for each remote. For moving baseline processing, this bit must be set properly for the master as well.

iii) mben_bin_type (raw GPS measurement data)

```
typedef struct                  /* measurement record (44 bytes) */
{
        short size;             /* size in bytes */
        char prn;                       /* prn number */
        unsigned char locktime; /* seconds since last loss of lock (255 max)
                                                0 = no loss of lock */


        double ca_range;        /* ca pseudo range in meters */
        double phase_l1;        /* phase in cycles (on ca channel) */
        double phase_rate_l1; /* phase_rate in cycles */

        double p1_range;        /* pcode on l2 (m) */
        double p2_range;        /* l2 phase in cycles */

}       mben_bin_type;
```

The satellite prn number ranges from 1-32. The locktime indicates the number of seconds since carrier loss of lock. This can be reset when the receiver indicates a cycle slip. It should range from 1-255. If the locktime is greater than 255, it should be left at 255.

The ca_range variable is the raw pseudorange measurement in meters (normally C/A code). The phase_l1 variable is the L1 carrier phase in L1 cycles. This quantity should change in the opposite direction to the pseudorange. phase_rate_l1 is the L1 doppler value. If not known, then this parameter should be computed by differencing the ca_range or phase_l1 from neighboring epochs. The ca_range method tends to me more reliable. Ins such a case, the standard deviation for the doppler should be increased in the CFG file (use PHASE_RATE_SD) to 1.0 m/s. The units for phase_rate_l1 are L1 cycles/sec and the sign coincides with delta phase/delta time.

For single frequency data, p1_range and p2_range should be zeroed. Otherwise, use p2_range fro the L2 carrier phase value (same direction as L1 phase) and p1_range for P-code on L2).

b) Ephemeris structure (eph.h)

```
typedef struct
{
        int prn;                /* prn */

        int wn;                 /* GPS week num */
        long tow;               /* sec of GPS week */
        double tgd;             /* group delay */
        long aodc;              /* clock date issue */
        long toc;                       /* (sec) */
        double af2,             /* clock corr sec/sec2 */
        af1,                    /* sec/sec */
        af0;                    /* sec */
        long aode;              /* orbit date issue (IODE) */
        double deltan;          /* mean anomoly corr
                                   semi-circles per sec*PI */
        double m0,              /* mean anomoly at ref time
                                   semi-circles*PI */
        e,                      /* eccentricity */
        roota;                  /* sqr root a (meters 1/2) */
        long toe   ;            /* ref time (sec) */
        double cic,             /* rads */
        crc,                    /* metres */
        cis,                    /* rads */
        crs,                    /* meters */
        cuc,                    /* rads */
        cus;                    /* rads */
        double omega0,                  /* long of asc node
                                   semi-circles*PI */
        omega,                  /* arg of perigee
                                   semi-circles*PI */
        i0;                     /* incl angle at ref time
                                   semi-circles*PI */

        double omegadot,                /* rate of right asc
                                   semi-circles/sec*PI */
        idot;                   /* rate of incl
                                   semi-circles/sec*PI */

}       eph_type;
```

This structure holds the broadcast ephemeris obtained from the GPS receiver in real-time. A description of the variables is given in the ICD-200 document.

c) Epoch data structure (engine.h)

This structure is used to send data to the DLL. It contains structures described in (a).

Each master or remote record uses the following structure:

```
typedef struct
{
        header_bin_type b_hdr;                  /* indicates receiver type!!
                                                (other variables can be ignored*/
        pben_bin_type b_pben;                   /* set times, static/kinematic flag,
                                                positions for movbase */
        mben_bin_type b_mben[MAX_ENGINE_CHAN];  /* raw data, see gps_io.h */
        int valid;                              /* must be filled in!! */
        double cpu_time;                        /* computer time (optional, used for
age
                                                computation) [seconds]*/

}       gps_epoch_type;
```

The b_hdr, b_pben and b_mben variables are described in (a).

For b_hdr, only the receiver variable needs to be filled in.

It is important to set the valid variable in order to tell the software that data is present. This allows some remotes to be "dropped out" if data is not available.

Under Windows 95/NT, the cpu_time can be filled in with the GetTickCount() function (remember to divide by 1000.0) for proper age and latency computations. The cpu_time refers to the estimated computer time that the measurement was made.

2. Output structures

This section describes returned by the DLL.

a) Solution structure (engine.h)

```
typedef struct
{
        char prn;                       /* 1-32 */
        float elev, az;         /* degrees */
        double ambiguity;       /* -1000 to 1000 cycles */
        char extra[64];

}       gps_satsol_type;
```

This structure gives information about each satellite. The ambiguity is the last few digits of the ambiguity value.

```
typedef struct
{
        double corr_time;                   /* exact time in GPS time frame */
        double sol_status;                  /* see below (see SOLUTION_??? from
above) */

        double phi, lamda, ht;          /* degrees, meters */
        double sde, sdn, sdh;           /* position standard deviation */
        double ve, vn, vh;                  /* velocity (m/s) */
        double vsde, vsdn, vsdh;            /* velocity standard deviation (m/s) */
        double lle, lln llh;                /* local level vector */

        int qf;                         /* quality indicator 1-6, 7 = single pt */
        double dd_dop;                      /* double difference dop */
        double amb_drift;                   /* drift on ambiguities */
        double l1_rms, ca_rms,              /* Meas. rms in kalman filter (m) */
                p_rms, dl_rms;
        int num_less_than_4;            /* number of consecutives epochs < 4 satellites */

        int kar_satus;                  /* status of KAR solution (KAR_???) */
                                        /* 0-not engaged (KAR_OFF) */
                                        /* 1-estimating (KAR_ESTIMATING) */
                                        /* 2-search failed, will try again (KAR_FAILED) */
                                        /* 3-failed too much time (KAR_TIMEOUT) */
                                        /* 4-passed tests (KAR_PASSED) */
                                        /* 5-navigating with passed solution (KAR_NAV)
*/

        float kar_seconds;              /* second that kar has been enaged for (1 only) */
        int kar_valid;                  /* data below is valid - only filled in for 2 & 4 */
        float kar_best_rms;             /* RMS of best intersection */
        float kar_reliability;          /* reliability */
        float float_fixed_sep;          /* (m) 999 not available */
        int kar_frequency;              /* 0 - single, 1 - dual */
        float kar_sec_used;             /* number of seconds used */
        float kar_avg_stats;            /* average satellites used */
        int kar_passed;                     /* passed or failed! (0=failed, 1=passed)*/

        long num_good_meas;                 /* number of meas. that passed tests */
        long num_bad_meas;              /* number of meas. that failed tests */
        long num_total_meas;            /* number of total measurements processed */
        int num_sats_without_eph            /* number of satellites withoug ephemeredes
*/
```

```
        int sk_mode;                    /* 0-static, 1-kinematic */

        char extra[256];

        int num_sats;                   /* number of satellites */
        gps_satsol_type chan[MAX_ENGINE_CHAN];      /* data for each channel */

}       gps_blsol_type;
```

This structure is available for each remote. The corr_time is the exact time corrected for receiver clock biases.

The sol_status can have one of the following values

```
#define SOLUTION_NONE  0
#defineSOLUTION_SINGPT          1
#define SOLUTION_DGPS   2
#define SOLUTION_KALMAN       3
```

Phi and lamda are the geographic latitude and longitude, and are positive for the northern and eastern hemispheres. The height is in meters. Their estimated standard deviations are given by the sde, sdn, and sdh values, also in meters. These standard deviations can sometimes be optimistic. A sometimes better indicator is the quality number qf, which is based on observed data. 1 is best and 6 is worst. Stable solutions are normally 1 or 2. Quality numbers of 5 or 6 normally have C/A code accuracies. The dd_dop is an indicator of satellite geometry and is roughly equivalent to PDOP squared.

The local level velocities are given by ve, vn and vh in m/s. Their standard deviations are given by svde, vsdn and vsdh. The base t remoter local level vector is given by lle, lln and llh. The units are meters.

For kinematic ambiguity resolution, the kar__status and kar_seconds are the most meaningful. However, the other parameters can be used for debugging purposes.

the sk_mode indicates if this epoch was processed in either static or kinematic mode.

```
typedef struct
{
        int size;                       /* record size */
        int max_bl;             /* dimension of baseline */
        int max_chan;           /* dimension of of channels */

        double rcv_time;                /* 0-604800 */
        int week_number;                /* 0-1023 */

        int hours, minutes;     /* HMS time */
```

```
        double seconds;
        int month,day,year;     /* 1-12, 1-31, 1900.. */

        int attitude_valid;             /* roll, pitch + heading computed */
        double roll, pitch, heading;/* degrees */

        int sol_status;         /* 0-no sol, 1-single_pt, 2-DGPS, 3-Kalman/OFF */

        int num_eph_received;       /* number of unique ephemeredes received */
        int disk_write;         /* writing .OUT and .ANN files to disk */
        long num_epochs;        /* number of epochs processed */

        /*ambiguity/distance constraint special variables */
        int kar_valid;          /* statistics valid */
        int dist_const_passed; /* distance constraint passed */
        int amb_const_passed;       /* ambiguity constraint passed */
        float combined reliability;     /* combined reliability */
        int com_rel_passed;     /* if combined passed or failed */
        int num_intersections;/* number of intersections found */
        int kar_all_passed;     /* ALL combined KAR solutions passed */

        char extra[512];

        gps_blsol_type r[MAX_ENGINE_BL];        /* data for remote_i */

        //additional tiing functions (NT/95 only)
        double cpu_sol_time;  /* cpu time of solution (s) */
        double cpu_meas_time;       /* estimated cpu_time of receiver mesurement (s)
(from GPS time) */

}       gps_epsol_type;
```

The hours, minutes and seconds are in GPS time and NOT UTC.

The sol_status is more accurately obtained from the individual remotes.

The num_eph_received and the num_sats_withoug_eph for each of the remotes can be used to detect if enough epemeredes have been received. The disk_write variable should reflect the DISK_WRITE command in the .CFG file

The cpu_sol_time and cpu_meas_time indicates estimated computer times when the solution was computed and obtained from the GPS receiver (Win 95/NT only). These can be used for latency and age computations.

latency = cpu_sol_time - cpu_meas_time
age = GetTickCount()/1000.0 - cpu_meas_time

b) Buffering information (engine.h)

These structures are used in conjunction with the WhatIsInDataBuffers() function.

```
typedef struct
{
        int valid;              /* indicates whether there is valid data present */
        double gps_time;        /* GPS time (0-604800) seconds */
        double cpu_time;        /* CPU time (NT/95 only) seconds */
        int num_sats;   /* Number of satellites tracked */

}       buf_info_type;

typedef struct
{
        int station;            /* MASTER or REMOTE (see engine.h) */
        int number;             /* Remote number: 0, 1, 2 … */
        int num_records;                /* number of unprocessed records */

        buf_info_type newest;/* newest record in buffers */
        buf_info_type oldest;  /* oldest record in buffers */
        buf_info_type processed;        /* last record processed in buffers */

        char extra[256];                /* additional info in the future */

}       buf_list_type;
```

The newest structure contains information about the latest record that has been received. The oldest structure is the oldest unprocessed buffer present. The processed structure in the last buffer that has been used for processing.

For each of these, if there is vaid dat present. The GPS time (gps_time), computer time (cpu_time) and number of satellites (num_sats) will be given.

CHAPTER 8 RTENGINE

Section 1 Getting Started

RtEngine is a console mode Windows 9x/NT real-time GPS processing program. It supports one base and one or more remotes. It can also be configured for specialized applications like heading determination, distance/ambiguity constraints between remotes and moving baseline processing. For most applications, RTKNav would be used. Unlike RTKNav, however, RtEngine has the advantage of being able to start up remotely (i.e. from a command prompt).

In order to get RtEngine started; two configuration files must be created. First, the IN file contains information regarding the receiver logging and output ports. This file also defines a CFG file, which contains parameters necessary for the GPS processing engine. **The easiest is to use RTKNav to create these files, since RTKNAV's and RtEngine's input files are complete compatible. This is highly suggested!!!**

The following sections outline some important issues to consider. Section 2 in this chapter explains the actual format of the IN file. The CFG file parameters are shown in Appendix A. This section gives guidelines rather than exact format specifications.

8.1.1 Using RtEngine

RtEngine should be run from either the Windows 95/98/NT/2000 Start Button (select Run) or from a console window. The console window is suggested. It is also important that the .IN file is passed on the command line:

RtEngine *infile.in*

Please note that the PATH statement must be set to include the C:\Program Files\RtkNav. This should be performed automatically by the setup installation.

8.1.2 Adding Configuration (Config {})

The Config{} section contains the following:

- Name of .cfg file. This file contains the commands sent to RtDLL, which are the processing settings.
- Process Mode. This could be single frequency, dual frequency or C/A only. In addition, KAR can be enabled or disabled. (see Section 5.3.10)
- The LineUpMode defines how multiple remotes are synchronized (see Section 8.2.1)
- Verbose ON would print additional messages to the screen if it is not made console port (see Section 8.2.1).
- In MULTIENGINE version 2.1, VERBOSE: ON also writes a file called multiengine.log to the hard disk. VERBOSE ON is NOT RECOMMENDED for operational use. It should only be used for possible analysis of GPS data.

8.1.3 Adding Ports (Port {})

A port definition must be added for each port used by RtEngine. Ports may be used for the following purposes:

GPS receiver data input
Output/Command ports
Rebroadcasting of receiver data

For each port to be added, an port number must be assigned. This number should not be confused with either the comport number or the network port number. It is a arbitrary number between 1 and 1023, and it is used to differentiate ports.

The following port types exist. Normally, only serial and network ports are used.

Serial This is a comport on the computer. The baud rate and comport number must be defined. Additional information such as the parity can optionally be set.

Network This is a TCP/IP socket port. Network ports may be either TCP, UCP or Multicast (see Chapter 1 Section 10). The network port number must always be defined (there are not defaults). For Multicast, an IP address is also very important. For UDP, the IP address should be set to 255.255.255.255. For TCP, receiving data (i.e. GPS receiver input or command port) must have an IP address defined. For TCP, writing data (i.e. output port and rebroadcast) the IP address of the receiver must be defined.

File Input from a file (see Chapter 4)

Console RtEngine may turn the console display that it is running in into a command port. In such a case, a CONSOLE port must be added (see Chapter 8).

8.1.4 Adding Receivers (Master {} and Remote {})

For each receiver connected to RtEngine, the assigned port number must be defined along with a definition of the type of GPS receiver. The interval is also very important. For each Master{} and Remote{}, there must be one Port{} definition. If the data is to be rebroadcasted, then a second Port{} definition is required.

8.1.5 Adding Output and Command Ports (Output {} and Command {})

Output ports continuously output one or more NMEA style messages. They will not accept any data input. Command ports output such messages and accept commands. Normally, command ports are used, but an output port is practical if you just want to send records to a specific location. In the case of TCP, the handling of an output port and a command port is different. A command port is a server and continually checks for a connecting. An output port requires knowledge of the connecting parties IP address, and thus is not as flexible. RtkNav creates a command port using the Output {} identifier, but sets the “Command: ON” variable. This is the same as using the Command {} identifier.

8.1.6 Intervals and Export Records

To control how often a solution is to be computed and correspondingly an output record is to be sent to the output port, the interval parameters must be properly set in the IN file for the Master and Remote groups. A solution will only be computed when data can be lined up from the Master and all Remotes (see LineUpMode: in Section 8.2.1 in this Chapter). Therefore, the interval from master and remotes should coincide. Care should also be taken that the baud rate is high enough to handle the data being sent. Higher baud rates will also decrease the solution latency.

The best way to reduce latency is to allow the extrapolation of master data records. This allows the master data to arrive latent to the remote data. This function can be engaged using the LineUpMode of EXTRAPOL. Two solutions will be output in this manner. One least-squares solution will come first, and its master data is extrapolated. When the actual master record arrives, then a second Kalman Filter solution will be outputted. This second solution is the most accurate, but will be obviously later.

8.1.7 Controlling static and kinematic

By default, RtEngine sets all remotes to be kinematic. However, solution convergence will be better in static mode. To switch all remotes to static, press the *F3* key, while RtEngine is running. To switch back to kinematic, press *F3* again. If the display screen is a console port, then the DYNAMICMODE command must be used. *F3* will not work! The initial static/kinematic mode can be set in the IN file by using the StartMode: command.

8.1.8 Exiting RtEngine

Press *ESC* to quit. If the display is a console port, then type EXIT!

8.1.9 Setting the position of the Master

RtEngine cannot proceed until it knows the position of the master station. This can be defined one of three ways:

Use the MASTER_POS command in the .CFG file
Use the Position: parameter in the Master {} Group of the .IN file
Use MASTERPOS command in command port interface (See Section 5.3.17).
Send the master station position via the radio port. This position can be set by using the LOGGPS program, or receiving a type 3 record in RTCM. Early versions of Version 2.00, may not support these inputs

Once the base position has been set, it cannot be changed without restarting the program. Moreover, (a) will take precedence over (b) and (c/d), and (b) will take precedence over (c/d).

The position of the master should be in the same datum as defined in the .CFG (datum command). For proper ellipsoidal height determination, the master height should be ellipsoidal as well. If baseline lengths are not too long, then the orthometric height can be used for the master to determine orthometric heights at each remote.

8.1.10 Setting the ProcessMode

Another important aspect in running RtEngine is to set the processing mode. This is also defined in the IN file. Most importantly, whether the receiver is single frequency or dual frequency must be set. This is the first item in the ProcessMode: command. The second parameter must be FLOAT, while the third can enable Kinematic Ambiguity Resolution (KAR). KAR allows RtEngine to fix carrier phase ambiguities to integer values, which delivers centimetre accuracies. KAR is similar to other on-the-fly algorithms.

KAR works very well for dual frequency receivers, and can obtain integer solutions in a few minutes after a loss of lock. For single frequency, KAR can be used, but should only be used in open conditions with minimal loss of lock and multipath.

8.1.11 Moving Baseline Processing

Moving baseline processing occurs when the user wishes to obtain relative position and velocity information between base and *n* remotes and the base is not stationary. In order to perform moving baseline processing, the following command must be added to the CFG.

MOVING_BASE = ON

For azimuth and attitude determination, this command must also be used.

For moving baseline processing, it is also important that the master (and remotes) be defined as kinematic. This is performed with the StartMode command in the IN file.

Use the RTVEC output in the Embedded section of the IN file. The RTSOL will have the effects of autonomous positioning errors on the coordinate output (3-20 m). RTVEC gives the local level vector difference between the base and each remote

8.1.12 Using distance and ambiguity constraints

Requires 2 moving remotes and 1 stationary base

The distance constraint feature can be used to improve ambiguity resolution times. This requires that two remotes are defined in the IN file, and these two remotes must be mounted in a fixed fashion with respect to each other. The distance/ambiguity constraint feature takes advantage of the following conditions when performing a KAR fix:

- The distance between the remotes should be a certain distance given a certain standard deviation.
- The carrier phase ambiguities for each of the three vectors should cancel or add up to less than a tolerance of 0.07 cycles.
- If two solutions are found passing distance constraints, then the reliability should be above a certain tolerance.
- All RMS values should be less than 0.07 cycles.

When using this feature, the following command must be added to the CFG file:

DIST_CONST = ON *distance dist_stdev* ; both in metres

The distance should be obtained from GPS data and is the 3-D slope distance between the two units. The standard deviation should be 0.04 cm or less to be effective.

Sometimes the distance constraints can be fooled if the Kalman filter solution is outside of the search area. Therefore, the search area size should be increased slightly for single frequency:

KAR_CUBE = 1.2 4.0 ; search area in metres

Moreover, the KAR time length should not be too short, but can be shorter than regular single frequency initialization. The KAR minimum time should be set as follows:

KAR_MIN_TIME = 5.0 1.0 ; minimum search time in minutes

8.1.13 Azimuth determination

Requires 1 moving base and 1 moving remote. Distances between antennae must be known and stable. For RT-AZ version, baseline distance must remain less than 20 m.

Azimuth determination can be performed if two antennae are fix mounted to a particular craft. Since the base is moving, the moving baseline version must be used. In a prior calibration procedure, the separation between base and remote must be determined. This can be performed either in kinematic or static. KAR should be used for this procedure.

Once the distance between antennae is known, it can be used as a constraint in further positioning. Add the following command to the .CFG command.

AZ_DETERM = ON/OFF Distance DistSD

e.g. AZ_DETERM = ON 1.232 0.025

Both the *Distance* and *DistSD* are in metres. *DistSD* is the estimated accuracy of the distance measurement. However, it should also take into account carrier phase noise and movement of the antennae with respect to each other. Normally values between 0.015 m and 0.04 m are acceptable.

8.1.14 Attitude determination

Requires 1 moving base and 2 or 3 moving remotes. Antenna positions must be pre-calibrated and known in local body coordinate system of vessel. Antennae must be stable with respect to each other.

Steps to perform attitude determination:

- Create body coordinates of vessel using calibration survey. Each antenna needs a local coordinate on the vessel, which are used to define the axes for computing roll, pitch and

heading (see Appendix B). To compute body coordinates, the **Conv3D.exe** program must be used. It can be requested from the Waypoint Products Group, NovAtel Inc. if not installed with this software (look in the installation directory). Instructions are located in Appendix B.

- Save the coordinates (CRD vector file) to the directory containing the IN and CFG files. Give it a meaningful name.
- Enable moving baseline by adding the **MOVING_BASE = ON** command. In RtkNav, enable moving baseline processing from the *Advanced* tab.
- Add the CFG command **VECTOR_FILE = FileName.crd** (use the *User Defined* tab). This is the file created in **Conv3D.exe**.
- Add the CFG command **ATTITUDE = COMPUTE** (user defined options in RtkNav)
- Add the CFG command **DIST_UPDATE = OFF ON**
    - The first input disables vector input in Kalman filter, which causes divergence, while the second enables distance constraints in KAR, which is important.
- Add the CFG command **VECTOR_SD = 0.02**
    - This uses a 2 cm standard deviation for the position of the body coordinates. If you have a very stable system, then this value can be lowers. Values below 1 cm and above 4 cm are not suggested.
- Add the CFG command **MASTER_ID = *IdName***
    - *IdName* corresponds to the name given in the **Conv3d** (Make Body) program
- For each remote, add the CFG command **REMOTE_ID = *IdName***
    - *IdName* corresponds to the name given in the **Conv3d** (Make Body) program. Each name must be unique and cannot contain spaces or commas.
- Make sure that the *LineUpMode* is set to **ALL**
- Enable Kinematic Ambiguity Resolution (same place as *LineUpMode*)
- Ensure that the Master receiver is set to kinematic

Section 2 RtEngine – Input Configuration File

Version 2.00 files are not computable with Version 1.1. Files for the new version must be re-created.

The RtEngine program uses two configuration files. The .CFG file contains numerous configuration commands for the GPS computation engine, and it is described in Chapter 5 . The .IN file is necessary to define the various serial ports in use. The .IN file is defined here, and it uses the following style:

```
Group1 {
        Param1: var1 var2 …
        Param2: var1 var2 …
           :
}

Group2 {
        Param1: var1 var2 …
```

Param2: var1 var2 …
:
}
; a semicolon can be used to make comments and remove parameters

The following groups are necessary:

Config	Defines the .CFG file and processing mode
Port	Information for a input/output port
Master	Information about the master port
Remote	Information about a given remote port
Output	Information port outputting NMEA style records
Command	Input/Output port that can support commands

8.2.1 Config group

This group defines the mode for processing. This includes whether single or dual frequency processing is performed. It also tells if KAR is to be used or not. The .CFG file name is also defined in this group.

The following parameters may be defined:

Parameter	**Description**
ProcessMode: *mode*	*Mode* can either be DEFAULT, which processes in a 20 cm float solution or RTK for 2 cm solution using kinematic ambiguity resolution. DEFAULT is equivalent to SF FLOAT KAROFF, while RTK is equivalent to AUTO FLOAT KARON.
ProcessMode: *frequency static kar*	*Frequency* is SF for single frequency, DF or dual frequency CAONLY for code-only solution or AUTO for automatic frequency detection for kinematic ambiguity resolution. This is currently not working properly. s*tatic* must be FLOAT. k*ar* may either be KARON or KAROFF. The default mode is DEFAULT.
CfgFile: *filename.cfg*	Defines the file containing configuration parameters for the GPS processing engine. See Appendix A. There is no default, this file must be defined.
LineUpMode: *Mode [MsTol]*	This controls how the base and remote records are lined up. Use ALL for the Mode if data from master and all remotes must be available before a record is processed. If one remote has not data, then this record will be skipped for all remotes. Set the *Mode* to PARTIAL to process remote units that line up with the base with in a tolerance of *MsTol*

	milliseconds. Use EXTRAPOL to extrapolate the master data. This reduces the latency to a minimal value. Two solutions are exported. One for the extrapolated master data and a second one when the master data actually arrives. Make sure to set the command EXTRAPOL_EPOCHS. ALL is suggested unless the radio transmission link is intermittent. EXTRAPOL is not suggested for inverse applications. ON displays addition information to the screen (RtEngine only)
Verbose: ON/OFF	Input of external ephemeris file. Normally only used for replaying
EppFile: *FileName.epp*	This setting can be used to read data from disk instead of a serial port. This is useful for replaying data. *Flag* =
DiskRead: *Flag Delay* [*RecSize*]	OFF/GPB/RAW. *Delay* delay in millisecionds between reading records. *RecSize* record size in bytes for reading RAW data.

8.2.2 Port group

Parameter	Description
PortNum: *AssignedPortNum*	Assigned port number, which ranges from 1 to 1023. Each port number must be unique and is considered independent of either the comport or network port number.
Type: *PortType*	*PortType* = NETWORK/SERIAL/FILE/CONSOLE NETWORK = TCP/IP, SERIAL = serial ports, FILE=read GPS data from file (see DiskRead in Config{}). CONSOLE=RtEngine display screen
For SERIAL type:	
Comport: *num*	*num* defines the communications port number (1,2,3…). There is no default and must be used.
BaudRate: *baud*	*baud* defines the baud rate (1200,2400,4800…). The default is 9600.
Parity: *parity*	The *parity* can either be O for odd, E for even or N for none. The default is (N)one.
For NETWORK type:	
IP: *a.b.c.d*	*a.b.c.d* IP Address. For UDP, IP address is 255.255.255.255 while for MULTICAST it is 224 to 240 for *a*. For TCP, the IP address should be 0.0.0.0 for receive ports (ie. command and GPS receiver ports) and it should be the destination IP for send ports (i.e. output or rebroadcast ports).
NetPort: *NetPortNum*	*NetPortNum* is 1-65535. *NetPortNums* less than 1024 are reserved (e.g. FTP, TELNET, HTTP, …)

Protocol: *protocol mode*	*protocol* is MULTICAST, UDP or TCP (see Chapter 1 Section 10). *mode* is NORMAL or RAW. Currently, only NORMAL is supported.
NetMode: *netmode*	*netmode* is RECEIVE for GPS data input, SEND for output ports, REBROADCAST for a rebroadcast port and SERVER for command ports (TCP suggested).
For FILE type: InputFile: "*FileName"*	*FileName* is the input GPB or RAW data file. Note that DiskRead parameter in Config{} must be used.
FileOpt: *delay [recsize]*	*delay* is milliseconds delay between reading each record. For RAW mode, *recsize* will override the *recsize* from the DiskRead parameter in Config{}.
For CONSOLE: (no options)	

8.2.3 Master/Remote group

This group defines the parameters for the serial port connected to the master GPS receiver or radio. The base station position can also be defined here (**note the changes from version 1.1**)

Parameter	Description
FilePrefix: *prefix*	If this parameter is used, then raw GPS and ephemeris data will be logged to the *prefix.gpb* and *prefix.epp* in GPB mode. Otherwise, raw receiver data). Default is no raw data logging (see FileMode as well).
FileMode: *mode*	*mode* is OFF/GPB/RAW
Number: *RemoteNumber*	(Remote{} only) *RemoteNumber* is the remote ID number (1,2,3…). Each remote must have a sequential number. There cannot be any gaps. For one remote processing, this parameter will be assumed to be 1 if not defined.
PortNum: *AssignedPortNum*	*AssignedPortNum* port number assigned in Port{}
Interval: *value*	*value* defines the data interval that the GPS receiver is to output raw data at. Default is 1.0.
Receiver: *RxType RxSubType*	*RxType:* NOVATEL, ASHTECH, CMC, NAVSTAR, ROCKWELL, JAVAD or RADIO For NOVATEL, the *RxSubType* can be either 2151 or 3151. For Millenium receivers the 3151 setting must be used. OEM4 also supported For ASHTECH, the *RxSubType* can be one of MACM, G12, GG24 or Z12. For MARCONI, *RxSubType* is ALLSTAR For NAVSTAR, *RxSubType* is XR5 or XR6 For ROCKWELL, *RxSubType* is JUPITER For the RADIO (CURRENTLY NOT SUPPORTED)
RxPort: *portID*	*PortID* is 'P' for primary and 'S' for secondary. A/B may also be used for Ashtech, while 1 or 2 may be used for

	NovAtel.
Position: *latitude longitude height*	(Master{} only) This is the base station position. The *latitude* and *longitude* MUST be in *degree, minutes seconds* (space delimited), while the height MUST be metres. This parameter is optional, and it is important that the base station position be exact (<10m). If not defined, the base position must be obtained from either the .CFG file or sent over the serial port.
StartMode: *Mode*	This is the static/kinematic processing mode that the antennae is starting atUse NO to initially disable a port. The default is YES. NO to disable a port's operation.
Enable: YES/NO	Rebroadcast port. *AssignedPortNum* port number assigned in Port{}
RebPort: *AssignedPortNum*	

8.2.4 Output/Command group

This group defines the parameters for the serial port to which the ASCII embedded records are sent. This port may coincide with one of the other ports if the WRITEONLY status is used. A proper "Y" cable must also be used to enable dual port usage.

Parameter	Description
Status: *status*	The *status* can either be: OFF, WRITEONLY, READONLY or ON. Use OFF to disable the port. Otherwise, ON should normally be used.
Command: ON/OFF	ON if this is a command. OFF for an output port.
PortNum: *AssignedPortNum*	*AssignedPortNum* port number assigned in Port{}
Record: *RecName [interval]*	The *RecName* can be one of the records listed in Chapter 8 . The RTSIO requires an *interval*, while the others may optionally be able utilize the time interval (in seconds)

8.2.5 Reject group

The reject output records are based on certain tolerances. If any processed GPS records does not meet any of the tolerances described below, the record will not be written to the Output Port..

Parameter	Description
Mode: *Reject/Q6,7,8,9*	If mode = *reject*, the record is not sent to the output port. If mode = *Q8*, the record is send with a quality number of 8. *Q 6, 7, 8, 9* are the only numbers allowed!
DD_DOP: *0/1 dop_value*	*1* means reject a DD_DOP of > dop_value where DD_DOP uses a DOP generated by double differencing the base and the rover coordinates. *0* means do not use DD_DOP as a rejection tolerance
hz_sd: *0/1 hz_std_value*	*1* means use the horizontal standard deviation as a rejection for sending output records. *0* means not to use

height: *0/1 ht_value*	horizontal standard deviation as a rejection tolerance. *1* means use the approximate height of a reasonably flat area to reject output records. User must know the height value!

8.2.6 CFG file

See Appendix A for a complete listing of available commands. RtkNav also has a small help section in the User Defined Options, which should list commands as well.

Section 3 Sample Input Files

8.3.1 Sample IN File

```
$RTKIN RtkNav Ver2.00
; Header/configuration information
Config {
        ProcessMode: SF FLOAT KARON
        CfgFile: "rtknetwork.cfg"
        LineUpMode: partial 200
        Verbose: ON
}

; ================================
; Definition of each port
; ================================

; PortInfo for Master-GpsInput
Port {
        PortNum: 2
        Type: NETWORK
        IP: 234.5.6.7
        NetPort: 5002
        Protocol: MULTICAST NORMAL
        NetMode: RECEIVE
}
Port1 {
        PortNum: 2
        Type: SERIAL
        comport: 7
        baudrate: 19200
}

; PortInfo for Remote#1-GpsInput
Port {
        PortNum: 4
        Type: NETWORK
        IP: 234.5.6.7
        NetPort: 5004
        Protocol: MULTICAST NORMAL
        NetMode: RECEIVE
}

; PortInfo for Remote#2-GpsInput
Port {
        PortNum: 6
```

```
        Type: NETWORK
        IP: 234.5.6.7
        NetPort: 5006
        Protocol: MULTICAST NORMAL
        NetMode: RECEIVE
}

Port {
        PortNum: 100
        Type: CONSOLE
}

Port {
        PortNum: 101
        Type: NETWORK
        IP: 0.0.0.0
        NetPort: 6000
        Protocol: TCP NORMAL
        NetMode: SERVER
}
Port {
        PortNum: 102
        Type: NETWORK
        IP: 0.0.0.0
        NetPort: 6001
        Protocol: TCP NORMAL
        NetMode: SERVER
}
Port {
        PortNum: 103
        Type: NETWORK
        IP: 0.0.0.0
        NetPort: 6002
        Protocol: TCP NORMAL
        NetMode: SERVER
}

; ================================
; Definition of master and remotes
; ================================
; Definition for Master
Master {
        PortNum: 2
        Name: "M"
        ;fileprefix: m-test
        FileMode: off
        Position: 50 58 43.00000 -114 00 42.00000 1015.000
        Interval: 0.100
        Receiver: ashtech macm
        RxPort: P
        StartMode: S
}
; Definition for Remote#1
Remote {
        Number: 1
        PortNum: 4
        ;Name: "R1"
        FileMode: OFF
        Interval: 0.100
        Receiver: novatel 3151
        RxPort: P
        StartMode: K
}
```

```
; Definition for Remote#2
Remote {
        Number: 2
        PortNum: 6
        ;Name: "R2"
        ;fileprefix: r2-test
        FileMode: off
        Interval: 0.100
        Receiver: ashtech macm
        RxPort: P
        StartMode: K
}


; ================================
; Definition of output data
; ================================

Command {
        PortNum: 100
        Status: ON
}
Command {
        PortNum: 101
        Status: ON
}
Command {
        PortNum: 102
        Status: ON
}
Command {
        PortNum: 103
        Status: ON
}

; Output Records will be rejected on this basis
Reject {
        Mode: reject
        dd_dop 1 100.000
        hz_sd: 1 0.500
        height: 1 41.000 2.500
}

;End-of-file
```

8.3.2 Sample CFG File

```
;   PROJECT:    rtknetwork.cfg
;
;   DATE:       Oct. 23 2000  (date/time of processing)
;   TIME:       18:02:53
;   CREATED BY: RTKNav Version 2.00
;

DATUM       = WGS84          ; Processing datum
ELEV_MASK   = 10.0           ; Elevation mask (deg)

DOPPLER_TOL = 25.000         ; Bad doppler tolerance (m/s)

OMIT_SATS   = 0 0
```

```
SHOTGUN     = ON             ; Use filter reset (ON/OFF)
WRITE_BAD_EPOCHS = OFF       ; Save bad data to .fwd/rev file (ON/OFF)
;Second values for KAR are Dual frequency Wide-lane values
KAR_MIN_TIME = 4.00 2.00    ; Min. time for KAR, L1 and L2 (minutes)
KAR_CUBE    = 1.20   4.00    ; Kinematic ambiguity resolution cube size (m)
; Standard deviations and tolerances
RANGE_SD    = 7.00           ; C/A code stdev (m)
PHASE_SD    = 0.020          ; L1 phase stdev (m)
PHASE_RATE_SD = 1.000        ; L1 phase rate stdev (m)
AUTO_DOP_SD = ON               ; On for auto doppler standard dev.
PCODE_SD    = 2.00           ; P code stdev (m)
RMS_TOL     = 0.10 25.0 10.0 1.0; L1, CA, P RMS tolerance (m)  PPM scale
LOCKTIME_CUTOFF = 4.0        ; Carrier Locktime cutoff (seconds)

;Moving baseline options
MOVING_BASE = OFF
DISK_WRITE = OFF         ; Write Data To Disk
NUM_DATA_BUFFERS = 300         ; Data Buffer Size


; The following are Additional (user) items
EXTRAPOL_EPOCHS = 4 60
ISSUE_KAR_TIME = on 30
VERBOSE = ON
REJECT_PSR = ON 15.00
```

CHAPTER 9 USING SIOGPS

Section 1 Introduction and FAQ

9.1.1 What is SIOGPS?

SIOGPS is the communications library that RtkNav uses to communicate with serial ports and network ports (sockets). It also contains the decoding routines that convert raw GPS data to Waypoint's GPB format (see gps_io.h), which is the data structure used to send raw measurements to RtDLL. The sample source code and structure definition comes with the developer's kit. This must be purchased in addition to RtkNav.

9.1.2 How can I use SIOGPS?

As you may have gathered, there are a tremendous number of functions contained within SIOGPS. When this manual was written, there were 42 functions. The good news is that only a portion of this command set need be used. Many commands have been added in order to add features to RtkNav and are not needed by the average user. For example, several commands have been added to facilitate datalogging to disk and rebroadcasting, and although datalogging is important, it can be just as easily implemented outside of the DLL.

There are several ways that SIOGPS can be implemented in conjunction with RtDLL. In the next section, there are flow charts showing methods (a) and (c).

a) If SIOGPS is employed to read data for the device (i.e. serial or network port), and it is used to decode the raw receiver data to a format compatible with RtDLL, the LogRtkData() function can be used. This requires the least amount of code within your own application, but you do not have access to the raw data other from the GPS receiver. Decoded records can be accessed via two means. The MultiBuf variable passed to LogRtkData() can be used to access decoded records, while callback functions can be within your own code. See below for a description of a callback function. This second approach is the simplest.

b) If a user wishes to avoid the callbacks used by LogRtkData (), then use the ReadGpsPort() function. This will return decoded records that have been created directly from the raw data stream coming from the serial or network port. In this method, SIOGPS would still take care of connecting to the device. The decoded data comes via a "thread buffer", which is explained below. See method 'c' for the treatment of the thread buffer.

c) If you would like access to the raw data, but still would like to use SIOGPS to connect to the port, then you must use the GetDataByte() or GetDataBuffer() functions to retrieve the data from the port, and call the DecodeOneByte() to decode the data. Once enough bytes have been decoded, this function will return decoded records. Use the ReadThreadBufData() function to extract the necessary records, which can be sent to RtDLL using the manner described in Chapter 7 .

d) If you would like to use your own routines to connect to the serial or network port, then only the DecodeOneByte() function need be used. Again, ReadThreadBufData() is used to used to extract the necessary records.

9.1.3 What is a port number and why is it needed?

Port numbers are arbitrary numbers that SIOGPS uses to identify serial/network ports and/or receivers. Valid port numbers range from 1 to 1023. The numbers themselves must be assigned by the user and should not be confused with comport or the network port numbers, and there is no reason that they need to be the same. For instance, COM7 could be assigned to port 100, while network port 5001 on IP 192.168.50.60 could be assigned to port 500. The only issue that is important is that the port numbers be unique. No two receivers can share the same port number. If a user is rebroadcasting data (see below), then an additional port must be assigned to the output data stream. The port number will be used for most of the functions to identify the receiver/port. It could be considered a handle—except that the user defines its value.

9.1.4 What is a callback function?

Callbacks are functions that you define in your application, but are called from the processing or conversion DLL. Each of these callbacks is defined as a **__stdcall** function and prototypes are given in either SioGps.h or Engine.h. Callbacks are used to two reasons:

a) Convey information to the calling program (i.e. via the AddMessage function)
b) Transfer data when a record has been decoded (see LogRtkData ())

The prototypes of the CallBack functions should be defined as “C” and not “C++” functions (e.g. place an ‘extern “C” {}’ around the prototype).

9.1.5 Can I use Visual Basic?

No. Visual Basic is not compatible with SIOGPS. If implementation were a simpler process, such as with some of Waypoint’s other DLLs, VB can be used. However, RtDLL and SIOGPS have too many structures that need to be re-coded. Since VB does not support structure packing, this process would be a near impossible effort. Users must write their own C++ or C cover functions in order to use VB.

9.1.6 What is structure packing and why is it important?

Structure packing defines how each member is placed within a structure. By default most compilers pack on the 8-byte boundary. MFC likes this packing as well. However, whenever binary GPS receiver data files are decoded, 1-byte structure packing can make the process much easier from a software programming point of view. The 1 byte pack forces all structure elements to be placed so that there are no empty spaces. For this reason, RtDLL and SIOGPS libraries are developed with structure packing set to 1 byte. We have tried as much as possible to ensure structure packing is defined in our header files. However, when using these structures in your own code, be sure that the packing is enabled.

9.1.7 How do I define what type of GPS receiver I am connected to?

There are no auto-detection capabilities in SIOGPS. Users must know before hand the format of the data coming in. This means knowing the receiver type and the receiver sub-type (i.e. manufacturer and model). Both of these parameters are defined in the RXCFGPARAM structure (see siogps.h). The *RxType* defines the receiver manufacturer, while the *RxSubType* defines the model/format. Type list of *RxTypes* is given in gps_io.h. They start with B_XXXX. The sub-types are given in SIOGPS.h. They start with ID_XXXX.

The following combinations of RxType and RxSubType are currently supported:

RxType	**RxSubType**	**Description**
B_ASHP12	ID_G12	Ashtech G12 using MBN/PBN data structure
B_ASHP12	ID_GG24	Ashtech GG24 using MBN/PBN records
B_ASHP12	ID_MACM	Ashtech G12 using compact MACM data format—Suggested over ID_G12 for robustness considerations
B_ASHP12	ID_Z12DBEN	Ashtech Z-XXX using compact DBEN record.
B_ASHP12	ID_Z12	Ashtech Z-XXX using PBN and MPC record format
B_NOVATEL	ID_3151	NovAtel OEM-3 data format (uses RGEC)
B_NOVATEL	ID_2151	NovAtel OEM-2 data format (uses RNGB)
B_NOVATEL	ID_MILLENIUM _GLONASS	NovAtel OEM-3 with GLONASS capabilities. Requests addition records necessary for GLONASS post-processing. Log raw to permit post-mission decoding of these records.
B_NOVATEL	ID_OEM4	NovAtel OEM-4 data format (uses RAWCOMP record)
B_JAVAD	ID_JPS_GRIL	Javad GRIL format (less robust than OEM format to follow)
B_JAVAD	ID_JAVADOEM	Javad OEM format (highly suggested over GRIL)
B_MARCONI	ID_ALLSTAR	Canadian Marconi AllStar/SuperStar (uses Rec 21)
B_JUPITER	ID_JUPITER	Connexant Jupiter (uses Rec 1102)
B_NAVSTAR	ID_XR6	Connect to XR6 receiver
B_XR7	ID_XR7	Connect to XR7 receiver using MACM record
B_TRIMRT	ID_TRIMRT	Use for Trimble 4X00 series receivers
B_TRIMRT	ID_TRIMRT_SS	Use for old Trimble 4000SS receivers
B_GARMIN	ID_NONE	Used for GARMIN raw data format

9.1.8 Do I need to configure the GPS receiver?

If the GPS receiver is connected to a serial port, SIOGPS will send out the commands to configure the receiver. It will even loop through each of the baud rates to attempt to communicate. However, for network ports, users must take care of the configuration themselves. Configuration should be on a separate thread to logging (see multithreading below…).

9.1.9 How and why would I re-broadcast data?

Re-broadcasting is the process of sending raw GPS data to another serial or network port. This could allow users to also process the same data at another site. In order to enable rebroadcasting, users will need to first open the source and destination ports (see OpenSioPort()). The source port would be that connected directly to the GPS receiver. Then after that, call the StartRebroadcast() function to engage rebroadcasting.

9.1.10 How do I set the static/kinematic status of the raw data?

RtDLL needs to know if the data is static (stationary) or kinematic (moving). There are two ways of performing this, **where the first is by far the easiest**.

a) Use the function called SetStaticKinematicMode(). When the data is decoded, this will take care of ensuring that for a particular port number, the static/kinematic bit is set properly.
b) Set the status bit in the pben_bin_type structure. The second bit defines whether an epoch is static or kinematic. This is possible only when using the DecodeOneByte() function. The pben_bin_type structure can be extracted using the ReadThreadBufData() using the TB_REC_PBEN identifier.

9.1.11 What is a thread buffer and how do I use it?

Thread buffers are generic buffers used to pass decoded records back from a number of routines (e.g. LogRtkData(), DecodeOneByte() and ReadGpsPort()). The structure if this buffer is given in threadbuf.h, but users do not need to be concerned with the internal structure because sufficient interface functions are available. Users will want to mainly use two functions, although, there are more available:

a) GetThreadBufRecCount() is used to determine how many of a type of record exists. For most records, there tends not to be more than one of that record available. In many cases, there may be none of a particular record in the thread buffer. However, for the GPS measurement data (i.e. record TB_REC_MBEN), this number, if greater than zero, will be the number of satellites tracked.
b) ReadThreadBufData() is used to extract all of the records of a particular type into an array.

The following table shows what types of records can be inserted into the thread buffer.

#	Macro (ID)	Description	Structure Name	Header file	Used by RtDLL
1	TB_REC_PBEN	Position record	pben_bin_type	gps_io.h	Y
2	TB_REC_ MBEN	Measurement record (for each satellite)	mben_bin_type	gps_io.h	Y
3	TB_REC_ GPSEPH	Ephemeris record	ret_gpseph_ type	threadbuf.h	Y
4	TB_REC_LOCK	Locktime values with better resolution than mben_bin_type	ret_locktime_ type	threadbuf.h	N
5	TB_REC_SAT	Satellite elevation + azimuth	ret_satvis_type	threadbuf.h	N
6	TB_REC_POS	Position record with more information than pben_bin_type	ret_pos_type	threadbuf.h	N
7	TB_REC_VEL	Velocity from GPS receiver	ret_vel_type	threadbuf.h	N
8	TB_REC_ GPSALM	GPS almanac	gpsalm_type	almanac.h	N
9	TB_REC_ RAWSIZE	Size of records logged. Used for approx. latency computation	ret_rawsize_ type	threadbuf.h	Y
10	TB_REC_ RAWDATA	Raw data records. Used to extract raw data records (not always implemented)	ret_rawdata_ type	threadbuf.h	N
11	TB_REC_DOP	DOP values computed by GPS receiver	ret_dop_type	threadbuf.h	N
12	TB_REC_ EVENT	Event mark read by GPS receiver	ret_event_type	threadbuf.h	N
13	TB_REC_ MASTERPOS	Master position transmitted from base	ret_masterpos_ type	threadbuf.h	Y
14	TB_REC_ UTCIONO	UTC/IONO data from receiver	ret_utciono_ type	threadbuf.h	N
15	TB_REC_ GLNEPH	GLONASS ephemeris	ret_glneph_type	threadbuf.h	N
16	TB_REC_TIME	Additional time information	ret_time_type	threadbuf.h	N
17	TB_REC_ CALCPOS	replaces TB_REC_POS if position re-computed	ret_pos_type	threadbuf.h	N

9.1.12 Should I make my application multithreaded?

In the RtDLL section, the flow chart indicates that a single thread will work, and in theory it does. However, the final program is much more robust if multiple threads are used. The most common implementation uses three threads:

a) **Decoding:** Continuously grab data from serial or network port and convert to GPB format. Once decoding is complete, send data to RtDLL.
b) **Configuration:** Send commands to GPS receiver. This can be a long process; therefore, starting the decoding thread beforehand is highly suggested.
c) **Processing:** This is the procedure of continuously calling the RtDLL function ProcessEpochXXX().

Both RtDLL and SIOGPS have built-in mutex's to allow multiple threads from safely using them simultaneously. You may call RtDLL's AddDataToBuf() and ProcessEpochXXX() without anticipating problems. You need only use a mutex to protect your own data shared among threads. Users new to multithreaded programming should do some background reading first. Computer bookstores have a number of books solely devoted to this topic.

9.1.13 How and why should I log raw data?

Logging raw data is the processes of saving the carrier phase, pseudorange and other measurements to disk. There are two formats most commonly used:

a) **Raw**: byte-for-byte from the GPS receiver
b) **GPB format**: which is compatible with Waypoint's post-processing software.

Included with RtkNav is a utility to convert GPB to RINEX. In order to perform this conversion operation automatically from your application, you will need to develop this functionality yourself.

The easiest way to log raw data it to use LogRtkData(). It has this capability built in, and it allows you to choose between raw and GPB. If you choose not to use LogRtkData(), then a raw file can be created by just writing every byte to a binary file. Note that the GetDataByte() methodology should be used. See Method (c). A GPB file consists of the following:

a) file header is a header_bin_type structure
b) each epoch starts with a pben_bin_type structure
c) followed by num_sats multiplied by mben_bin_type
d) Use create_bin_file() to create a GPB file and write_bin_epoch() to add an epoch to the file (see gps_io.c).

The reason for logging data is twofold:

a) Customer support is much easier if the user has access to the file. In such a case, raw data is preferable to GPB since we can always convert to GPB after the fact
b) Users may wish to consider post-processing as an option to improve accuracies after the fact. Due to forward and reverse processing, post-processing tends to always be more accurate.

Section 2 Getting Started

This section is broken down into the steps required to implement SIOGPS. These steps include:

a) Load SIOGPS.DLL
b) Open Library within DLL
c) Open Ports

d) Configure GPS receivers
e) Main logging loops
f) Shut down

9.2.1 Loading the DLL

The DLL can be loaded using the function called LoadSioGps() located within the C++ file loadsiodll.cpp in the directory ..\newserial\. You must pass the DLL file name. A full path name is highly suggested. LoadSioGps() will fill an SIODLL structure containing function pointers to each of the functions within SIOGPS.

It will return one of the following:
Return:

0	SUCCESS
-1	failure to open DLL (i.e. DLL not found)
-2	not all functions loaded (happens when newer code used with older DLL)
-3	NULL pointer discovered or structure packing not turned on
1+	failure to connect to function # in structure. The order is given in the SIODLL. This normally indicates a mismatch in DLL versions.

To close the DLL at the end, use the windows FreeLibrary() on the DLL handle located within the SIODLL structure.

9.2.2 Opening SIOGPS library

This is performed by calling the DLL function InitSioLibrary(). It will reset all internal variables and ensure that the serial and network drivers are available. Please be aware that we need the WinSock2 driver, which is not available on some older versions of Windows 95. Be sure to check the return value. The function GetLastSioError() can be used to retrieve the message corresponding to the failure.

At this point, you may also with to utilize the function SetAddMessage(). This allows you to send SIOGPS a pointer to a callback function that gets called when various warnings and events are observed. At this point, you could display the message to the user or just log it to a file. This helps in diagnosing problems.

9.2.3 Connecting to Ports

The next few steps discuss the initialization procedure. Figure 9.1 illustrates this process in the form of a flow chart

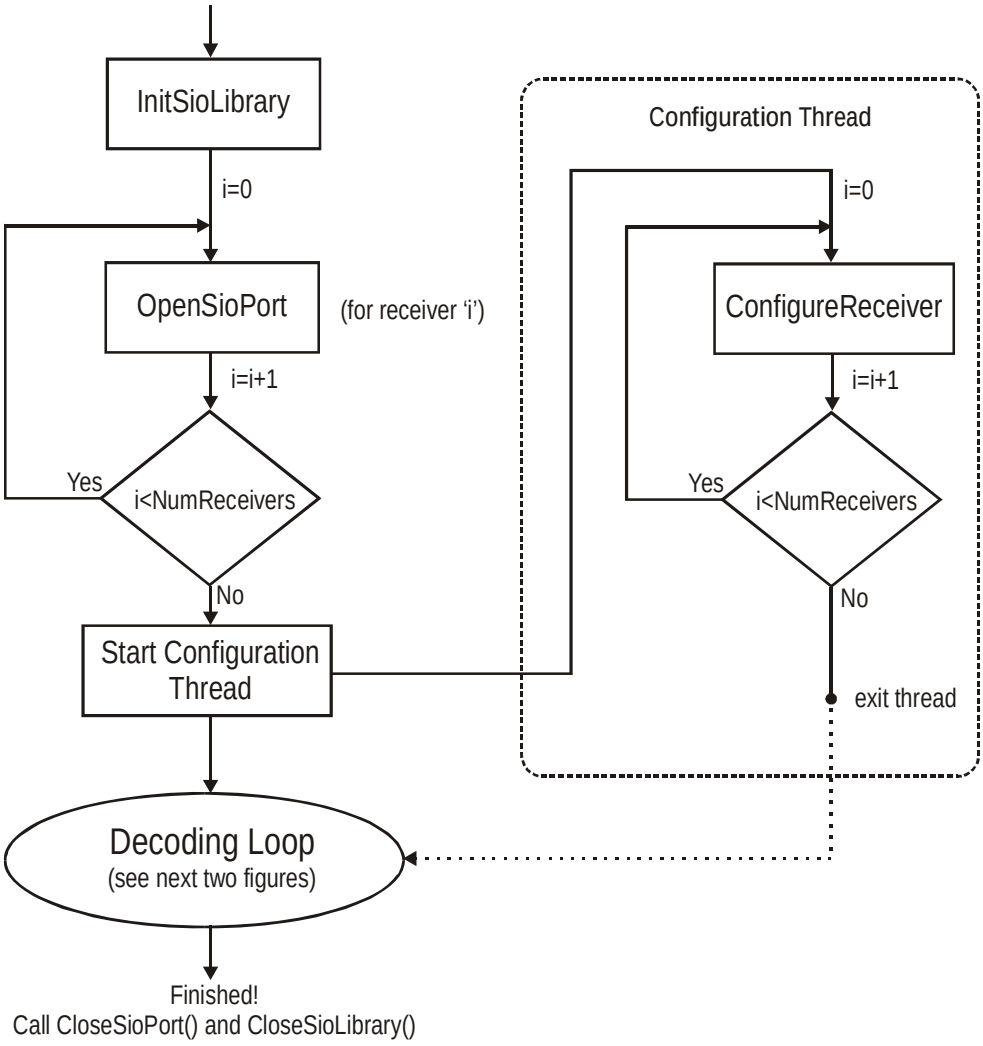


Figure 9.1: Flow chart for initialization

The first step involves calling the function OpenSioPort() for each. Even if you are using your own communications functions in conjunction with our decoder, you must still call this function. The difficulty in using OpenSioPort() is filling in the SIOPARAM structure properly, and most of this section is devoted to this very issue. The second parameter (*ConfigRxFlag*) can be used to postpone the sending of configuration commands or allow you to use your own configuration procedure. The methodology in Figure 9.1 has this flag set to FALSE, as configuration is implemented in its own thread.

The remaining part of this chapter is concerned with filling the SIOPARAM structure in.

Command variables:

Size sizeof(SIOPARAM). This ensures that the poper version of the DLL is being used. It must be filled in.

PortNum The is the arbitrary port number filled in by the user. It must be unique for each receiver or other output port. Valid PortNums are from 1-1023

PortType	This indicates the type of port this is. Valid types include	
	SIO_USER	This would be used if you are using your own routines to connect to the serial or network port. This allows you to use the DecodeOneByte function.
	SIO_SERIAL	Allows you to connect to a serial port.
	SIO_NETWORK	Allows you to connect to a network port using either UDP, TCP or MULTICAST.
	SIO_FILE	This is more added to allow RtkNav to replay data from disk. It allows users to read from disk instead of from a port.
	SIO_CONSOLE	Used to connect to a console port. This is a port that accepts user input and can display to screen. It is mainly added to permit RtEngine to turn the current window into a command port.
PortStatus	This variable is currently not used, but for future compatibly it should be set to SIO_GPSINPUT for connecting to a GPS receiver. See structure definition for more options.	

The following sections describe the sub-structures that need to be filled in.

9.2.4 Filling in PORTINFOSTRUCT (for Serial ports)

This structure needs to be filled in if you are connecting to a serial port.

Size	sizeof(PORTINFOSTRUCT) otherwise 0 if not used
comport	1,2,3…
baud	baud rate (e.g. 9600, 19200, 38400, 57600 or 115200)
parity	characters ‘N’ for none, ‘O’ for odd or ‘E’ for even
bits	data bits (e.g. 7 or 8)
stop	number of stop bits (currently always assumed to be 1)

9.2.5 Filling in NETPARAM (for Network ports)

This structure needs to be filled in if you are connecting to a network port

Size	sizeof(NETPARAM) or 0 if not used
NetType	SIO_MULTICAST for multicast mode SIO_UCP for UDP communications SIO_TCP for TCP mode. See 0for a description of these modes.
NetPort	This is the port number to be used (1-65535). For GPS data connections, values above 1024 are highly suggested in order to avoid conflicts.
IpAddress	This is the character string containing the IP address of the port being connected to. In TCP mode, if this port is being used as a server or receive port (i.e. it is being connected to by somebody else), then use “0.0.0.0”. In UDP mode, use “255.255.255.255”. In MULTICAST mode, use “234.5.6.7” .
SenderOr Receiver	This defines the mode for connection to the other port.

SIO_SOCKSEND	Connecting to another port mostly for sending purposes. This should be used for sending data to a specific location.
SIO_SOCKRECEIVE	Waiting to be connected from another port mostly for receiving purposes. This should be used for connecting to GPS receivers.
SIO_SOCKREBROADCAST	This port is used for setting up a rebroadcast port in tandem with a receive port for a given GPS receiver.
SIO_SOCKSERVER	This is used by RtkNav to implement the command port and is best combined with TCP mode.

RawFlag Not used right now. Set to false.

9.2.6 Filling in FILEINPPARAM (for using for reading from files)

This structure if only used for SIO_FILE mode. This is an input only port.

Size	sizeof(FILEINPPARAM) or 0 to ignore
FileName	Name of file to open for reading
InpType	SIO_INPGPB for reading from .GPB files. Ephemeris must be added to RtDLL independently SIO_INPRAW for reading byte-for-byte binary from the file. Be sure to increase the databuffers within RtDLL to compensate for files loosing synchronization.
DelayMs	For SIO_INPRAW mode only—this is the number of milliseconds to wait between reading each data block defined by RecSize
RecSize	Number of bytes to read for each data block (SIO_INPRAW mode only).

9.2.7 Filling in RXCFGPARAM (for connecting to a GPS receiver)

This can be used by all modes of input. It is used to define the receiver type and settings for configuring and decoding data.

Size	sizeof(RXCFGPARAM) or 0 to ignore
RxType	Type of GPS receiver. See gps_io.h (B_XXXX) for a list of possible receivers to choose from. Not all receivers listed in gps_io.h are implemented in SIOGPS.
RxSubType	Model of the GPS receiver. This is used to distinguish data formats or different configurations required by the same manufacturer. These are ID_XXXX given in siogps.h. See Section 8.2.3 and 9.1.7 for valid combinations of *RxType* and *RxSubType*.
DataInterval	Interval for requesting measurement record
PosInterval	Interval for requesting position record
AskForEvent	True if camera event marks are to be requested (may be ignored for some receivers)
AskForEph	True if ephemeris records are to be requested (may be ignored for some receivers)

AskForSatVis	True if satellite visibility records are to be requested (may be ignored for some receivers)
AskForSpeed	True if speed and heading record to be requested (NovAtel only) (may be ignored for some receivers)
AskForPos	True if position record to be requested (may be ignored for some receivers)
RxPort	SIO_PRIMARY (COM1, 'A', etc…) or SIO_SECONDARY (COM2, 'B', etc…)
FinalBaud	Should be same baud rate as in PORTINFOSTRUCT (-1 to ignore)
RxOptSize	Size of options structure (see rxopt.h). Use 0 to utilize internal defaults or specify later.
RxOptBuf	Structure containing receiver options, which are different for each GPS receiver (see rxopt.h)—Can also be defined later using DLL functions (see Decoder group of functions in Section 3).

9.2.8 Filling in RTKPARAM (for logging data from a GPS receiver)

This structure is only filled in if you plan to use LogRtkData() to read data from the ports and decode the information.

Size	sizeof(RTKPARAM) or 0 if not used
station	MASTER(1) or REMOTE(0)
remote	if (station== REMOTE) this indicates the remote index starting from zero. Ignored for MASTER.
StartMode	Indicates if receiver is to start in kinematic (moving) or static (stationary) mode. For most applications including monitoring, the MASTER is static and the REMOTEs are kinematic.
cbAddData ToBuf	Pointer to callback function that LogRtkData() calls when a measurement record is decoded. This can either be the AddDataToBuf function within RtDLL or your own intermediate function, which gives you access to the decoded data. The definition for this function is given by ADDDATATOBUF. This is not a prototype, and if you use a intermediate function, you should also provide a "C" prototype (i.e. include 'extern "C" {}' around the prototype to disable name mangling).
cbAddEphemeris DataRecord	Pointer to callback function that is called when an ephemeris record is completely decoded. Function definition given by ADDEPHEMERISDATARECORD. See variable *cbAddDataToBuf* for more information.
cbSetMaster Coord	Added for future ability to accept master position via the GPS input port. Currently, no such records have been implemented.

9.2.9 Datalogging settings

The following variables are only needed if you wish to log raw data within LogRtkData(). If you are using a methodology that does not utilize LogRtkData(), then logging should be performed

external to SIOGPS. Data logging can also be started using the OpenSioLogFile() function, but LogRtkData() must still be used for reading and decoding receiver data.

Parameters (within SIOPARM):

LogFileMode	SIO_LOGNONE disables logging SIO_LOGRAW logs data byte-for-byte as it arrives from the GPS receiver SIO_LOGGPB logs decoded GPB records compatible with Waypoint's post-processing software.
LogFileName	File name to log to. Full path name is highly suggested
DiskWriteInterval	Data interval to write to. To use input data interval set this value to 0.0

9.2.10 Reading and decoding data

As the FAQ "How can I use SIOGPS?" mentions, there are several means to implement SIOGPS (i.e. (a) through (d)). Methods (a) and (c) are the most common and are shown in Figure 9.2 and Figure 9.3.

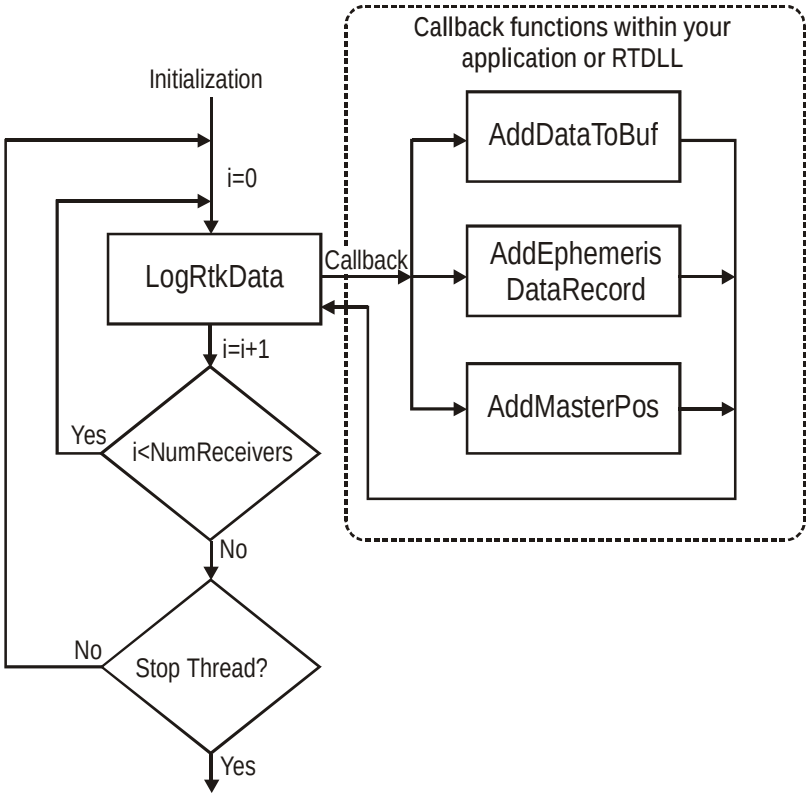


Figure 9.2: Using LogRtkData() to read and decode raw data [Method (a)]

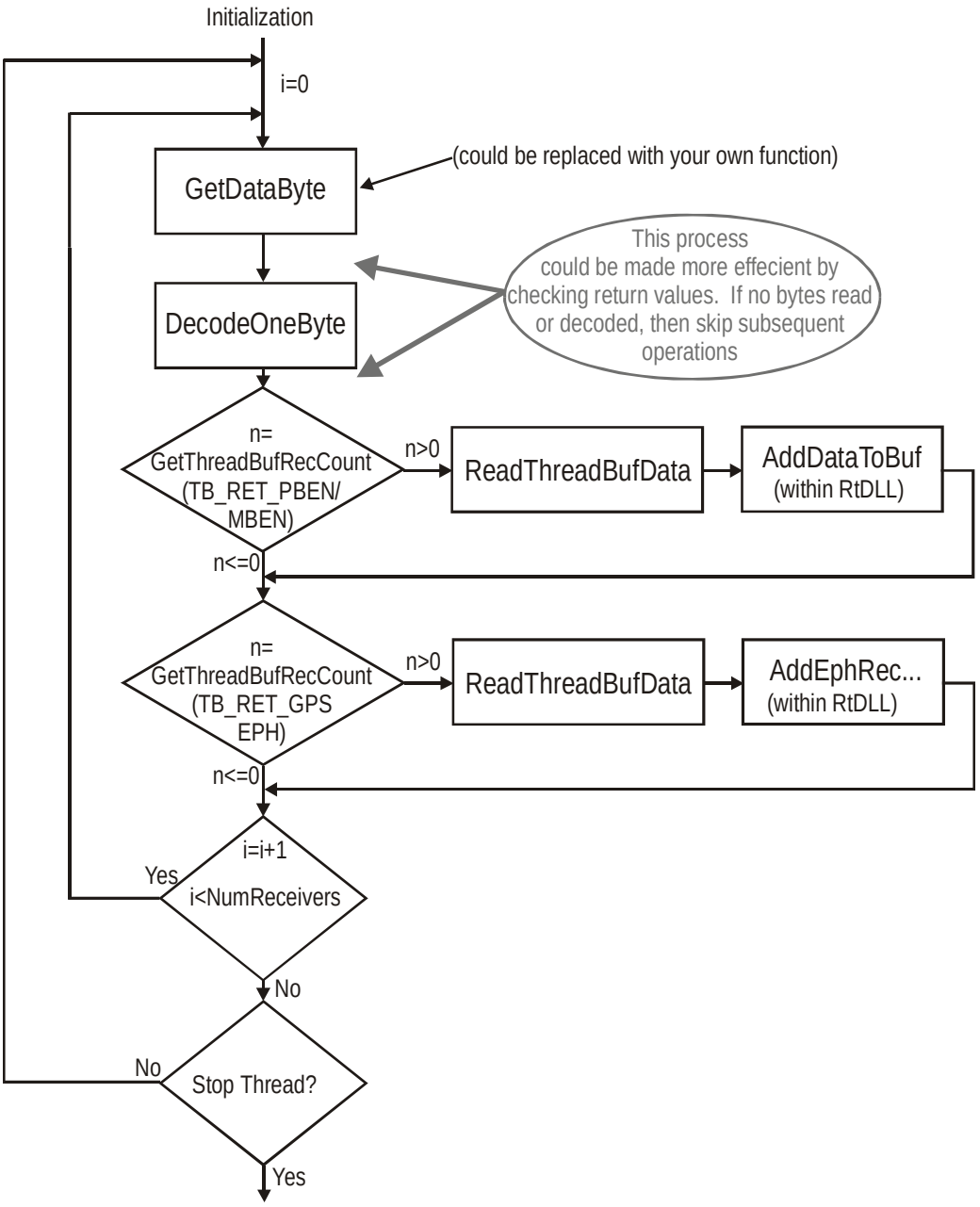


Figure 9.3: Decoding one byte at a time [Method (c)]

9.2.11 Method (a) — Using LogRtkData() function

The following shows some sample source code for using LogRtkData(). User can have access to decoded records by supplying their own AddDataToBuf() callback function (see previous section).

```
// global variables
int StopCommunciationThread;          // set to TRUE to exit thread
SIODLL Sio;                           // structure containing function pointers
                                      // to SIODLL
int    MasterPortNum;                 // port number for master receiver
```

```
int    RemotePortNum[MAX_REMOTE];      // port numbers of each of the remotes
int    NumRemotes;                     // number of remotes currently being processed
char   err_str[1024];                  // error string used internally

// unlogging thread (start with _beginthreadex())
unsigned __stdcall CommunicationThread( void *ptr )

{
     int i;

     StopCommuncationThread = 0;

     while( !StopCommuncationThread )
     {
          /* get serial data from ports */
          if( Sio.hLogRtkData( MasterPortNum, NULL )==TB_RET_ERROR )
          {

               //Sio.hGetLastSioError( err_str );
               //AddMessage( -1, err_str );
               //user may wish to comment in to see error messages
          }

          for( i=0; i<NumRemotes; ++i )
          {
               if( Sio.hLogRtkData( RemotePortNum[i], NULL )==TB_RET_ERROR )
               {
                    //Sio.hGetLastSioError( err_str );
                    //AddMessage( -1, err_str );
                    //user may wish to comment in to see error messages
               }
          }

          // free up some time for other threads
          Sleep(20);
     }

     _endthreadex( 0 );
     return 0;
}
```

9.2.12 Method (c) — Using byte-by-byte decoding

The following shows some sample source code for using the byte-wise unlogging. This gives user access to raw as well as decoded data. Note that this code has not been compiled. It is provided as a guideline only.

```
// global variables
int    StopCommunciationThread;        // set to TRUE to exit thread
SIODLL Sio;                            // structure containing function pointers
                                       // to SIODLL
engine_dll_type Eng;                   // structure containing RtDLL functions
int    MasterPortNum;                  // port number for master receiver
int    RemotePortNum[MAX_REMOTE];      // port numbers of each of the remotes
int    NumRemotes;                     // number of remotes currently being processed
int    MasterRxType;                   // B_XXX
int    RemoteRxType[MAX_REMOTE];       // B_XXX for each remote
char   err_str[1024];                  // error string used internally

// function to process data from one GPS receiver
// input:
//        PortNum - port number for a particular receiver
//   IsMaster - true if master
//   RemoteIndex - index of remote number (0,1,2...)
//   RxType - receiver type (see gps_io.h)
//   ThreadBuf - buffer used for decoding records
void UnlogReceiver( int PortNum, int IsMaster, int RemoteIndex, int RxType, void *ThreadBuf )
```

```
{
     int byte;

     // continously grab bytes until none left
     while( (byte=Sio.hGetDataByte( PortNum ))>=0 )
     {
          // decode data byte (i.e. add to decoding buffers)
          int r = Sio.hDecodeOneByte( PortNum, byte, ThreadBuf );

          // extract measurement data (determine if position and measurement
          //                           records available first)
          if( Sio.hGetThreadBufRecCount( ThreadBuf, TB_REC_PBEN ) &&
              Sio.hGetThreadBufRecCount( ThreadBuf, TB_REC_MBEN ) )
          {
               gps_epoch_type EpochData;
               memset( &EpochData, 0, sizeof(gps_epoch_type) );
               EpochData.b_hdr.receiver = RxType;

               if( !ReadThreadBufData( ThreadBuf, TB_REC_PBEN, 1, &EpochData.b_pben ) ||
                   !ReadThreadBufData( ThreadBuf, TB_REC_MBEN, MAX_ENGINE_CHAN, EpochData.b_mben
               ) )
               {
                    // print error message, as this should not happen
                    continue;
               }

               // grab system time, which is used for lineing data up in RtDLL
               EpochData.cpu_time = GetTickCount()/1000.0;

               // add data to buffer
               Eng.lpAddDataToBuf( IsMaster ? MASTER : REMOTE,
                                   RemoteIndex,
                                   &EpochData );
          }

          // extract ephemeris records
          if( Sio.hGetThreadBufRecCount( ThreadBuf, TB_REC_GPSEPH )  )
          {
               ret_gpseph_type EphRec;
               if( !ReadThreadBufData( tb, TB_REC_GPSEPH, 1, &EphRec ) )
               {
                    // again, this is an error
                    continue;
               }

               Eng.lpAddEphemerisDataRecord( &EphRec );
          }

          // continue until no data bytes read
     }
}

// unlogging thread (start with _beginthreadex())
unsigned __stdcall CommunicationThread( void *ptr )

{
     int i;

     StopCommuncationThread = 0;

     // allocate thread buffer
     char ThreadBuf = new char[Sio.hGetThreadBufSize()];
     // check if allocation succeeded here ...

     while( !StopCommuncationThread )
     {
          // unlog master
          UnlogReceiver( MasterPortNum, TRUE, 0, MasterRxType, (void *)ThreadBuf );

          // unlog remotes
          for( i=0; i<NumRemotes; ++i )
```

```
                UnlogReceiver( RemotePortNum[i], FALSE, i, RemoteRxType[i], (void *)ThreadBuf );

            // free up some time for other threads
            Sleep(20);
        }

        delete [] ThreadBuf;

        _endthreadex( 0 );
        return 0;
}
```

9.2.13 Other modes of usage:

No sample flow charts or code is given for other usages.

Method (b) merely involves passing a pointer to the MultiBuf parameter of LogRtkData(). This will give user access to a thread buffer, which can be extracted in the manner shown in Method (c). If the ReadGpsPort() function is used, it replaces the GetDataByte() and DecodeOneByte() subroutines in the previous example.

If you are logging data external to SIOGPS, method (d), then the GetDataByte function in the previous example is replaced with your own function. Otherwise the procedure is the same. Users in this situation can also utilize LogRtkData() via the MultiBuf. In this case, they would fill in a USERRTKDATA structure and pass that as the MultiBuf. Many of the variables within that structure. Consult the header file siogps.h for filling in this structure.

9.2.14 Shutting the system down

This is a four step procedure:

a) Stop all decoding threads and wait form this operation to be complete.
b) Call CloseSioPort() for each receiver and open port. This will stop logging and rebroadcasting as well as close the port
c) Call CloseSioLibrary(). This will also close any ports that have not been closed. For this reason, step (b) is optional.
d) Close the DLL using the Windows FreeLibrary() API function.

Section 3 Function description

This section describes the usage for each of the functions contained within SIOGPS. For a description of the structures see Section 2 and the header files. Functions can be broken down into the following categories:

Category	Function	Description
Open/Close	InitSioLibrary	Opens the library and initializes any variables.
	CloseSioLibrary	Closes any open ports, releases all handles and frees memory
	OpenSioPort	Opens a serial, network or decoding (user) port. (see Section 9.2.3)
	CloseSioPort	Stops rebroadcasting, closes port and stops logging

Utility	GetLastSioError	Fills a string with the last error message
	SetAddMessage	Permits messages from logging and other warnings to be sent to the callback function
	SioWaitSec	Waits for a specified time (use Windows Sleep instead)
	IsPortValid	Returns TRUE if port is connected
Configuration	ConfigureReceiver	Sends commands to GPS receiver (serial ports only)
	GpsShutDown	Sends commands to a GPS receiver to tell it to stop outputting records.
Decoding	OpenDecoder	Permits decoding to start on a port. Not normally used as OpenSioPort also calls this function
	FreeDecoder	Frees memory for decoding (CloseSioPort calls this function as well)
	SetDecoderOptions	Allows user to set decoding options (see rxopt.h)
	FillDecoderDefaults	Fills a buffer with the defaults for a given port that is configured as connected to a GPS receiver
	DecodeOneByte	Used to add one byte to the decoding routines. Fills thread buffer with decoded records (if any)
	SetStaticKinematicMode	Defines whether future epochs are to be static or kinematic
Rebroadcast	StartRebroadcast	Engages rebroadcasting of GPS raw data to another port. Ports must be opened first
	StopRebroadcast	Stops rebroadcasting—does not close ports
Multi-purpose	ReadGpsPort	Reads data from a GPS port and tries to decode it. It will return once one or more records have been decoded or there is no more data in buffers.
	LogRtkData	This function does much the same as above—except that it also sends the raw data to callback functions defined in the OpenSioPort function (see Section 9.2.3)
Enable/ Disable	EnableDisablePort	This function can be used to stop logging and decoding of a problem port
	IsPortEnabled	Returns TRUE if a port is enabled (i.e. has not been disabled)
Data Ports	SetSerialDataPort	Can be used to alter the comport settings (i.e. baud, parity, etc…) for a given serial port.
	ReConnectDataPort	Used primarily with network ports. This function can be used to re-establish a port that is not responding. It closes the port and tries to re-open it.
	IsSerialPortAvailable	Returns true if a comport number has a valid serial port attached and another application is not using it. Should be called before ports are opened.
	GetDataByte	Gets one byte from the opened port. Return –1 if none there
	GetDataBuffer	Gets a buffer from the opened port.
	GetDataBytesToBeRead	Gets number of data bytes in buffers

	GetDataTotalBytes	Gets total number of bytes read or written to/from a port
	SendDataString	Sends a NULL terminated string to the port. It will send a CR LF after sending the string
	SendDataByte	Send one byte to the port
	SendDataBuffer	Send buffer to the port
	GetDataPortConnectInfo	Gets information on the status of a port connection. Useful for network server ports
ThreadBuf	GetThreadBufRecCount	Gets number of records of a given type in a thread buffer
	GetThreadBufRecSize	Gets size of record for a given type. Useful for checking if a record has been changed (i.e. DLL compatibility)
	ReadThreadBufData	Extracts 'n' records of a given type into an array
	GetThreadBufSize	Gets the size that the threadbuf should be allocated to be
	SetThreadBufSize	Allows user to change the default thread buffer size.
LogFiles	OpenSioLogFile	Starts logging raw data to a file in LogRtkData()
	CloseSioLogFile	Stops logging to a file
	SaveSioLogFile	Closes and re-opens a file in case the computer crashes
	SetSioLogFileInterval	Sets interval (filter) for logging data

9.3.1 ConfigureReceiver

Description: Sends commands to GPS receiver connected to serial port.
Category: Configuration
When to use: After port is opened. Can also be used to startup a dead receiver.
Pitfalls: Cannot be used with network ports. This process can take a few seconds for each receiver, so data records might be lost of logging/decoding is not operating in the background.

Prototype: *int __stdcall ConfigureReceiver(int PortNum, RXCFGPARAM *pRxCfg)*

Input:	*PortNum*	Port number to configure receiver for
	pRxCfg	Pointer to RXCFGPARAM structure. Normally, this pointer is passed as NULL to use the RXCFGPARAM defined during the OpenSioPort() function. Otherwise, a structure can be passed to override the original settings. See Section 9.2.7 for a description of RXCFGPARAM structure, which is defined in siogps.h
Output:	(none)	
Return:	0	success
	1	failure (see GetSioLastError())

9.3.2 CloseSioLibrary

Description: Closes all ports and frees all memory.
Category: Open/Close
When to use: At the end
Pitfalls: Close after all communications threads have stopped

Prototype: *void __stdcall CloseSioLibrary()*

Input: (none)
Output: (none)
Return: (none)

9.3.3 CloseSioLogFile

Description: Stops logging to a raw or .GPB logfile
Category: Log Files
When to use: At end—CloseSioPort() also calls this function
Pitfalls: (none)

Prototype: *void __stdcall CloseSioLogFile(int PortNum)*

Input: *PortNum* Port number to close logfile for
Output: (none)
Return: (none)

9.3.4 CloseSioPort

Description: Closes the serial or network port. Stops rebroadcasting and logging to files. Also frees any memory associated with this port.
Category: Open/Close
When to use: After you are finished with a port
Pitfalls: Close after logging threads have stopped

Prototype: *void __stdcall CloseSioPort(int PortNum)*

Input: *PortNum* Port number (1-1023)
Output: (none)
Return: (none)

9.3.5 DecodeOneByte

Description: Accepts a byte and adds it to internal decoding buffers. It will try and look for a complete record using the receiver type specified in OpenSioPort(). See the RXCFGPARAM structure located within SIOPARAM (see siogps.h). If decoding errors are detected,

DecodeOneByte will try and rewind to next byte in order to try decoding any missed records (for some decoders only).

Category: Decoders

When to use: After reading one or more bytes from a serial or network port. OpenSioPort() must be called first.

Pitfalls: Make sure that you properly specify the receiver type and sub-type on entry into OpenSioPort(). See RXCFGPARAM structure in siogps.h. Thread buffer must be allocated to at least GetThreadBufSize() bytes. Data may not be altered in any way before adding to DecodeOneByte(). Watch out for baud rate being too slow for number of bytes being transmitted. More that one type of record can be passed back simultaneously in the thread buffer.
The return value is only used as a guideline to determine what types of records are located in the thread buffer. Use the GetThreadBufRecCount() to determine exactly what records are present.
See also LogRtkData() and GetDataByte()

Prototype: *int __stdcall DecodeOneByte(int PortNum, unsigned char InByte, void *ThreadBuf)*

Input:	*PortNum*	Port number for given receiver
	InByte	Byte value read from device (0-255)
Output:	*ThreadBuf*	Buffer filled with decoded records (see Section 3). Use GetThreadBufCount() to determine if a certain type of record is there. Use ReadThreadBufData() to extract desired records (may be an array).
Return:	TB_RET_???	see threadbuf.h
	translates to:	
	<0	error
	0	no data
	>0	one or more valid records decoded

9.3.6 EnableDisablePort

Description: If a port is operating intermittently, users may chose to ignore it. This can also be implemented by not calling DecodeOneByte() or LogRtkData(). However, disabling this feature and calling these functions as per usual will cause the data from the port to be cleared but no records to be decoded.

Category: Enable/Disable

When to use: After you have determined that a port is not operating properly. Should be use in conjunction with similar function in RtDLL. Must be called after OpenSioPort().

Pitfalls: Make sure that you keep track if port has been disabled (see IsPortEnabled())

Prototype: *void __stdcall EnableDisablePort(int PortNum, int EnableFlag)*

Input:	*PortNum*	Port number to enable or disable

	EnableFlag	0-disable, 1-enable
Output:	(none)	
Return:	(none)	

9.3.7 FillDecoderDefaults

Description: Fills buffer with the factory defaults. Must be called after the port is opened so that SIOGPS knows which receiver the defaults are for

Category: Decoders

When to use: After calling OpenSioPort()

Pitfalls: Make sure that structure size is OK. Each receiver decoding has its own structure (see rxopt.h)

Prototype: *int __stdcall FillDecoderDefaults(int PortNum, void *pOpt, int OptSize)*

Input:	*PortNum*	Port number specified with OpenSioPort()
	OptSize	Size of options structure that you expect to receive
Output:	*pOpt*	Buffer to accept options structure (see rxopt.h)
Return:	0	Success
	1	Failure most likely due to wrong *OptSize* (see GetSioLastError())

9.3.8 FreeDecoder

Description: Frees memory associates with a given ports decoder.

Category: Decoders

When to use: CloseSioPort() calls this function so there is no reason to use it.

Pitfalls: none

Prototype: *void __stdcall FreeDecoder(int PortNum)*

Input:	*PortNum*	Port number
Output:	(none)	
Return:	(none)	

9.3.9 GetDataByte

Description: Reads one byte from the serial or network device. Can be used in conjunction with DecodeOneByte() to read and convert a data stream from a GPS receiver.

Category: Data Ports

When to use: After OpenSioPort() function called

Pitfalls: Port must be opened as SIO_SERIAL, SIO_NETWORK or SIO_FILE (not suitable with SIO_USER ports)
This function must be called with a sufficient frequency so that the internal buffers (8192 bytes) do not fill up. For this reason, it is best to implement it on a separate thread to RtDLL.

Ports can go dead while bursting data in and out at the same time. The FIFO gets jammed and can only be reset by opening and closing the port.
See also LogRtkData() and DecodeOneByte()

Prototype: *int __stdcall GetDataByte(int PortNum)*

Input:	*PortNum*	Port number to read data from
Output:	(none)	
Return:	0-255	data byte value
	-1	No bytes to read

9.3.10 GetDataBuffer

Description: Reads a buffer from the serial or network device. Slightly more efficient that GetDataByte()
Category: Data Ports
When to use: After OpenSioPort() function called
Pitfalls: *See GetDataByte(). Also see LogRtkData() and DecodeOneByte()*

Prototype: *int __stdcall GetDataBuffer(int PortNum, void *Buf, int MaxSize)*

Input:	*PortNum*	Port number to read data from
	MaxSize	Maximum number of bytes to read (i.e. size of *Buf*)
Output:	*Buf*	Buffer allocated to *MaxSize* bytes to be filled
Return:	*NumBytes*	Number of data bytes copied to *Buf*
	0	No bytes available in input buffers
	-1	Error (see GetSioLastError())

9.3.11 GetDataPortConnectInfo

Description: Returns information about the status of a serial or network port. Most useful with network ports since this function will indicate the IP address of the connecting party for TCP receive and server ports. This function fills a CONNECTPARAM structure (see siogps.h).
Category: Data Port
When to use: After opening port. Use to determine the status of a network port. Good diagnostic tool
Pitfalls: Be sure to fill Size member of the CONNECTPARAM structure before calling function. May not be as informative for UDP and MULTICAST ports as TCP. However, will still indicate if port is connected. To check if function succeeded, check *PortNum* member of CONNECTPARAM structure

Prototype: *void __stdcall GetDataPortConnectInfo(int PortNum, CONNECTPARAM *pConnect)*

Input:	*PortNum*	Port number to get information for	
Output:	*pConnect*	CONNECTPARAM structure where:	
		Size	=sizeof(CONNECTPARAM)—use must fill this in
		PortNum	Filled in by function if successful. Should be used as a check.
		PortType	SIO_NETWORK, SIO_SERIAL …
		IsOpen	TRUE if port is successfully opened
		IsConnected	Only applicable for network ports. Indicates true if another party is connected to the port
		NetType	This indicates the type of network port (e.g. SIO_TCP, SIO_UDP, SIO_MULTICAST)
		NetTransmitMode	Mode defined by OpenSioPort(). SIO_SOCKSEND, SIO_SOCKRECIVE, SIO_SOCKSERVER or SIO_SOCKREBROADCAST
		ConnectNetIp	Character string of IP address connected to—most practical for TCP connections.
		ConnectNetPort	Network port number connected to
Return:	(none)		

9.3.12 GetDataBytesToBeRead

Description: Returns number of data bytes in the input buffers for a particular device.

Category: Data Port
When to use: Before reading
Pitfalls: Currently not implemented—may be added in the future

Prototype: *int __stdcall GetDataBytesToBeRead(int PortNum)*

Input:	*PortNum*	Port number
Output:	(none)	
Return:	-1	Function not available or other error (see GetSioLastError())
	NumBytes	Number of bytes in the input buffers

9.3.13 GetDataTotalBytes

Description: This returns the total number of bytes that have either been read or written to a port. It is useful in conjunction with LogRtkData() as the user has no access to the raw data stream. This function is useful to diagnose if serial data is arriving if records are not being decoded.

Category: Data Port
When to use: After port is opened
Pitfalls: none

Prototype: *unsigned int __stdcall GetDataTotalBytes(int PortNum, int Flag)*

Input:	*PortNum*	Port number for device
	Flag	0 Return total number of bytes read
		1 Return total number of bytes written
		2 Return both number of bytes read and written
Output:	(none)	
Return:	-1	Error
	NumBytes	Total number of bytes

9.3.14 GetLastSioError

Description: Grabs the last error message string
Category: Utility
When to use: Call after an error has been returned from any of the SIOGPS functions.
Pitfalls: Watch out for multithreaded applications because another thread may cause the string to get overwritten.

Prototype: *void __stdcall GetLastSioError(char *str)*

Input:	(none)	
Output:	*str*	String to fill with last error message
Return:	(none)	

9.3.15 GetThreadBufRecCount

Description: Used to determine how many records of a given type are located in a thread buffer returned by DecodeOneByte(), ReadGpsPort() and LogRtkData(). See Section 3 for a list of possible records and their corresponding structures. Most of these structure are given in ../util/threadbuf.h or ../util/gps_io.h
Category: ThreadBuf
When to use: After calling DecodeOneByte(), ReadGpsPort() and LogRtkData()
Pitfalls: More than one type of record can be returned at once. In addition, some record types (e.g. TB_REC_MBEN, TB_REC_SAT and TB_REC_LOCK) return arrays of records.

Prototype: *int __stdcall GetThreadBufRecCount(void *ThreadBuf, int RecID)*

Input:	*ThreadBuf*	Thread buffer returned from DecodeOneByte(), ReadGpsPort() and LogRtkData()
	RecID	Record ID to determine how many exist in *ThreadBuf*. This will be one of TB_REC_??? shown in threadbuf.h. See thread buffer FAQ in Section 3 .
Output:	(none)	
Return:	Number of records in of that type or 0 if none.	

9.3.16 GetThreadBufRecSize

Description: Returns the structure size of a particular record. This is used to ensure compatibility between the SIOGPS DLL and your current source code.
Category: ThreadBuf
When to use: Before using ReadThreadBufData() and after thread buffer has been filled by DecodeOneByte(), ReadGpsPort() or LogRtkData().
Pitfalls: Make sure that structures are packed. Only works for records contained in threadbuf.

Prototype: *int __stdcall GetThreadBufRecSize(void *ThreadBuf, int RecID)*

Input: *ThreadBuf* Thread buffer returned from DecodeOneByte(), ReadGpsPort() and LogRtkData()
RecID Record ID for determining size of. This will be one of TB_REC_??? shown in threadbuf.h. See thread buffer FAQ in Section 3 .
Output: (none)
Return: structure size of record corresponding to *RecID*—see Section 3 for list of records.

9.3.17 GetThreadBufSize

Description: This function can be used to determine the size that a thread buffer should be allocated to be. The internal decoding functions (e.g. DecodeOneByte(), etc…) check this number to ensure that a buffer overrun does not occur.
Category: ThreadBuf
When to use: Before allocating your thread buffer
Pitfalls: Using the value returned by this function is much safer than using the TB_DEFAULT_SIZE macro in threadbuf.h as that is subject to change.

Prototype: *int __stdcall GetThreadBufSize( )*

Input: (none)
Output: (none)
Return: Current thread buffer size in bytes.

9.3.18 GpsShutDown

Description: This function sends command(s) to the GPS receiver to stop outputting records. It is only implemented for receivers that support this feature. For NovAtel it involves sending an UNLOGALL command, while for Ashtech the following two commands are sent: $PASHS,RAW,ALL,A,OFF and $PASHS,RAW,ALL,B,OFF
Category: Configuration
When to use: At end of your program before calling CloseSioPort().

Pitfalls: All data output is stopped. Configuration commands must be resent. This function is not called from CloseSioPort().

Prototype: *void __stdcall GpsShutDown(int PortNum)*

Input:	*PortNum*	Port number to send shut down command to.
Output:	(none)	
Return:	(none)	

9.3.19 InitSioLibrary

Description: This function connects to the windows network and serial drivers. It also initializes internal variables.
Category: Open/Close
When to use: It must be called after DLL is opened and before any other functions are to be used
Pitfalls: Make sure that WinSock2 is loaded on your system

Prototype: *int __stdcall InitSioLibrary()*

Input:	(none)	
Output:	(none)	
Return:	0	Success
	1	Failure (see GetLastSioError())
	2	Hardlock error (see GetLastSioError())

9.3.20 IsPortEnabled

Description: Can be used by software to check if a port has been disabled. Used in conjunction with the EnableDisablePort() function.
Category: Enable/Disable
When to use: After a port has been opened
Pitfalls: none

Prototype: *int __stdcall IsPortEnabled(int PortNum)*

Input:	*PortNum*	Port number to check if enabled
Output:	(none)	
Return:	(none)	

9.3.21 IsPortValid

Description: Returns true if a port is opened properly.
Category: Utility
When to use: After port is opened

Pitfalls: Will return true even if data bytes are not arriving. Use GetDataTotalBytes() function to determine if data is arriving.

Prototype: *int __stdcall IsPortValid(int PortNum)*

Input:	*PortNum*	Port number to determine if opened
Output:	(none)	
Return:	1	Port open
	0	Port not opened or OpenSioPort() failed

9.3.22 IsSerialPortAvailable

Description: This function can be used to determine if a particular serial port is available. For instance, RtkNav uses this function to fill the drop-down list box of comports that are present. It loops through all comports (1-32) and continually calls this function.

Category: Data Ports

When to use: Before ports are opened but after OpenSioLibrary()

Pitfalls: If ports are used by another application, they will not be found. Ports must be visible to windows before they can be found.

Prototype: *int __stdcall IsSerialPortAvailable(int comport)*

Input:	*comport*	1 for COM1, 2 for COM2, etc…
Output:	(none)	
Return:	0	Port NOT available
	1	Port available for use

9.3.23 LogRtkData

Description: This function can be used to read data from a GPS receiver connected to a serial or network port. It will continuously log and decode data until no bytes are in the read buffers for that device. Decoded measurement and ephemeris records will be sent to RtDLL or application via callback functions defined during port opening (see Section 9.2.3). Users can have access to decoded records in two ways:

a) Send a thread buffer (pointer) via the *MultiBuf* parameter
b) Specify callback functions that exist within their own application.

The main purpose of LogRtkData() is to interface easily with RtDLL. This is because LogRtkData() calls the callback functions defined in the RTKPARAM substructure of SIOPARAM during OpenSioPort(). See Section 9.2.8 for more information on using LogRtkData().

For ports defined as SIO_USER (see Section 9.2.3), the *MultiBuf* parameter is a USERRTKDATA structure, which contains a buffer to

bytes to decode. This buffer would normally be filled using a third party serial/network library. This structure is defined in siogps.h, and it has the following members:

USERRTKDATA Structure:

Size	Sizeof(USERRTKDATA)—must be filled in by user
AllocBufSize	Allocated size of input buffer (*Buffer*)
CurBufSize	Current number of bytes in *Buffer*
Buffer	Buffer of bytes read from external device.
CurLoc	Current number of bytes in *Buffer* that LogRtkData() has decoded. If this number comes back less than *CurBufSize*, then additional bytes should be added to the end of *Buffer* or LogRtkData() should be continually called before adding more data. *CurLoc* should start as zero and will otherwise be modified by LogRtkData()
ThreadBuf	Optional pointer to a thread buffer to give user access to decoded records.
Note:	The implementation of the USERRTKDATA structure has not been fully tested

Category: Multi-purpose

When to use: After port is opened

Pitfalls: Many:

a) Incorrectly defined receiver type and sub-type
b) Incorrectly specified or coded callback functions (see example code)
c) Not calling LogRtkData() with sufficient frequency so that it falls behind data stream
d) Calling LogRtkData() too often so that it takes over the CPU
e) Receiver gone dead—try reconfiguring
f) If you define your own callback, be sure not to stay in there too long. In addition, don't forget to call AddDataToBuf() and AddEphmerisRecord() functions in RtDLL to send data over.
g) Intermittent or invalid port definition in OpenSioPort()
h) Baud rate too slow for size and volume of records

See also DecodeOneByte() and GetDataByte()

Prototype: *int __stdcall LogRtkData(int PortNum, void *MultiBuf)*

Input:	*PortNum*	Port number connected to GPS receiver
	MultiBuf	NULL to ignore For SIO_SERIAL and SIO_NETWORK ports, users can pass a Thread buffer as this pointer to gain access to decoded records (use ReadThreadBufData() to extract records/arrays).
Output:	*MultiBuf*	For SIO_USER ports, users can pass an input data buffer using a USERRTKDATA structure (see siogps.h)
Return:	TB_RET_???	see threadbuf.h
	translates to:	
	<0	error

0	no data
>0	one or more valid records decoded

9.3.24 OpenDecoder

Description: The function enables decoding for a given port. Since this function is already called in OpenSioPort(), there are not many situations that require this function to be called by the user.

Category: Decoders
When to use: Never
Pitfalls: none

Prototype: *int __stdcall OpenDecoder(int PortNum)*

Input:	*PortNum*	Port number
Output:	(none)	
Return:	0	success
	1	failure

9.3.25 OpenSioLogFile

Description: Starts logging raw or decoded GPS data to a file. Used if logging within the SIOPARAM is not used. Otherwise, this function can be ignored.

Category: Log Files
When to use: After opening the port
Pitfalls: File name must be valid and cannot be opened by another application. Internal logging is only possible from LogRtkData(). Be sure to periodically call SaveSioLogFile() to ensure that minimal data is lost if a power loss occurs.

Prototype: *int __stdcall OpenSioLogFile(int PortNum, int LogFileMode, char *LogFileName)*

Input:	*PortNum*	Port number (1-1023)
	LogFileMode	SIO_LOGRAW logs data byte-for-byte as it arrives from the GPS receiver SIO_LOGGPB logs decoded GPB records compatible with Waypoint's post-processing software.
Output	(none)	
Return:	0	Success
	1	Failure (see GetLastSioError())

9.3.26 OpenSioPort

Description: This function opens a serial, network, console, file or user port. Users are primarily interested in serial, network or user ports. A user port is one where SIOGPS is just used for decoding a raw data stream, which is

normally obtained externally to SIOGPS. This function must be called prior to any other function utilizing a port number (*PortNum*). For the most part, this function is used to initialize ports connected to GPS receivers; however, that need not be the case. See Section 9.2.3 for more information on opening a port. This is where the SIOPARAM structure is defined.

Category: Open/Close

When to use: Before using a particular port but after OpenSioLibrary() is called.

Pitfalls: Selecting ports that cannot be opened or have another device using them. In addition, problems often arise when the SIOPARAM structure is not filled in properly—see 9.2.3 .

Prototype: *int __stdcall OpenSioPort(SIOPARAM *pSio, int ConfigRxFlag)*

Input:	*pSio*	Pointer to SIOPARAM structure (see Section 9.2.3 for details on how to fill this structure in).
	ConfigRxFlag	TRUE if this receiver is to be configured after opening. ConfigureReceiver() function can be used if this is False.
Output:	(none)	
Return:	0	Success
	1	Failure (see GetLastSioError())

9.3.27 ReadGpsPort

Description: Continuously reads a serial or network port until one of the following:

a) No bytes remain

b) One or more records have been decoded.

Receiver type must be specified in RXCFGPARAM structure located within SIOPARAM when OpenSioPort() is called. If decoding errors are detected, ReadGpsPort() will try and rewind to second byte to try unlogging any missed records records (for some decoders only).

Category: Multi-purpose

When to use: After port opened as a GPS port with OpenSioPort()

Pitfalls: Make sure that you properly specify the receiver type and sub-type (i.e. RXCFGPARAM structure filled in properly on entry into OpenSioPort()). Thread buffer must be allocated to at least GetThreadBufSize() bytes. Watch out for baud rate being too slow for number of bytes being transmitted. More that one type of record can be passed back simultaneously in the thread buffer.

Prototype: *int __stdcall ReadGpsPort(int PortNum, void *ThreadBuf)*

Input:	*PortNum*	Port number for given receiver
Output:	*ThreadBuf*	Buffer filled with decoded records (see Section 3). Use GetThreadBufCount() to determine if a certain type of record is there. Use ReadThreadBufData to extract desired records (may be an array).

Return:	TB_RET_???	see threadbuf.h
	translates to:	
	<0	error
	1	no data
	>0	one or more valid records decoded

9.3.28 ReadThreadBufData

Description: This function is used to extract a particular record from the thread buffer returned by DecodeOneByte(), ReadGpsPort() and LogRtkData(). Use GetThreadBufRecCount() to determine how many records exist of a particular type.

Category: ThreadBuf

When to use: After calling GetThreadBufRecCount() to determine if a record exists

Pitfalls: *FillBuf* not being allocated to the correct size. Structure packing not enabled.

Prototype: *int __stdcall ReadThreadBufData(void *ThreadBuf, int RecID, int MaxNum, void *FillBuf)*

Input:	*ThreadBuf*	Thread buffer returned by decoding routines. May contain many records.
	RecID	Record ID to determine how many exist in *ThreadBuf*. This will be one of TB_REC_??? shown in threadbuf.h. See thread buffer FAQ in Section 3 .
	MaxNum	Maximum number of elements of array to fill. Set to 1 to just fill one structure.
Output:	*FillBuf*	Pointer to structure or array of structures Be sure to allocate correctly.

Return: Number of records filled in *FillBuf*
0 if none filled

9.3.29 ReConnectDataPort

Description: This function can be called to reconnect a network port that it not responding. For non-server ports, it closes the connection and re-established it meaning that some data may get lost. This command is internally called in SIOGPS for receive and send ports if the connection is lost. For a TCP server connection, this command can be continuously called to check if the connection has either been broken or changed.

Category: Data Port

When to use: After a connect has been broken and SIOGPS did not handle the stoppage to your satisfaction

Pitfalls: Data is lost during the reconnection process.
Only works for network connections
Reconnection can take some time if the internet is involved.

Prototype: *int __stdcall ReConnectDataPort(int PortNum)*

Input:	*PortNum*	Port number to reconnect
Output:	(none)	
Return:	0	success
	1	failure (see GetSioLastError())

9.3.30 SaveSioLogFile

Description: Closes and re-opens a logfile
Category: Log Files
When to use: Every 'n' minutes to ensure that if the power fails that minimal data is lost.
Pitfalls: Make sure that another thread is not writing to this file at the same time. There is a built-in mutex, but it is always good to be safe.

Prototype: *int __stdcall SaveSioLogFile(int PortNum)*

Input:	*PortNum*	Port number to perform operation for (1-1023)
Output:	(none)	
Return:	0	Success
	-1	Port or file not opened
	-2	Mutex timed out
	-3	Failed to re-open raw data file
	-4	Failed to re-open GPB file
	-5	Failed to re-open ephemeris file
	-6	Invalid type of logfile

9.3.31 SendDataBuffer

Description: Sends a buffer of bytes to the serial or network device.
Category: Data Port
When to use: After port is opened
Pitfalls: Sending too many buffers at once may overload the internal buffers which are 8K.

Prototype: *int __stdcall SendDataBuffer(int PortNum, void *Buf, int BufSize)*

Input:	*PortNum*	Port number to send byte to
	Buf	buffer of bytes to send out port
	BufSize	Number of bytes in *Buf*
Output:	(none)	
Return:	0	success
	1	failure (see GetLastSioError())

9.3.32 SendDataByte

Description: Sends one byte to the serial or network device.

Category: Data Port
When to use: After port is opened
Pitfalls: Less efficient than SendDataBuffer()

Prototype: *int __stdcall SendDataByte(int PortNum, unsigned char OutByte)*

Input:	*PortNum*	Port number to send byte to
	OutByte	0-255, byte value
Output:	(none)	
Return:	0	success
	1	failure (see GetLastSioError())

9.3.33 SendDataString

Description: This function sends a NULL terminated string to a particular device. This function also sends a carriage return (0x0D) and line feed (0x0A) before and after the string. SendDataString() is useful for sending ASCII commands to a GPS receiver.
Category: Data Port
When to use: After port is opened. Use to aid in receiver configuration.
Pitfalls: Do not send binary data. To send bytes without CRLF use SendDataBuffer() function.
Sending data while receiving can sometimes jam the ports.
Be cautious of the correct baud rate.

Prototype: *int __stdcall SendDataString(int PortNum, char *Str)*

Input:	*PortNum*	Port number to send data string to
	Str	NULL terminated string
Output:	(none)	
Return:	0	success
	1	failure (see GetLastSioError()

9.3.34 SetAddMessage

Description: Sets callback function that is to receive any decoding or logging warnings or error messages—especially for debugging.
Category: Utility
When to use: Call after InitSioLibrary()
Pitfalls: Make sure that you define your callback function properly (i.e. __stdcall with 'C' prototype). *gpstime*<0 indicates that time is not known.

Prototype: *void __stdcall SetAddMessage(ADDMESSAGE cbAddMessage)*

Input: *cbAddMessage* Pointer to callback message. It should be defined as: *void __stdcall AddMessage(double gpstime, char *str)*

Output: (none)
Return: (none)

9.3.35 SetDecoderOptions

Description: This function can be used to override the internal decoding options for a particular receiver. The header file rxopt.h has structures for each of the various formats. To retrieve the internal defaults (i.e. defined by SIOGPS), use the FillDecoderDefaults() function.
Category: Decoders
When to use: After opening a port and before decoding data or calling LogRtkData()
Pitfalls: Make sure that correct structure is used for the receiver type and sub-type that you have selected. Make sure that structures are packed.

Prototype: *int __stdcall SetDecoderOptions(int PortNum, void *pOpt, int OptSize)*

Input:	*PortNum*	Port number
	pOpt	Pointer to structure containing options (e.g. ashopt_type or nov_opt_type)—see rxopt.h
	OptSize	Size of structure
Output:	(none)	
Return:	0	Success
	1	Failure most likely due to incorrect structure size (see GetSioLastError())

9.3.36 SetSerialDataPort

Description: Allows user to alter the serial port settings (e.g. baud, parity, etc…) after a port has been opened. See Section 9.2.3 for a description of the PORTINFOSTRUCT structure which is defined in siogps.h
Category: Data Ports
When to use: After port is opened
Pitfalls: If you change the baud rate, make sure to tell the other device to change its baud rate before calling this command.

Prototype: *int __stdcall SetSerialDataPort(int PortNum, PORTINFOSTRUCT *pComInfo)*

Input:	*PortNum*	Port number of the serial port that is to be altered (note that PortNum is not the comport number but rather the port number—see Section 3)
	pComInfo	PORTINFOSTRUCT containing the baud, parity, stop bits and data bit settings (see siogps.h)
Output:	(none)	
Return:	0	success
	1	failure (see GetSioLastError())

9.3.37 SetSioLogFileInterval

Description: Sets the data interval that is used as a filter when to write epochs to disk. This only works in conjunction with .GPB files, as raw files are written byte-for-byte as the data arrives from the serial port.

Category: Log Files

When to use: Must be used after OpenSioPort is called. Can even be used after logging has engaged.

Pitfalls: Interval must be a multiple of the input data interval.

Prototype: *int __stdcall SetSioLogFileInterval(int PortNum, double DiskWriteInterval)*

Input:	*PortNum*	Port number to perform operation for (1-1023)
	DiskWriteInterval	Interval value in seconds. Use 0.0 to log at the input data rate.
Output:	(none)	
Return:	0	Success
	-1	Port not opened
	1	Mutex timed out

9.3.38 SetStaticKinematicMode

Description: Changes the static/kinematic flag for future epochs of a receiver connected to a particular port.

Category: Decoding

When to use: After port is opened and every time you wish to switch modes

Pitfalls: Initial static/kinematic mode defined in the RTKPARAM structure (StartMode variable).

Prototype: *void __stdcall SetStaticKinematicMode(int PortNum, int SkMode)*

Input:	*PortNum*	Port number to change dynamic mode for
	SkMode	0-static, 1-kinematic
Output:	(none)	
Return:	(none)	

9.3.39 SetThreadBufSize

Description: This function can be used to change the size that a thread buffer filling routines such as DecodeOneByte(), LogRtkData() and ReadGpsPort() check to prevent buffer overruns. This only refers to the size of the thread buffer and has nothing to do with internal raw data buffering.

Category: ThreadBuf

When to use: Before calling DecodeOneByte(), LogRtkData() or ReadGpsPort()

Pitfalls: If this value is set too small, some records may get lost. The minimum value should be 16K (see TB_DEFAULT_SIZE in threadbuf.h which is the default size).

Prototype: *void __stdcall SetThreadBufSize(int NewBufSize)*

Input:	*NewBufSize*	New size of thread buffer in bytes
Output:	(none)	
Return:	(none)	

9.3.40 SioWaitSec

Description: Function that waits a specified number of seconds. This function merely calls the windows Sleep() function. Therefore, users are better off just calling Sleep() directly.

Category: Utility
When to use: Never
Pitfalls: none

Prototype: *void __stdcall SioWaitSec(float sec)*

Input:	*sec*	Number of seconds to wait
Output:	(none)	
Return:	(none)	

9.3.41 StartRebroadcast

Description: Engages rebroadcasting, which is the process of sending the input bytes from a given receiver to another serial or network port. Normally, rebroadcasting is over a network port, but this is not necessary.

Category: Rebroadcast
When to use: After both ports have been opened
Pitfalls: Network connection must be stable. TCP less reliable that MULTICAST or UDP. Both source and destination ports must be opened prior to calling this function.

Prototype: *int __stdcall StartRebroadcast(int SrcPortNum, int DestPortNum)*

Input:	*SrcPortNum*	Port number connected to GPS receiver
	DestPortNum	Port number to receive raw data (i.e. output port)
Output:	(none)	
Return:	0	success
	1	failure (see GetSioLastError())

9.3.42 StopRebroadcast

Description: Stops a rebroadcast operation

Category: Rebroadcast
When to use: After StartRebroadcast() has been engaged and before CloseSioPort() is called. CloseSioPort() will also call this function automatically.

Pitfalls: none

Prototype: *void __stdcall StopRebroadcast(int PortNum)*

Input: *PortNum* Destination port defined in StartRebroadcast()
Output: (none)
Return: (none)

APPENDIX A SUMMARY OF COMMANDS

The following lists the available commands and a short description of their usage. Any subset of the following may be used for your particular input file.

Command	**Description**
ATTITUDE = OFF/COMPUTE/STATE	GPS attitude option only. COMPUTE by least squares, add attitudes as STATEs in the Kalman filter or disable.
ATT_DENSITY = 5	Spectral density for the attitude states in deg/sec**2.
BASE_SAT = *sv_num*	Satellite PRN number of base satellite used for differenced computations. Normally, this value should be left at 99, which will cause the program to automatically choose the *highest* satellite. The default value is 99.
BIAS_DENSITY = 0.0	This is the spectral density of the ambiguity states and should be left at zero (default).
CYCLE_TEST = *mode*	This is the method in which cycle slips are detected. For most receivers the default is DOPPLER, which uses the phase rate (doppler) to detect cycle slips. Using locktime to detect cycle slips can be invoked by setting the *mode* to LOCKTIME. For most robust results with your receiver, *mode* should be set to BOTH which will cause both LOCKTIME and DOPPLER cycle slip detection to be invoked. For locktime to work, binary data (.GPB) version 1.01 or higher must be used. The version number of the data file can be changed from within VIEWGPB (*F7* key). Default is DOPPLER.
CYCLE_TOL = *tol*	Tolerance used to detect cycle slips on the L1 phase. These tolerances generally vary from 1 - 15 cycles. This value depends on receiver type, vehicle dynamics and multi-path effects. For data rates longer than 1 second, this value may have to be increased accordingly (e.g. multiply by 15 for a 15-second data rate). This is due to noise effects in the phase rate (doppler). Multi-path environments may require at least 5 cycles even in static mode. Small cycle slips reported by GPS_PROC may

	indicate that CYCLE_TOL is too low. This value is multiplied by 10 during kinematic mode. The default value is 2.0*processing_interval.
DATUM = *system*	The following coordinate systems (datums) are currently supported: WGS84, NAD27 and NAD83. NAD83 is considered the same as WGS84. Other systems can be made available -- Call us. Default is WGS84.
DIST_CONST = ON/OFF DIST SDEV	Enable/disable distance constraint for GPS attitude module (only). DIST in metres indicates the measured (constrained) distance between two antennas. SDEV indicates the standard deviation of the measured distance. Default off.
DISK_WRITE = ON/OFF	RTK only. Default is OFF. Indicates whether output is to be written to the hard disk.
DUAL_FREQUENCY = *on/off on/off off/relative/free*	OFF/ON - Use P-code for long baseline processing. OFF/ON - Use L2 phase for ambiguity resolution. OFF/RELATIVE/FREE – Use relative ionospheric correction or long baseline L3 iono-free baseline processing.
ELEV_MASK = *angle*	Cut-off elevation for excluding satellites from the computations. This value is expressed in degrees. This *elevation mask* value may have to be increased to 15 degrees or more in high multi-path environments or during ionospheric storms. Some data tracked under 10 degrees may exhibit noise characteristics. Default value is 15.0.
END_TIME = *gps_time*	Time to stop processing in GPS seconds. The default value is 999999.0. For reverse processing, the default is 0.0.
EPH_FILE = *file[.epp]*	File that contains the satellite ephemeris information. The default is *master_file.epp*.
EXCEL_FILE = *file[.csv]*	This is an ASCII file of all the information position, time, RMS and ambiguities that is comma delimited. This file can be easily read into a

	spreadsheet such as Microsoft Excel©. The format is the first row of the file. Default is no output. This function is obsolete!
EXTRAPOL_EPOCHS=*nExtrap MaxSec*	This function should be used with either the EXTRAPOL LineUpMode: in the .IN file, or the ProcessEpochMsBufEx() function. It sets the window size in epochs used for extrapolation, and it also sets the maximum time range over which extrapolation is performed. *nExtrap* is the number of epochs that should be used for extrapolation. Values between 5 and 10 are normally used. When the master data is arriving at higher data rates, then the window size can be increased. For lower rates, it should be decreased. *MaxSec* is normally set to 180 seconds.
FIX_AMB = *sv amb_value*	This allows you to fix the ambiguity value for a given satellite. This can be useful to force a certain set of ambiguities on a solution--especially in kinematic mode. Note: the ambiguity value will change significantly for a different base satellite. Ambiguity value is specified in cycles. Default is none.
GEN_FILE = *fname[.gen]*	Send epoch by epoch output in a *generic* format: *time X Y Z VX VY VZ rms num_sats* Default is no output.
HL_PORT = *port_address*	The HEX address of the printer port containing the hardware lock. A value of *zero* will use LPT1. For other ports, the actual port address must be entered. Common values are 378 for LPT1, 278 for LPT2 and 3BC for LPT3. The default is zero.
INTERVAL = *master_int [remote_int]*	This specifies the processing interval in seconds. It should be equal to or greater than the recording interval for proper time length computations. If this value is larger than the recording interval, then this new value will be used for processing. The default value is 1.0.
IONO_DIST = *dist_in_km*	Baseline distance in km at which relative iono-free processing will begin.

KAR_CUBE = *cube_size*

Size of kinematic ambiguity resolution (KAR) search *cube* in metres. A cube +/- *cube_size/2* will be searched from the initial approximate position, which is obtained from the program following the loss of lock. The default value is 2.0 m. This value should be increased if it is suspected that the remote position is outside of the search cube. However, larger values increase the possibility of an incorrect intersection found.

KAR_MAXSV = *num_sats*

Maximum number of *good* satellites over which KAR will not be invoked. A value of 3 would mean that if there are cycle slips and 4 or more good satellites, the program will correct for cycle slips instead of KAR. 3 is the default value and should be left there.

KAR_RELTOL = *tol*

Reliability is calculated by dividing the lowest intersection RMS by that of the second lowest. Reliable intersections should have values of 1.5 or higher and preferably greater than 2.0. Default is 1.5.

KAR_RMSKEEPTOL = *tol*

If the RMS from a KAR solution is higher than this tolerance (cycles), then a warning will result. If there are still 4 good satellites *(see KAR_MAXSV)*, this solution will not be used. Default value is 0.06 cycles.

KAR_TIME = *time_length*

Length of time that KAR will scan for cycle slip free data with 5 or more satellites following the serious loss of lock. Increasing this value will improve the reliability of KAR, but it may also increase the number of seconds skipped between loss of lock and start of KAR. Decreasing KAR_TIME will decrease this *skipping* effect but may also lower the reliability. For C/A code receivers, this value should be 900 seconds or greater. This value can be lowered for L2 phase receivers. Default is 1200 seconds.

KAR_RMSUSETOL = *tol*

This is the tolerance (cycles) with which intersections will be kept in the list. This value should be 0.20 or higher. The default is 0.20 cycles.

KAR_MIN_TIME = *8.0 0.50*

Minutes. These are the times in minutes that the program will process a float solution before attempting an OTF KAR solution on L1 only or L1/L2 respectively.

KAR_MAX_TIME = *30*

Minutes. After this number of minutes, KAR will stop attempting to perform an ambiguity solution. Possible reasons for this are poor data quality or too long a baseline.

KAR_RMS_TOL = 0.075

Tolerance for KAR statistical test on the RMS phase in cycles.

KAR_REL_TOL = 1.50

Tolerance for KAR statistical test on the reliability of the chosen KAR solution.

KAR_SEP_TOL = 2.0

Tolerance for allowable separation between the float and fixed KAR solutions.

KAR_MAX_DOP = 7.0

Tolerance for allowable DOP during a KAR solution.

KAR_L2_NOISE = HIGH/LOW

Default is HIGH. Model used for KAR L1/L2 ambiguity search.

KAR_ELEV_MODEL = ON/OFF

Default is ON. KAR uses the KAR_TWOSTAGE_SAT highest satellites for its ambiguity search.

KAR EPOCH_FILTER = *interval*

Interval between storing measurements for KAR usage. A smaller number will cause more memory to be used, but may improve KAR reliability to a small degree.

KAR_EPOCH_SIZE = *epochs_l1 epochs_l2*

Number of epochs between KAR ambiguity searches if L1 only or L1/L2.

KAR_TWOSTAGE_SATS = 6

Use this maximum number of satellites in the KAR ambiguity search routines.

L2_SLIP_TOL = 0.20

Cycles. Tolerance in L2 cycles at which an L2 cycle slip will be assumed.

LOCKTIME_CUTOFF = 8

Seconds. Phase data will be ignored for the first 8 seconds after locking onto the satellite. Change this

	value to 0 to process all phase data or a large value to ignore the first n seconds of lock. This gives the phase lock loop a chance to stabilize.
MASTER_FILE = *[path]file_prefix[.gpb]*	This is the name and location of the master station binary GPS data file. This data must be in the .GPB format. If your data is not in this format, use one of the conversion utilities supplied. If this value is not entered, the program will prompt for it.
MASTER_ID = *station_name*	GPS attitude option only. Unique station id for the master station file. Required with MASTER_FILE command for attitude determination.
MASTER_POS = *lat. long. ht [hi]*	These are the coordinates of the master station. The latitude and longitude must be entered in *degrees minutes seconds* with spaces in between. For those only interested in differential vectors between the stations, a rough pseudorange position is sufficient. This can be found using the VIEWGPB utility **or** selecting interactive input from the first menu and selecting an averaged position. If the antenna height (metres) is not present, this value will be assumed to be *zero*. Latitude is positive in the Northern Hemisphere and negative in the Southern Hemisphere. Longitude is positive in the Eastern Hemisphere and negative in the Western Hemisphere (Americas).
MOVING_BASE = ON/OFF	Moving Baseline Option Only. If ON, this indicates to the GrafMov module that the base station is in dynamic mode as well as the remote. If MOVING_BASE=OFF, conventional processing is performed.
MOVING_BASE_FILE = *fname[*.MOV*]*	.MOV file is an ASCII output of the local level vectors associated with relative moving baseline processing.
NUM_DATA_BUFFERS = 30	RTK option only. Indicates the number of epochs of data that are to be buffered in memory. The program will process the oldest set of non-processed measurements.

OMIT_SATS = *sv1 sv2 ....*

This is a list of satellites (PRN numbers) to omit from processing. This may need to be done if a satellite is bad. The default is no omissions.

OUTPUT_MODE = NORMAL/EXTENDED/OLD

Determines output format for the ASCII .FWD and .REV files. EXTENDED includes velocity and ambiguity values. OLD indicates the file format prior to GrafNav version 5.03.

OUT_PREFIX = *file_prefix*

Normally the output file prefixes will be the same as the input .CFG file. These are *prefix.FML, .RML or .ANN (GrafNet Only), prefix.fss or .rss for GrafNav and .sum for GrafNet* and *prefix.fwd or rev for GrafNav and .out for GrafNet*. This can be used to save multiple output file copies of a project. Care should be taken with this command because the user may loose track of the output files.

PCODE_SD = *stdev*

P-code measurement standard deviation in metres. By making this value 1.0 m or less, the program will converge faster in static mode and be more resilient to cycle slips in kinematic. However, it will also add noise to a solution, which is mainly controlled by the *precise* carrier phase. The default value is 2.0 m. P-code processing and P-code data is required for this option.

PHASE_SD = *stdev*

L1 carrier phase measurement standard deviation in metres. The default value is 0.02 m and it is best left there.

PHASE_RATE_SD = *stdev*

L1 phase rate (doppler) measurement standard deviation in metres/second. The default value is 0.04 m/s and it is best left there.

POS_DENSITY = 1.0

This is the spectral density of the position states. You may want to increase this value to 10 *or more* under high dynamics. This value should be left at 1.0 (default).

PROCESS_DIR = *direction*

Processing direction is either FORWARD or REVERSE. Reverse processing can be useful if there are a major series of (fatal) cycle slips during a kinematic run. All features supported under forward processing are supported under reverse

processing except for the feature that skips past epochs with satellite data dropouts. Also the fixed static solution is not currently supported with reverse. The default is FORWARD.

PRECISE_EPH_FILE = *fname[*.SP3*] NGS ON/OFF*

Use precise ephemeris.
Precise filename[.sp3] Format (NGS) Enable/Disable

RANGE_SD = *stdev*

CA code measurement standard deviation in metres. For noisy or poor quality pseudorange observations, this value can be increased. The default value is 7 m.

RAPID_CUBE = *cube_size*

Size of quick static ambiguity search cube in metres. A cube +/- *cube_size/2* will be searched from the initial approximate, which is obtained from the first pass of the program. The default value is 1.5 m. This value should be increased if it is suspected that the remote position is outside of the search cube. However, larger values increase the possibility of an incorrect intersection found.

RAPID_STEP = *interval*

Size of quick static ambiguity search cube interval in metres. Raising this value to 0.03 will speed up processing considerably. For very slow machines you may wish to raise it to 0.04. The default value is 0.02 m.

RAPID_TIME = *time_length*

Length of time over which to apply quick static ambiguity search cube. The default value is 600 seconds. This time must be within the static data length.

RAPID_TOL = *tol*

Tolerance for rejecting quick static intersections. This would reduce/increase the number of intersections picked in quick static. Valid values are 0.70-0.95. Defaults are 0.80 for L2 phase, and 0.90 for L1 phase only (C/A code).

REJECT_PSR = ON/OFF *Rejection Tol.*

This will reject bad pseudoragnes. The first parameter can be used to enable (ON) or disable (OFF) this rejection filter. In addition, the user can set the tolerance (in meters). This value should be

at least the maximum length of the base-remote separation.

REMOTE_FILE = *[path]file_prefix[.gpb]*

This is the name and location of the remote station binary GPS data file. This data must be in the .GPB format. If your data is not in this format, use one of the conversion utilities supplied. If this value is not entered, the program will prompt for it.

REMOTE_ID = *station_name*

GPS attitude option only. Unique station id for each of the remote station files. Required with REMOTE_FILE command for attitude determination.

REMOTE_POS = *lat. long. ht [hi]*

These are the coordinates of the remote station. The latitude and longitude must be entered in *degrees minutes seconds* with spaces between. The program now computes a differential pseudo-range solution at the start of the program if REMOTE_SD is greater than 1.0 metres. This means that this position can be many kilometers out and still work. Although entering the position is not necessary, this command must be used if the remote antenna height (m) is to be used. If the antenna heights were entered in real-time with LOGGPS (F2 key), then this value should be set to 0.0. Latitude is positive in the Northern Hemisphere and negative in the Southern Hemisphere. Longitude is positive in the Eastern Hemisphere and negative in the Western Hemisphere (Americas).

REMOTE_SD = *stdev*

Standard deviation of REMOTE_POS in metres. To fix the initial position, this value should be set to zero. To *really* fix a solution when starting in kinematic mode, the FIX_AMB command can be used in conjunction. Default value is 100 m.

RMS_TOL = *l1_tol ca_tol p_tol*

Tolerance in metres for printing out the message: *Warning: data_type RMS is #.#. Worst PRN is # with resid. #.#.* The first value is for L1 phase. The second for C/A code. The third is for P code. For a more experienced user who wishes to detect possible noise in the data, the following should be used:

RMS_TOL = 0.1 25 15

	The *ca_tol* can be lowered to 10 for Narrow Correlator receivers. Defaults are: 1.0, 50.0 and 10.0 metres.
SEARCH_FORWARD = *epochs*	Number of epochs to search forward if a satellite drops out. If there are a lot of satellite drop outs due to unstable serial data collection, this value can be increased. A value of *zero* may produce unstable results. Default is 2 epochs.
START_TIME = *gps_time*	Time to start processing in GPS seconds. This is used to start processing in mid-data stream. It may also be useful to by-pass some erroneous data at the start of the data set. The default value is 0.0 (999999.0 for reverse processing).
STATIC_CYCLE_TEST = *mode*	Method for detecting cycle slips in static mode. If this command is not specified the *mode* defined by CYCLE_TEST will be used. All of these modes are supported (CYCLE_TEST) with one additional method. This is the phase trend (TREND) cycle slip detection method. This fits a polynomial through the phase data to determine the cycle slip value. This is much more precise than the sometimes noisy doppler value. It can generally be used to detect 1 cycle slips *(see TREND_CYCLE_TOL command)*. The TREND mode is automatically implemented for the fixed solution. Default is same as CYCLE_TEST.
STRIP_FILE = *fname[*.SIN*]*	This is an input file which is used for a certain kind of GPS assisted photogrammetry. The ambiguities for each photo line can be approximated by a so-called strip methodology, rather than by conventional OTF routines. The file format is: *Strip_id GPS_start_time GPS_stop_time*
TREND_CYCLE_TOL = *tol*	Phase trend cycle slip tolerance. By lowering this to 0.5, very small cycle slips (1 cycle) can be detected. However, on longer data intervals (>5 sec.), this may produce *false* cycle slips due to noise in the phase. Therefore the default value is 10 cycles.
TROPO_MODEL = SAAS/BLACK	Default SAAS. Two different tropo models can be selected.

TIME_CORR = 0.0 0.0	Seconds. Time correction to master and remote files. This may be useful if a receiver has logged data in UTC time rather than GPS time.
VECTOR_UPDATE = OFF/ON OFF/ON	Filter Constraint – OFF or ON – Kalman filter to use input distance constraint. KAR distance constraint OFF/ON – distance constraint used in KAR solution – GPS attitude option only.
VECTOR_FILE = *fname[*.CRD*]*	GPS attitude option only. Input coordinate file for calibration of the initial antenna attitude quantities.
VEL_DENSITY = 1.0	This is the spectral density of the velocity states. You may wish to increase this value under very high dynamics. This value should be left at 1.0 (default).
WRITE_BAD_EPOCHS = OFF/ON	Default is OFF. Use ON to write bad data to the .FWD/.REV files. This option is useful if the user wishes to view data at epochs where the RMS_TOL values are exceeded. Normally, data which is greater than RMS_TOL is not written to file.
WRITE_RESIDUALS = ON/OFF	default OFF. If ON, then write out each L1 phase and CA-code residual for each satellite to a .RL1 and .RCA file.

APPENDIX B ATTITUDE SOFTWARE

RTKNav attitude determination will compute the roll, pitch, and yaw of a vehicle or other object, given that data is available from three or more fixed mounted GPS antennae. The receiver antennae must be arranged in a non-collinear fashion. The software will also require the relative positions of the antennae, which are essentially their coordinates in the local body frame of the vehicle or object. These can be obtained through the calibration procedure described in Section 1 of this appendix. In addition to the attitude, the software will also compute the relative vectors between the GPS antennae used. The following steps need to be performed:

1. Compute the coordinates of each receiver in the body frame of the vehicle.
2. Create the project, and set the relevant options.

The first step is described in Section 1 of the appendix, while the second step is described in Section 2.

Section 1 Make Body Coordinates

Purpose

The *Make Body Coordinates* dialog box allows the user to define the body coordinate system for the GPS antenna locations. The output of this process is a CRD file that will be read by RTKNav. The CRD file will contain the body coordinates of each of the antenna stations. These stations refer to the GPS antennae used solely for the multi-antenna computation. This is a calibration procedure that only needs to be performed once per installation.

The main purpose of this calibration procedure is to produce x, y, and z coordinates for each fixed mounted GPS antenna in the frame of the vessel, aircraft or vehicle. This is the body coordinate system and is required for two reasons:

- Defines where the roll, pitch and yaw angles are referenced.
- Used as distance constraint information to improve multi-antenna KAR performance.

Figure B 1 shows this body coordinate system. *Make Body Coordinates* basically solves for the roll, pitch and heading (-ve yaw) for the calibration installation. These are the angles required to rotate the antenna stations from local level to the body frame. This procedure requires a minimum of three antenna stations.

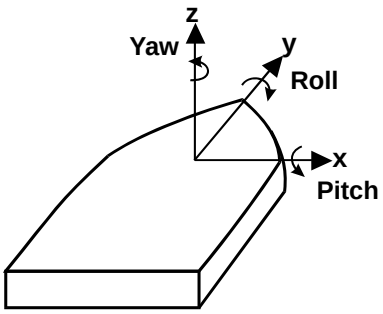


Figure B 1: Body Coordinates Axis

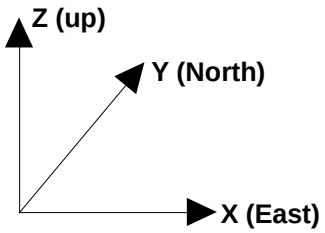


Figure B 2: Local Level Coordinate System

What is needed to start?

Before running *Make Body Coordinates*, the following information is required:

- **GPS baselines:** Using the standard version of GrafNav, coordinate/baseline information must be obtained for each of the fixed mounted antenna stations. The vessel/aircraft/vehicle must be approximately level (<10°) during calibration. In fact, it is best to level the vessel/aircraft/vehicle to a position expected during travel. The GPS baseline data is computed as follows:

  - **Baseline Computation**
    In the calibration procedure, data must be captured from each of the antenna stations simultaneously. Each baseline is processed separately with GrafNav, but it is suggested that the same base station be used throughout. It is highly suggested that one of the vessel/aircraft/vehicle antennae be used as the base. This procedure is greatly simplified for cases when the calibration is performed in static mode. At least 15 minutes of data should be collected. In static mode, the GrafNav fixed solution can be used giving a very accurate baseline resolution. In kinematic mode, KAR should be used if possible. Single frequency KAR requires at least 20 minutes of data, although 40 to 120 minutes are suggested. Make sure that no antenna heights are entered during processing. If very large base movements (+100m) are encountered, then GrafMov should be used.

  - **Coordinates**
    The local level or ECEF coordinates can be obtained from numerous sources. The easiest two are:
    - FSS or RSS file for static calibration. Look for the Fixed Static Solution block. The local level vector values are DE/DN/DZ: *x y z*, and the ECEF vector values are VECTOR: *x y z*. These values are with respect to the master station.

    - FWD or REV file or kinematic calibration. Be sure to use the same epoch for each of the stations. The first three values in the second row of each data block refers to the local level east, north and up values respectively.

- **Station names**
  Assign each of the antenna stations an ID. This ID can be alpha numeric but cannot contain spaces. This will later on be assigned to each GPB file for processing. Be sure to include the master station, its local level or ECEF coordinates will be [0,0,0] if the same master is used throughout. The first station, which is often the master station, is termed the reference station; it will be given final body coordinates of [0,0,0].

- **Constraint information:** Information on how to define the body coordinate system is required. There are two possibilities:

  - **Angular definition**
    You can specify absolute angles within the body frame between two stations (from and to). This will define the axes. Three angles need to be specified. The body azimuth is rotation about the z-axis and defines heading. The easiest approach is to pick two stations along one axis, but this is not required. Roll and Pitch are defined by tilt values. Preferably these tilt values (Tilt-x and Tilt-y) are orthogonal and along the body x and y-axes. However, you will have to do your best. For these inputs, enter the vertical angular difference between the level plane and the vector between the 'from' and 'to' stations. See Figure B 3 for an example.

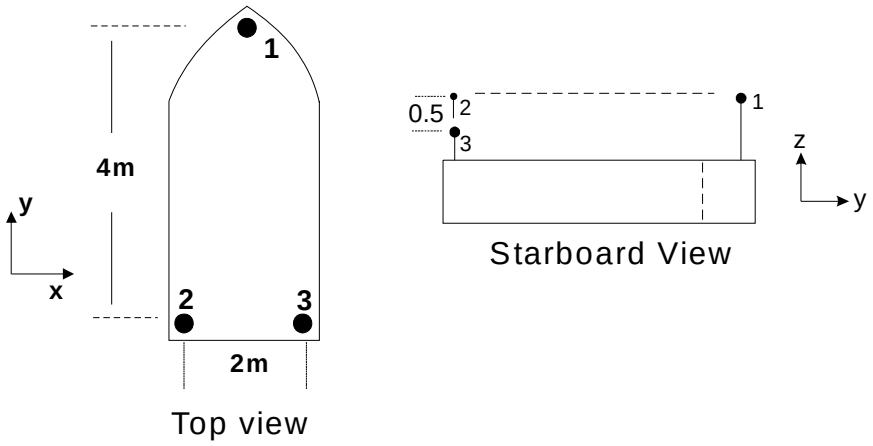


Figure B 3: Local Level Coordinate System

The body azimuth is defined as 90° from stations 2 to 3.

The tilt along the x-axis (Tilt-x) is defined as -14.04° from stations 2 to 3. This is computed using the formula ($\theta = \tan^{-1}[(Z_{to}-Z_{from})/HzDist]$), where HzDist is the horizontal distance (m).

The tilt along the y-axis cannot be directly observed, therefore an approximation of the tilt must be made either by using stations 3 to 1, or 2 to 1. Using 2 to 1, Tilt-y can be set to 0.0.

More details are given in the Procedure Section.

- **Coordinate definition**
  If externally-obtained (i.e. surveyed) antenna phase centre coordinates are available, then these can be used to define the body coordinate system. With a proper survey, this method may produce more accurate results than the angle-based method. Since the final coordinates of the reference station are [0,0,0], all input body coordinate measurements must be referenced to this station (i.e. the body coordinates of the reference station must be subtracted from each coordinate). Therefore, the coordinates for this reference point must be known. Minimums of three body coordinate measurements are required for stations other than the reference. In order to generate a proper seed value, one of these stations (other than the reference) must have both X and Y set. Best results are obtained with an X, Y, and Z set on one station and Z on another.

Procedure

The *Make Body Coordinates* dialog box is shown below, in Figure B 4. It must be filled in the following manner before the final computation can be made.

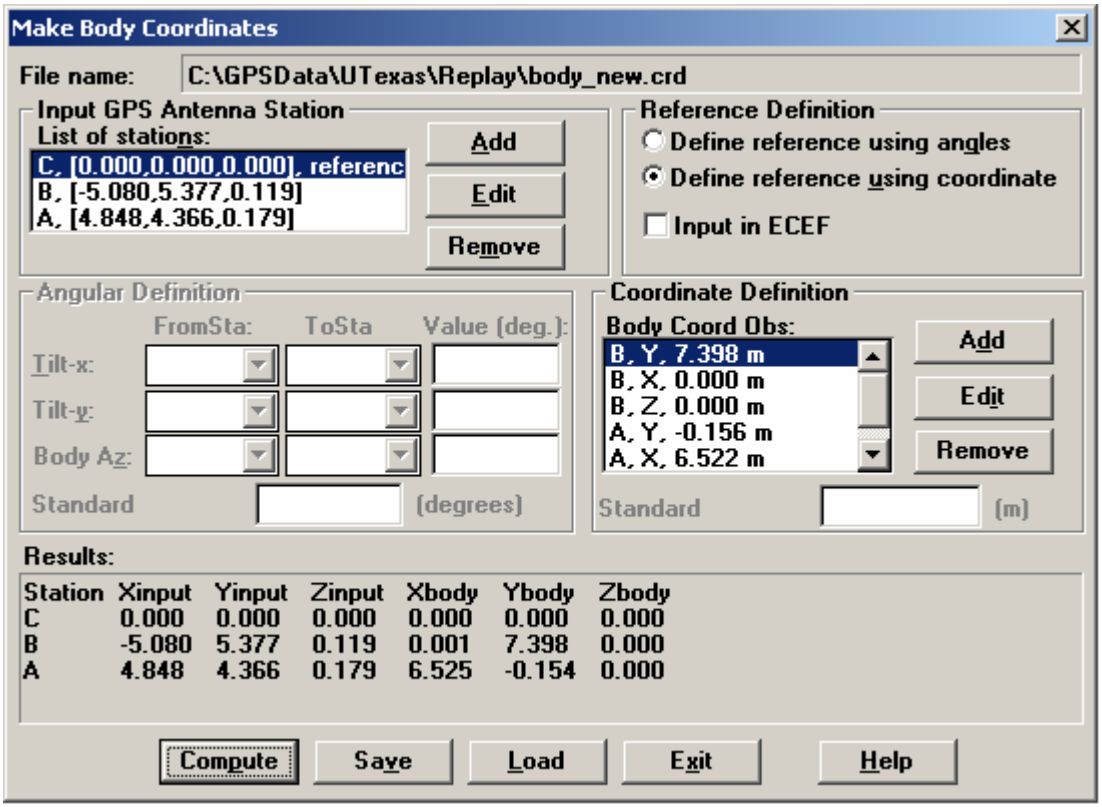


Figure B 4: Make Body Coordinates Dialog Box

- **Add GPS Antenna Stations:** This process adds, antenna station IDs along with their local level or ECEF coordinates. The dialog box is shown below in Figure B 5.

  Accumulate data from the GPS calibration and assign IDs to each of the fixed antenna stations.

For each station, click **Add** to key in the station name and antenna phase centre coordinate values (local level or ECEF) determined from the GPS survey. Be sure to add the reference station first.

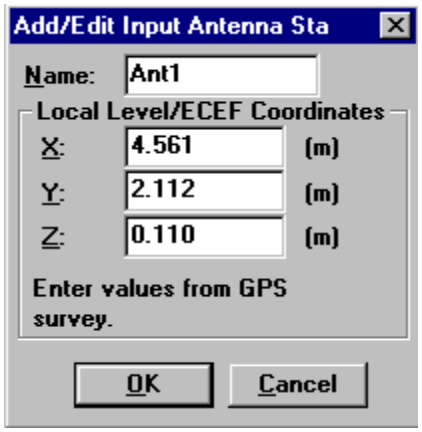
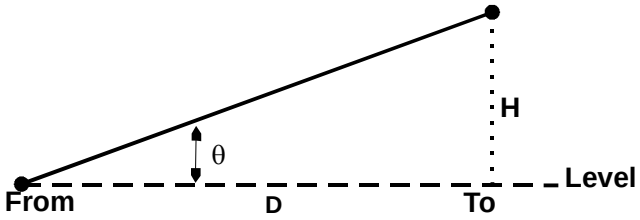


Figure B 5: Add/Edit Input Antenna Station

- **Axes Definition:** There are two methods that can be used to define the axis: the angle based method, and the coordinate based method. If the coordinates of the antennae were entered in an ECEF frame, then check the *Input in ECEF* box.

  - **Angle Observation Method**
    Select two stations suitable for the definition of levelness along the x-axis (Tilt-x). Set the 'To' and 'From' station IDs. Enter the value of the angle (in degrees) between the level plane vector between from and to station. A positive value is required if the 'To' station is above the 'From' station while a negative value is required if the To station is below. See Figure B 6.



θ=atan(H/D)

Figure B 6: Angle Observation Method

The same procedure is repeated for Tilt-y. Define the horizontal axes by entering a body azimuth between two stations. 0° would be the positive body y-axis and 90° would be the positive body x-axis. See Figure B 7.

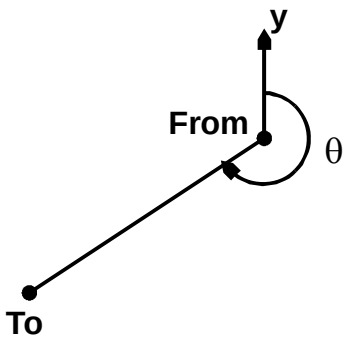


Figure B 7: Angle Observation Method

- **Coordinate Observation Method:** Using known body coordinate values, coordinate observations can be added. Compute the body coordinates for two or more stations in addition to the reference station. Subtract the body coordinate values of the reference station to obtain relative coordinate values. Add body coordinate observations one value at a time by pressing the Add button. Ideally, X, Y and Z should be added for one station and Z for another. Values should not be added for the reference station.

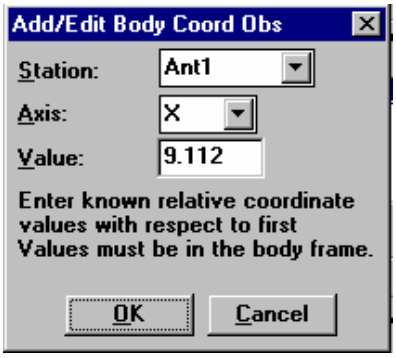


Figure B 8: Coordinate Observation Method

- **Compute Body Coordinates:** Press the **Compute** button. If the solution worked, a window will appear which shows the roll, pitch and heading values required to transform the input local level antenna stations into the body frame. If ECEF is originally entered, then the ECEF to local level is taken into account with the latitude and longitude values. The angles are expressed as the rotation from body -> local level.

  Otherwise, an error message will appear. For convergence or inversion errors, you may have to alter some of the input values to try another definition type. Check over all input numbers, or add more observations.

  The body coordinates will appear in the results window. Check to make sure that they make sense. Save the body coordinates to the CRD file by pressing the **Save** button. Enter a meaningful file name.

Section 2 RtkNav

Once the CRD file has been created, the user must incorporate it into their RtkNav project using the following steps:

- Enable moving baseline by adding the **MOVING_BASE = ON** command. Alternatively, this can be done in RtkNav by going to *View* | *Processing Configuration.*. and engaging the **Moving Baseline ON** option under the *Processing* tab. See Figure B 9.

- Make sure that the *Lineup Tolerance* is set to **All data must be received on time** via the *Processing* tab under *View* | *Processing Configuration.…*. See Figure B 9.

- Engage kinematic ambiguity resolution by enabling the **KAR On** option under the *Processing* tab via *View* | *Processing Configuration.…*. See Figure B 9

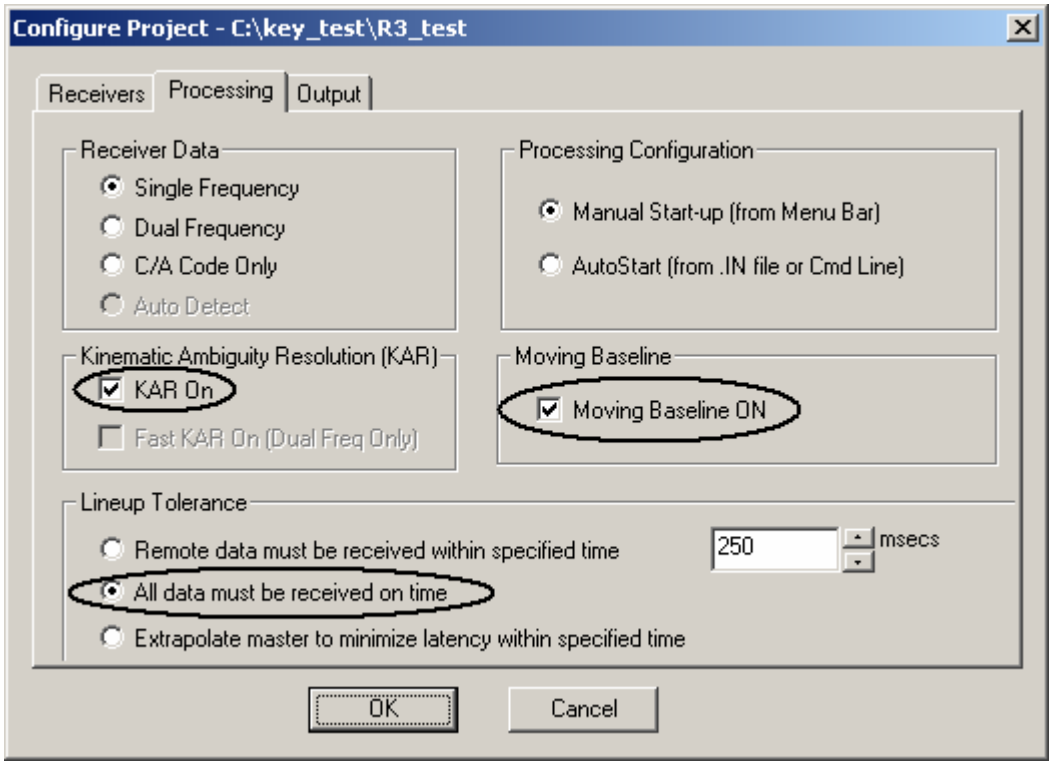


Figure B 9: Processing Options Tab

- Add the following commands via the *User Defined* tab, under *Processing* | *Options.…*

  - **VECTOR_FILE = FileName.crd**
    Where *FileName.crd* is the file created in Section 1 of this appendix.

  - **ATTITUDE = COMPUTE**

- **DIST_UPDATE = OFF ON**
  Where *OFF* disables vector input in Kalman filter, which causes divergence, while the *ON* distance constraints in KAR, which is important.

- **VECTOR_SD = 0.02**
  This uses a 2 cm standard deviation for the position of the body coordinates. If you have a very stable system, then this value can be lowers. Values below 1 cm and above 4 cm are not suggested.

- **MASTER_ID = *IdName***
  IdName corresponds to the station name given to the base file in the **Conv3d** program.

- **REMOTE_ID = *IdName***
  IdName corresponds to the name given in the **Conv3d** program. Each name must be unique and cannot contain spaces or commas.
  Note: this command needs to be entered for each remote antenna.

- Ensure that the master receiver is set to kinematic mode. This can be done by selecting *View* | *Project Configuration…* Select the base station file from the list and click **Edit…**. In the *Edit GPS Unit Wizard* window that appears, select the *GPS Mode* tab. Be sure to select the **Kinematic** radio button here.

The user can now begin processing by selecting *Processing* | *Start Processing…* To view the attitude information, select *View* | *Attitude Data…*

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