GENEQ inc.

SXBlue GPS

Reference Manual

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- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

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Preface

Welcome to the SXBlue GPS Manual and congratulations on choosing to purchase this high-performance GPS receiver.

The SXBlue GPS receiver provides a high level of performance, delivering sub-meter positioning using either its built-in SBAS demodulator or external corrections, at up to 5 Hz output. The SXBlue GPS features raw measurement output for post processing applications, and delivers excellent phase measurement quality. It also features Bluetooth and serial communications.

We have written this document to assist a customer in becoming familiar with the SXBlue GPS functionality and system operation, but also with GPS, and DGPS.

The chapters that follow provide detailed information on the SXBlue GPS receiver, including the hardware and software interface, in addition to various descriptions of technologies and features that it supports.

Some notable features of the SXBlue GPS receiver follow:

- 12-channel GPS engine (2 channels dedicated to SBAS tracking)
- Sub-meter horizontal accuracy 95%
- Raw measurement output (via documented binary messages)
- Position and raw measurement update rates of 5 Hz max
- COAST™ technology provides consistent performance with old correction data
- Optional e-Dif - A base station-free way of differentially positioning
- WAAS/EGNOS and external differential sources
- Quick times to first fix
- One full-duplex serial port, can be used to configure the product, or to output or receive RTCM corrections
- One Bluetooth module for virtual serial port communication
- 3 W power consumption

Organization

This manual contains the following chapters:

Chapter 1: Quick Start - provides information to help you get your system running quickly.

Chapter 2: Introduction - introduces you to the SXBlue GPS and some of its main features.

Chapter 3: Features - provides details on the fundamental operating modes of the SXBlue GPS receiver and its associated default parameters.

Chapter 4: Operation Basics - describes how to configure and operate the SXBlue GPS receiver.

Chapter 5: NMEA 0183 Messages - describes the subset of NMEA 0183 commands and queries supported by the SXBlue GPS receiver.

Chapter 6: Frequently Asked Questions - This chapter provides answers to frequently asked questions about the SXBlue GPS receiver.

Chapter 7: Troubleshooting - provides you with diagnostic information to aid in determining a source of difficulty for a particular installation.

Chapter 8: Complete NMEA 0183 Interface - describes the subset of NMEA 0183 commands and messages supported by the SXBlue GPS.

Chapter 9: Binary Data - describes the Binary messages supported by the SXBlue GPS.

Appendix A – Specifications - details the technical characteristics of the SXBlue GPS.

Appendix B – Interface - provides instructions to interface the SXBlue GPS with external devices.

Appendix C – Introduction to GPS and SBAS - provides both general and specific information relating to GPS and SBAS.

Appendix D – Resources - This appendix lists a number of different resources that may be useful for the advanced user.

The Index provides a listing of the locations of various subjects within this manual.

Customer Service

If you encounter problems during the installation or operation of this product, or cannot find the information you need, please contact your dealer, or Geneq Customer Service. The contact numbers and e-mail address for Geneq Customer Service are:

Telephone number:	+1-514-354-2511
Fax number:	+1-514-354-6948
E-mail address:	support@geneq.com

Technical Support is available from 8:30 AM to 5:00 PM Eastern Time, Monday to Friday.

To expedite the support process, please have the product model and serial number available when contacting Geneq Customer Service.

In the event that your equipment requires service, we recommend that you contact your dealer directly. However, if this is not possible, you must contact Geneq Customer Service to obtain a Return Merchandise form before returning any product to Geneq. If you are returning a product for repair, you must also provide a fault description.

Geneq will provide you with shipping instructions to assist you in returning the equipment.

World Wide Web Site

Geneq maintains a World Wide Web home page at the following address:

www.geneq.com

A corporate profile and product information are available at this site under the Geomatics section.

Document Conventions

Bold is used to emphasize certain points.

Notes, Cautions, and Warnings

Notes, Cautions, and Warnings stress important information regarding the installation, configuration, and operation of the SXBlue GPS receiver.

Note - Notes outline important information of a general nature.

Cautions - Cautions inform of possible sources of difficulty or situations that may cause damage to the product.

Warning - Warnings inform of situations that may cause harm to you.

1. Quick Start

The purpose of this chapter is to help you get your SXBlue GPS receiver running quickly. This chapter is not intended to replace the balance of this reference manual and it assumes that you have a reasonable amount of knowledge with installation and operation of GPS navigation systems.

If you are new to GPS and SBAS, we recommend that you consult Appendix C for further information on these services and technology.

The SXBlue GPS receiver system is composed of two main pieces: SXBlue GPS receiver, and the GPS antenna.

1.1 Receiving Your Shipment

If you find that any of these items are damaged due to shipment, please contact the freight carrier immediately for assistance.

1.2 Unpacking Your SXBlue GPS System

When you unpack your SXBlue GPS system, please ensure that it is complete by comparing the parts received against the packing slip. Unless your system has been equipped differently than a standard SXBlue GPS system, you should find the following parts in your system:

- One SXBlue GPS Receiver
- One Low Profile or one Precision Antenna with BNC connectors
- One RS-232 cable
- Power option (Battery/Charger or Power Cable)
- Optional nylon carrying case

Note - If, for some reason, you find a discrepancy between your packing slip and the contents of your shipment, please contact the sales person with which you placed your order immediately.

1.3 Cable Connections

The connections required by the SXBlue GPS are very straightforward. All cables necessary for complete operation are provided. The SXBlue GPS comes in three different voltage configurations and needs to be connected to a power supply (4.5 to 9 VDC, 9 to 18 VDC or 18 to 36 VDC) and to the antenna. Refer to the label on the back of the receiver to find out your SXBlue GPS voltage range.

The power connector on the SXBlue GPS is a miniature 2-pin, circular locking connector and the RF connector is a female BNC. The power connector is labeled ‘PWR’ and the GPS RF input connector is labeled ‘ANT’. There is no power switch to turn on the SXBlue GPS. Once the proper voltage input is applied to the connector, the system will start up.

To communicate with the SXBlue GPS, you have two options, one miniature 3-pin, circular locking connector is available on the front panel, labeled ‘RS-232’, giving access to the RS-232 serial port of the SXBlue GPS. The other option is Bluetooth communication (which is wireless) using a Bluetooth-enabled PDA with a Bluetooth compatible software. If you have a PDA or computer that does not support Bluetooth natively, you often can supplement your computing device with a Bluetooth card (CF, PCMCIA, SD) or USB dongle. When configuring your Bluetooth device for communication with the SXBlue GPs make sure that pairing (or bonding) with password (or passkey) is not supported.

Caution – By default, the SXBlue GPS receiver offers 5.0 VDC across its RF connector to power an active GPS antenna’s low noise amplifier (LNA). Connection to a GPS antenna that doesn’t support a 5 VDC input could damage the antenna.

The following figure shows the various connections required for the SXBlue GPS.

Figure 1-1 Cable Interface

1.4 Configuring the SXBlue GPS

The SXBlue GPS has two primary communication ports referred to as Serial and Bluetooth. The Serial and Bluetooth ports are fully independent and you may configure each port to have different messages output at different rates. The Serial port may be configured for external correction input or output binary message information or even RTCM corrections from a SBAS demodulator.

Note – The serial port is available via the single 3-pin connector located on the front panel labeled “RS-232”. The pin-out for this connector is provided in Table 1-5.

1.5 NMEA 0183 Message Interface

The SXBlue GPS uses a NMEA 0183 interface for interfacing, which allows you to easily make configuration changes by sending text-type commands to the receiver.

Where appropriate, relevant commands for making the configuration changes are discussed in the following chapters. Chapter 8 and 9 however are devoted to describing the NMEA interface in detail.

1.6 Binary Message Interface

In addition to the NMEA interface, the SXBlue GPS also supports a selection of binary messages. There is a wider array of information available through the binary messages, plus binary messages are inherently more efficient with data. If your application has a requirement for raw measurement data, for instance, this information is available only in a binary format. Consult Chapter 9 for more information on Binary messages.

1.7 PocketMAX

PocketMAX is a free utility to assist you with controlling and monitoring your SXBlue GPS receiver. It requires a device that runs a Windows PocketPC 2000, 2002, or 2003 operating system. The PocketMAX Manual provides detailed information on how to interact through both serial and Bluetooth communications between your SXBlue GPS receiver and your PDA based PocketMAX utility. This program allows you to graphically monitor the status and function of the SXBlue GPS, in addition to providing an interface for its control. The PocketMAX Manual is available from Geneq. We recommend that you gain your initial experience with the SXBlue GPS using this utility and then, if you wish, migrate your work to a dumb terminal.

1.8 Default Parameters

Although presented in the following chapters, this section provides tables that detail the default parameters of the SXBlue GPS as delivered.

Table 1-1 Default Applications

Application
WAAS (SBAS) – Default, e-Dif (if available)

Table 1-2 Default Port Settings

Port	Baud Rate	Data Bits	Parity	Stop Bit	Interface Level
Serial Bluetooth	9600 Fixed 9600	8 8	None None	1 1	RS-232C Virtual serial port

Table 1-3 Default GPS NMEA Message Output

Port	GPS NMEA Messages	Update Rate
Serial	GGA, GSA, GSV, VTG, ZDA	1 Hz
Bluetooth	GGA, GSA, GSV, VTG, ZDA	1 Hz

Table 1-4 Default Parameters

Max DGPS Age	Elevation Mask
3600 seconds	10°

1.9 Pin-Outs

The following tables detail the pin-out of the serial port of the SXBlue GPS (mating connector is a Conxall 16282-3SG-3XX) and the PWR port (mating connector is a Conxall 16282-2SG-3XX).

Table 1-5 Serial Port Pin-out, RS-232C Interface Level

Pin	Signal	Description
1	RXD – serial	NMEA 0183, binary, and RTCM input
2	TXD – serial	NMEA 0183, binary, and RTCM output
3	Sig. Ground	Signal return

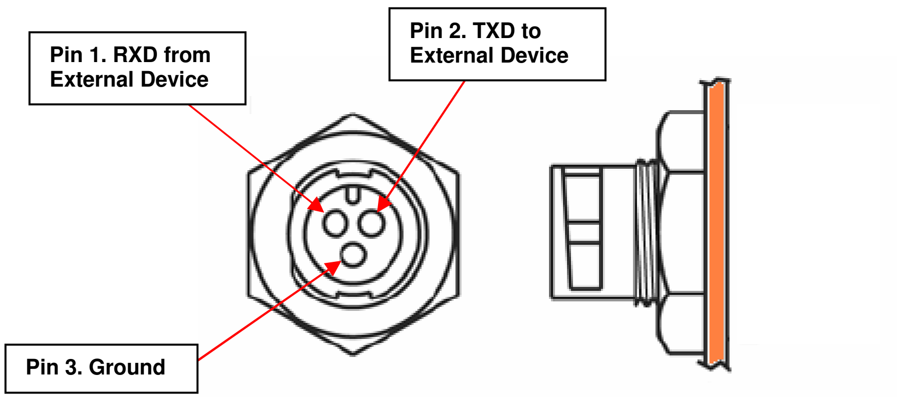

Figure 1-2 RS-232 Connector Pin-out

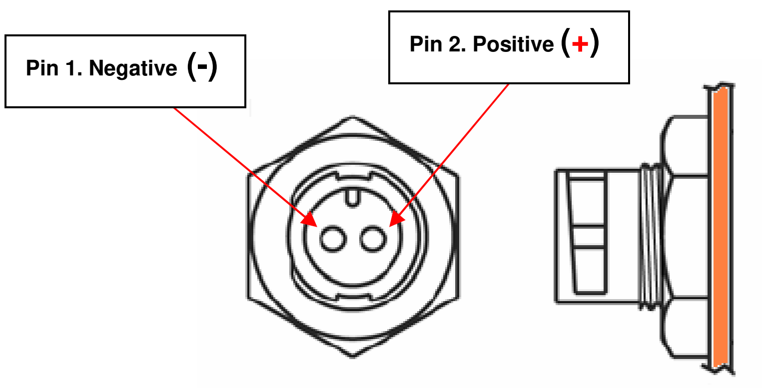

Figure 1-3 PWR Connector Pin-out

2. Introduction

This chapter provides a brief introduction to the SXBlue GPS and some of its high-level features. The remaining chapters provide more detailed information on the workings of the product.

As mentioned in the previous chapter, if you are new to GPS and SBAS, we recommend that you consult Appendix C for further information on these services and technology.

When powered for the first time, the SXBlue GPS will perform a 'cold start', which involves acquiring the available GPS satellites in view and the SBAS differential service.

If SBAS is not available in your area, you may use an external source of RTCM SC-104 differential corrections. If you choose to use an external source of correction data, you will need to ensure that the external source supports an eight data bit, no parity, and one stop bit configuration (8-N-1) and a baud rate between 4800 and 38400 baud.

This chapter describes the various modes of operation and features of your SXBlue GPS receiver.

2.1 GPS

The following sections describe the general operation of the SXBlue GPS receiver.

2.1.1 Satellite Tracking

The SXBlue GPS automatically searches for GPS satellites, acquires the signal, and manages the associated navigation information required for positioning and tracking. This is a hands-free mode of operation. Satellite acquisition quality is described as a signal to noise ratio (SNR). A higher SNR is indicative of better quality signal reception.

Note – The GPS engine is always operating, regardless of the DGPS mode of operation.

2.1.2 Positioning Accuracy

The SXBlue GPS is a sub-meter (horizontally), 95% accurate product under ideal conditions (minimum error).

Keeping in mind that this horizontal performance specification is a real world but ideal scenario test, obstruction of satellites, multipath signals from reflective objects, and operating with poor corrections will detract from the receiver's ability to provide accurate, reliable positions. Differential performance can also be compromised if the SXBlue GPS is used in a region without sufficient ionospheric map coverage. If external corrections are used, the baseline separation between the remote and base station antennas can affect performance.

Since the SXBlue GPS will be used in the real world, blockage of the line of sight to SBAS satellites is often inevitable. The COAST technology provides solace from obstruction of SBAS or other differential correction services for up to 30 to 40 minutes, depending on the amount of tolerable performance drift. Section 2.3 provides with a description of the Coast technology.

The estimated positioning precision is accessible through the use of our PocketMAX utility discussed in the PocketMAX Manual and NMEA 0183 command responses as described in Chapter 6 (The GST NMEA data message). As the receiver is not able to determine accuracy with respect to a known location in real time (this is traditionally performed in post-mission analysis), the precision numbers are relative in nature and are approximates.

2.1.3 Update Rates

The update rate of each NMEA and binary message of the SXBlue GPS can be set independently with a maximum that is dependant upon the message type. Some messages have a 1 Hz maximum, for example, while others are 5 Hz.

Higher update rates are valuable for applications where higher speeds are present (such as aviation) or more frequent updates are required for manual navigational tasks, such as Agricultural Guidance.

2.2 SBAS

The following sections describe the general operation and performance monitoring of the SBAS demodulator within the SXBlue GPS receiver.

2.2.1 Automatic Tracking

The SBAS demodulator featured within the SXBlue GPS will automatically scan and track the SBAS satellite signals. This automatic tracking allows the user to focus on other aspects of their application rather than ensuring the receiver is tracking SBAS correctly.

The SBAS demodulator features two-channel tracking that provides an enhanced ability to maintain acquisition on a SBAS satellite in regions where more than one satellite is in view. This redundant tracking approach will result in more consistent acquisition of a signal when in an area where signal blockage of either satellite is possible.

2.2.2 SBAS Performance

The performance of the SBAS receiver is described in terms of a differential LED. SBAS requires a line of sight to the SBAS satellites in order to acquire the signal.

The BER number indicates the number of unsuccessfully decoded symbols in a moving window of 2048 symbols. Due to the use of forward error correction algorithms, one symbol is composed of two bits. The BER value for both SBAS receiver channels is available in the RD1 NMEA data message described in detail in chapter 8.

A lower BER indicates that data is being successfully decoded with fewer errors, providing more consistent throughput. The bit error rate has a default, no-lock value of 500 or more. As the receiver begins to successfully acquire the signal, it will result in a lower bit error rate. For best operation, this value should be less than 150 and ideally less than 20.

Space-Based Augmentation Systems broadcast an ionospheric map on a periodic basis that may take up to 5 minutes to receive upon startup. The SXBlue GPS uses the GPS broadcast ionospheric model until it has downloaded the SBAS map, which can result in lower performance as compared to when the map has been downloaded. This will be the case for any GPS product supporting SBAS services.

Caution – When the map has been downloaded, you may observe a position jump due to the potential difference between the GPS ionospheric model and the ionospheric SBAS map. To minimize the impact of this issue on your use of the SXBlue GPS, you may wish to wait up to five minutes before using the SXBlue GPS or issue the $JQUERY,GUIDE<CR><LF> message to 'ask' the SXBlue GPS if it feels performance will be sufficient for operation.

2.3 COAST™ Technology

The SXBlue GPS receiver incorporates the COAST™ technology that allows it to operate with old correction data for up to 30 to 40 minutes or more without significant accuracy degradation. The feature's performance is attributed to sophisticated algorithms that are able to anticipate how errors change during a period of correction loss.

Traditional receiver technology would experience an increasing degradation with increasing age of corrections, resulting in less than adequate performance over a shorter period of time. COAST technology provides more consistent positioning during periods when signal loss occurs, thus bridging the gap to when the signal is reacquired. This means that the SXBlue GPS is more tolerant than competing products to loss of SBAS or externally input RTCM SC-104 corrections.

2.4 e-Dif – Extended Differential Option

The SXBlue GPS receiver is designed to operate with the optional e-Dif software. e-Dif is a mode where the SXBlue GPS can perform with differential-like accuracy for extended periods without the use of a differential service. It models the effects of ionosphere, troposphere, and timing errors for extended periods by computing its own set of pseudo-corrections.

e-Dif may be used anywhere geographically and is especially useful where SBAS networks have not yet been installed, such as South America, Africa, Australia, and Asia. Since e-Dif is an option, it will either come pre-installed inside your SXBlue GPS, or you may order the option at a later time. It can be easily installed in the field using a PC computer and some simple software if not pre-installed.

Positioning with e-Dif is relatively jump-free, provided that the SXBlue GPS maintains lock on at least four satellites at one time. The accuracy of positioning will have a slow drift that limits the use of e-Dif for approximately 30 to 40 minutes, however, it depends on how tolerable your application is to drift, as e-Dif can be used for longer periods.

You should test this mode of operation and determine if it's suitable for your application and for how long you're comfortable with its use. As accuracy will slowly drift, you need to determine at what point you would like to recalibrate e-Dif in order to maintain a certain level of accuracy.

Figure 1-4 displays the static positioning error of e-Dif, while it is allowed to age for 14 consecutive cycles of 30 minutes. The top (red) line indicates the age of the differential corrections. The SXBlue GPS computes a new set of corrections using e-Dif during the calibration at the beginning of each hour. After the initialization, the age correspondingly increases from zero until the next calibration.

The position excursion from the true position (the lines centered on the zero axis are Northing (blue) and Easting (pink)) with increasing correction age is smooth from position to position, but you can see that there is a slow drift to the position. The amount of drift will depend on the rate of change of the environmental errors and how these change from the models used inside the e-Dif software engine.

It's up to you for how long you would like e-Dif to function before performing another calibration. We recommend that you test this operating mode to determine the level of performance that's acceptable to you.

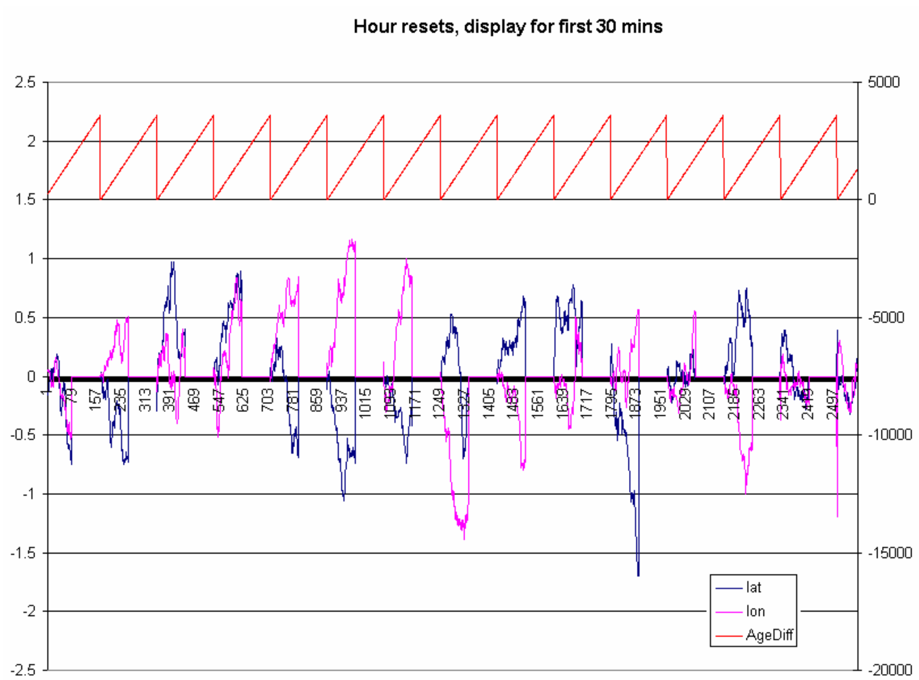

Figure 1-4 e-Dif Error Drift

To use e-Dif, an option must be purchased from Geneq. The SXBlue GPS system comes pre-installed with e-Dif firmware and a simple key command is needed to enable the application for use. Please contact Geneq for more information on this feature.

2.5 Post Processing

The SXBlue GPS receiver is able to output raw measurement data for post processing applications. The raw measurement and ephemeris data are contained in the Bin 95 and 96 messages documented in chapter 9. Both messages must be logged in a binary file.

A DOS-based RINEX translator is available; however, RINEX has no facility to store station information. Please contact Geneq if you wish to use this utility.

2.6 Evaluating SXBlue GPS Performance

The SXBlue GPS receiver performance has been evaluated with the objective of determining best-case performance in a real-world environment. Static testing has shown that the SXBlue GPS achieves a performance better than one meter 95% of the time.

The qualifier of 95% is a statistical probability. Often you may see manufacturers using a probability of 'rms' or standard deviation. Performance measures with these probabilities are not directly comparable to a 95% measure since they are a lower probability (less than 70% probability). This means that less often, a product would position within a radius of the prescribed amount.

The following table summarizes the common horizontal statistical probabilities.

Table 2-1 Horizontal Accuracy Probability Statistics

Accuracy Measure	Probability (%)
Rms (root mean square)	63 to 68
CEP (circular error probability)	50
2drms (twice the distance root mean square)	95 to 98
R95 (95% radius)	95

It is possible to convert from one statistic to another using the following table. Using the value where the 'From' row meets the 'To' column, multiply the accuracy by this conversion value.

Table 2-2 Horizontal Accuracy Statistic Conversions

		To			
		CEP	rms	R95	2drms
From	CEP	1	1.2	2.1	2.4
	rms	0.83	1	1.7	2.0
	R95	0.48	0.59	1	1.2
	2drms	0.42	0.5	0.83	1

For example, if Product A after test results in an accuracy of 90 cm 95% (R95) and you want to compare this to Product B that has a sub-meter horizontal rms specification, select the value from where the 'R95' row and the 'rms' column intersect (to convert to rms).

You will see that this conversion value is 0.59. Multiply the 90 cm accuracy by this conversion factor and the result will be 53 cm rms. If you now compare this to Product B's specification of sub-meter rms, you can see the first Product A would offer better performance.

To properly evaluate one receiver against another statically, they should be using identical correction input (from an external source) and also share the same antenna using a power splitter (equipped with appropriate DC-blocking of the receivers and a bias-T to externally power the antenna). With this type of setup, the errors in the system are identical with the exception of receiver noise.

Although this is a comparison of the GPS performance quality of a receiver, it excludes other performance merits of a GPS engine. The dynamic ability of a receiver should be compared in a similar way with the test subjects sharing the same antenna. Unless a receiver is moving, its software filters are not stressed in a similar manner to the final product application. When testing dynamically, a much more accurate reference would need to be used, such as an RTK system so that a 'truth' position per epoch is available.

Further, there are other performance merits of a GPS engine, such as its ability to maintain a lock on GPS and SBAS satellites. In this case, the same GPS antenna should be shared between the receiver test subjects. For the sake of comparing the tracking availability of one receiver to another, no accurate 'truth' system is required, unless performance testing is also to be analyzed. Again, an RTK system would be required; however, it's questionable how its performance will fair with environments where there are numerous obstructions, such as foliage. Other methods of providing a truth reference may need to be provided through observation times on surveyed monuments or traversing well-known routes.

If you require assistance in developing a test setup or procedure for evaluating the SXBlue GPS, please contact Geneq.

3. Features

This chapter describes the main features of the SXBlue GPS system. The SXBlue GPS system is composed primarily of the following parts:

- An SXBlue GPS receiver
- An antenna
- Associated cables

This chapter provides details on the fundamental operating modes of the SXBlue GPS receiver and its associated default parameters.

3.1 System Parts List

The following list of standard equipment is included with the SXBlue GPS system:

- One SXBlue GPS Receiver
- One RS-232 Interface Cable
- One Antenna
- Power Cable or Battery/Charger

3.2 Cable Interface

The SXBlue GPS receiver requires power and antenna cable interfaces. The data cable is optional if you intend to use the wireless Bluetooth interface. The following figure shows the various connections located on the front and rear panels of the SXBlue GPS enclosure.

Figure 3-1 Cable Interface

When choosing a route for SXBlue GPS cables.

- Avoid running cables in areas of excessive heat
- Keep antenna cables away from corrosive chemicals
- Do not run the extension cable through door or window jams
- Keep the cable away from rotating machinery
- Do not bend excessively or crimp the extension cable
- Be careful not to apply tension to the cable
- Remove unwanted slack from the cable at the opposite end to the antenna
- Secure the cable route using plastic tie wraps

Warning – Improperly installed cables near machinery can be dangerous

3.3 Environmental Requirements

The equipment supplied with the SXBlue GPS system has specific environmental limits that you should ensure are met when storing and using the system.

The SXBlue GPS receiver is designed to be stored between -40°C and +85°C. The operating temperature range is -40°C and +70°C. The SXBlue GPS is specified to operate with humidity up to 95% non-condensing.

The antennas are designed to operate in an outdoor environment with 100% relative humidity, condensing.

3.4 Power Requirements

The SXBlue GPS is powered via a power cable that interfaces to the enclosure's 'Power' connector. This system accepts input voltages between 4.5 to 9 VDC, or 9 to 18 VDC or 18 to 36 VDC (depending on your SXBlue GPS model). For best performance, the supplied power should be continuous and clean. The following table details the power specifications of the SXBlue GPS.

Table 3-1 Power Requirements

Input Voltage	Average Input Current	Input Power Nominal
4.5 to 9 VDC	< 865 mA @ 5 VDC	< 4.35 W
9 to 18 VDC	< 270 mA @ 12 VDC	< 3.25 W
18 to 36 VDC	< 125 mA @ 24 VDC	< 3.00 W

3.5 Antenna Placement

The GPS antenna included should be mounted pursuant to the following requirements:

- The SXBlue GPS receiver computes a position based upon measurements from each satellite to the location of the GPS antenna's phase center. Mount the GPS antenna in the location for which you desire a position. When choosing a location to mount the antenna, please ensure that there is an unobstructed hemisphere of sky available to the GPS antenna. This will ensure that GPS and SBAS satellites are not masked by obstructions, potentially reducing system performance.
- It is important to locate any transmitting antennas away from the GPS antenna by several feet or more. This will help to ensure that tracking performance of the SXBlue GPS is not compromised, giving you the best performance possible.
- Make sure that there is sufficient length of the antenna extension cable available in order to be able to connect it to the SXBlue GPS enclosure.

Do not locate the antenna where environmental conditions exceed those specified in Section 3.3.

3.6 Powering the SXBlue GPS Receiver

Caution – Do not apply a voltage higher than the maximum voltage labeled on your SXBlue GPS as this will damage the receiver and void the warranty

To turn on the SXBlue GPS receiver using the power cable:

- Connect the red wire of the cable's power input to DC positive (+).
- Connect the black wire of the cable's power input to DC negative (-).

The SXBlue GPS features minimal reverse polarity protection to prevent damage if the power leads are accidentally reversed. Confirm polarity of voltage source before applying power to the SXBlue GPS.

A 1.0 Amp fast-blow fuse, situated in-line of the power input of the extension cable, protects the SXBlue GPS receiver from power surges. The fuse container should remain accessible after installation.

The SXBlue GPS will start when an acceptable voltage is applied to the power leads of the extension cable. Be careful not to provide a voltage higher than the input range as this could damage the system.

Caution – Do not operate the SXBlue GPS receiver with the fuse bypassed. Such a modification will void the product warranty.

3.7 Serial Port Interface

There is one serial port on the SXBlue GPS and it is compatible with the RS-232C interface level to communicate with external data loggers, navigation systems, PC computers, PDAs and other devices. This serial port is accessible via the front panel of the SXBlue GPS enclosure and has an 'RS-232' label. You can interface most devices to the SXBlue GPS directly with the serial cable (supplied with the SXBlue GPS), accommodating any gender changes necessary, or with the addition of a null modem as necessary.

The serial port should be used for firmware updates. The following table provides the pin assignments for the serial port.

Table 3-2 Serial Port Pin-out, RS-232C Interface Level

Pin	Signal	Description
1	RXD	NMEA 0183, binary, and RTCM input for the MAIN port
2	TXD	NMEA 0183, binary, and RTCM output for the MAIN port
3	Sig. Ground	Signal return

Figure 3-2 displays the RS-232 socket connector pin-out as seen on the SXBlue GPS receiver (Mating connector is a Conxall 16282-3SG-3XX).

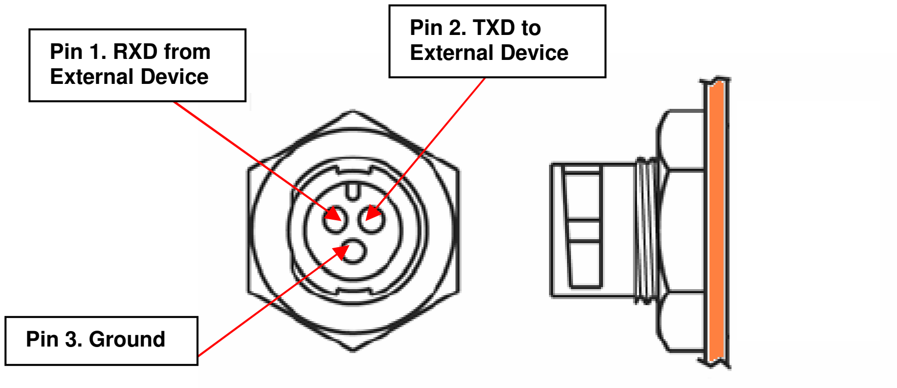

Figure 3-2 RS-232 Connector Pin-out

Refer to Appendix B for further interfacing information.

Note - For successful communications, the baud rate of the SXBlue GPS serial ports must be set to match that of the devices to which they are connected. Chapter 8 describes the baud rate change command.

3.8 Bluetooth Interface

Bluetooth is a wireless communication technology that enables seamless data connections between a wide range of devices through short-range digital two-way radio. In the case of the SXBlue GPS, it is equipped with Bluetooth technology and requires another Bluetooth device with which to communicate (a Bluetooth-capable PDA, for example). The Bluetooth wireless module inside the SXBlue GPS is a power class 1 device supporting version 1.1 of the Bluetooth standard, and has been certified.

The Bluetooth port should not be used for firmware updates; it is recommended you use the serial port for any software updates. Also, the SXBlue GPS does not support pairing (or bonding) using passwords (or pass codes, etc). The Bluetooth interface has been kept simple to emulate a serial port profile and simple cable replacement.

3.9 Factory Default Parameters

The following tables show the application (firmware) present within the SXBlue GPS engine and the default communication parameters.

Table 3-3 Firmware Applications

Application
WAAS (SBAS) – Default
e-Dif (if available)

Table 3-4 Default Port Settings

Port	Baud Rate	Data Bits	Parity	Stop Bit	Interface Level
Serial	9600	8	None	1	RS-232C
Bluetooth	9600 (fixed)	8	None	1	RS-232C

Table 3-5 Default GPS NMEA Message Output

Port	GPS NMEA Messages	Update Rate
Serial	GGA, GSA, GSV, VTG, ZDA	1 Hz
Bluetooth	GGA, GSA, GSV, VTG, ZDA	1 Hz

Table 3-6 Default Parameters

Max DGPS Age	Elevation Mask
3600 seconds	10°

Note - Any changes you make to the SXBlue GPS configuration need to be saved with the $JSAVE NMEA command in order to be present for a subsequent power-cycle.

3.10 LED Indicators

The SXBlue GPS features diagnostic LEDs that provide a quick indication of the receiver's status. These LEDs are visible on the front panel display.

The five diagnostic LEDs visible on the front panel display of the SXBlue GPS provide the following information:

Table 3-7 LED Indicator Definitions

LED	Color	Function
	Red	Power indicator – when the SXBlue GPS is powered, this LED will illuminate
	Green	GPS lock indicator – this LED will blink a few times on startup. Once the SXBlue GPS achieves a solid GPS lock, this LED will remain illuminated. If this LED continues to blink, it could be an indication of a receiver hardware failure.
	Orange	DGPS position indicator – this LED will illuminate when the receiver has achieved a differential position and the pseudorange residuals are below that set with the $JLIMIT command. The default value is a pseudorange residual of better than 10.0 meters. If the residual value is worse than the current threshold, the orange DGPS LED will blink indicating that differential mode has been attained but that the residual has not yet met the threshold.
	Yellow	Differential lock indicator – this indicator will illuminate continuously when the SXBlue GPS has achieved a solid SBAS lock with better than a 150 bit error rate (BER) or when it is successfully receiving externally input RTCM corrections. If the SBAS BER is higher than 150 but the receiver is still locked, this LED will blink, showing that lock is marginal.
	Blue	Bluetooth indicator – this LED will illuminate when there is a Bluetooth connection between the SXBlue GPS and a Bluetooth compatible device and off when there is no Bluetooth connection.

Once power is applied to the SXBlue GPS, the power LED will illuminate solidly and the GPS LED will blink a few times, followed by a lamp test. Once the GPS lock LED has finished blinking a few times, you will see the GPS lock, Differential lock, and the DGPS position LEDs illuminate in sequence a few times and then go out.

When the SXBlue GPS acquires a GPS lock, the green GPS lock LED will illuminate solidly. Similarly, the differential LED will illuminate when the SBAS demodulator has acquired lock, or externally input corrections are being successfully received. The orange DGPS position LED will illuminate when the receiver has acquired a GPS lock, differential lock, and has applied corrections within the position solution. The above table provides more detail on LED status.

The following image displays the front panel layout of the SXBlue GPS receiver, including the location and labeling of each LED. For more information on LED operation and troubleshooting, refer to Chapter 7.

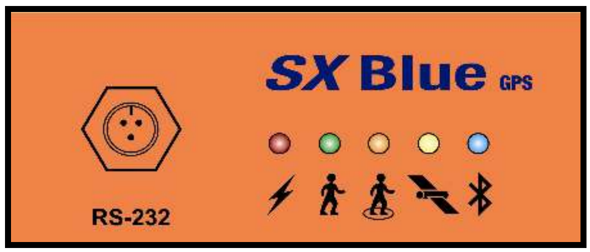

Figure 3-3 SXBlue GPS Front Panel

4. Operation Basics

This chapter introduces the general operational features of the SXBlue GPS system, operating modes, and receiver default operating parameters.

4.1 Powering SXBlue GPS

As described in Chapter 2, Introduction, the SXBlue GPS is powered by either connecting the battery to the power (PWR) connector (in the case of the 4.5 to 9 VDC model) or by connecting the red and black power leads of the power cable to the appropriate power source and ground. Refer to Table 3.1 in section 3.4 and the back label of the SXBlue GPS for proper voltage ratings. Once battery or both leads of cable are connected, the SXBlue GPS will be immediately powered.

With the application of power, the SXBlue GPS system will proceed through an internal start-up sequence; however it will be ready to communicate immediately.

When installed such that the antenna has an unobstructed view of the sky, the SXBlue GPS will provide a position quickly, within approximately 60 seconds. SBAS lock requires approximately 30 seconds to acquire.

Note - It can take up to 5 minutes for a full ionospheric map to be received from SBAS. Optimum accuracy will be obtained once the SXBlue GPS is processing corrected positions using complete ionospheric information.

4.2 Communicating with SXBlue GPS

The SXBlue GPS features two serial ports that may be configured independently from each other (Serial and Bluetooth). The ports may be configured for any mixture of NMEA 0183, binary, and RTCM SC-104 data. The usual data output is limited to NMEA data messages since these are industry standard.

Note - If you require different data types to be output from the SXBlue GPS simultaneously (such as NMEA and binary or NMEA and RTCM), ensure that the software used for logging and processing of the data has been designed to correctly parse the different data types from the single stream of data. Alternatively, you may also use the two ports (serial and Bluetooth) to separate the different data types and at different output rates.

4.2.1 NMEA 0183 Interface

NMEA 0183 is a communications standard established by the National Marine Electronics Association (NMEA) and provides data definitions for a variety of navigation and related equipment. Such instruments supported include gyrocompasses, Loran receivers, echo sounders, GPS receivers, and more. NMEA functionality is virtually standard on all GPS equipment available. NMEA has an ASCII character format that allows you to read the data via terminal software on the receiving device (if possible). One second of example NMEA data from the SXBlue GPS follows:

```
$GPGGA,141823.00,4536.79732,N,07333.95861,W,2,09,1.0,49.6,M,-32.4,M,5.4,0313*4E
$GPVTG,151.61,T,,M,0.08,N,0.15,K,D*36
$GPZDA,141823.00,9,7,2004,00,00*63
$GPGSA,M,3,06,08,10,17,18,21,24,26,29,,,,1.7,1.0,1.3*31
$GPGSV,3,1,11,06,40,234,48,08,18,056,42,10,43,066,45,16,00,319,*7F
$GPGSV,3,2,11,17,43,121,45,18,21,264,45,21,39,304,45,24,10,125,45*7E
$GPGSV,3,3,11,26,69,160,48,27,07,031,39,29,73,109,45,,,,*45
```

The SXBlue GPS supports a variety of standard and proprietary NMEA messages. These messages are used to configure the SXBlue GPS and also contain the required information from the SXBlue GPS. You may configure a selection of NMEA 0183 data messages on one port at various update rates (each message has a maximum update rate) and a different selection of NMEA 0183 messages with different rates on the other port.

Chapters 8 and 9 present information relating to the NMEA interface of the SXBlue GPS. Appendix D - Resources provides contact information should you wish to purchase a copy of the NMEA 0183 standard.

4.2.2 Binary Interface

Binary messages may be output from the SXBlue GPS simultaneously as NMEA 0183 data. Binary messages have a proprietary definition and would likely require custom software support if you wish to use them. Binary messages are inherently more efficient than NMEA 0183 and would be used when you require maximum communication efficiency. Use of binary messages for most users is not recommended - the NMEA interface allows you to control the operation of the SXBlue GPS and also receive most types of information regarding status and positioning information.

Note – If you wish to log binary data, please ensure that your logging software has opened the file as a binary file, otherwise you may lose data.

4.2.3 RTCM SC-104 Protocol

RTCM SC-104 is a standard that defines the data structure for differential correction information for a variety of differential correction applications. It has been developed by the Radio Technical Commission for Maritime services (RTCM) and has become an industry standard for communication of correction information. RTCM is a binary data protocol and is not readable via a terminal program. It appears as ‘garbage’ data on-screen since it is a binary format and not ASCII text. The following is an example of how the RTCM data appears on-screen:

```
mRMP@PJfeUtNsmMFM{nVtIOTDbA^xGh~kDH`_FdW_yqLRryrDuhcB\@}N`ozbSD@O^}nr
GqkeTlpLLrYpDqAsrLRrQN{zW|uW@H`z]~aGxWYt@I`_FxW_qqLRryrDCikA\@Cj]DE]|
E@w_mlroMNjkKOsmMFM{PWDwW@HVEbA^xGhLJQH`_F`W_aNsmMFM[WVLA\@S}amz@ilIu
Pqx~_IZhTCpLLrYpdP@kOsmMFM[kVDHwVGbA^P{WWuNt_SW_yMsmMnqdrhcC\@sE^ZfC@
}vJmNGAHJVhTCqLRryrdviStW@H_GbA^P{wxu[K
```

RTCM has various levels of detail; however the highest level is the message. RTCM defines numerous messages that contain specific information. The SXBlue GPS receiver processes the C/A code and does not support more advanced methods of differential positioning, such as real-time kinematic (RTK) that uses different RTCM message types. Considering this fact, only certain RTCM messages are important for use with the SXBlue GPS:

- Type 1 and Type 9 messages, both of which contain similar information. These two messages contain pseudorange corrections and range rate corrections to each GPS satellite.
- The Type 2 message contains delta differential corrections that are used when the remote receiver is using a different satellite navigation message than used by the base station.
- The Type 5 message contains GPS constellation health information used for improving tracking performance of a GPS receiver
- The Type 6 message contains null information, and is broadcast so that a beacon receiver demodulating the data from the broadcast does not lose lock when the beacon station has no new data to transmit.

Note - RTCM is a local area data standard. This means that when positioning with external correction input to the SXBlue GPS from an external source or outputting corrections from the SXBlue GPS to another GPS receiver, performance will degrade as a function of distance from the base station. The additional degradation will depend on the difference in observed orbit and ionospheric errors between the reference station and the remote unit. A general rule of thumb would be an additional 1 m error per 100 miles. This error is often seen as a bias in positioning, resulting in a position offset. The scatter of the receiver is likely to remain close to constant.

The RTCM SC-104 data output by the SXBlue GPS is converted from the RTCA SC-159 data broadcast by SBAS networks.

Appendix D - Resources contains the contact information should you wish to purchase a copy of the RTCM SC-104 specification.

4.3 Configuring SXBlue GPS

All aspects of SXBlue GPS operation may be configured through the serial port with the use of NMEA 0183 commands via a terminal software, or using the PocketMAX utility discussed in the PocketMAX manual. These commands are described in the Chapters 8 and 9. The following items are user-configurable:

- Selecting one of the two on-board applications (SBAS or e-Dif, if present)
- Setting the baud rate of the serial RS-232 port
- Choosing which NMEA data messages to output on the dual serial ports and the update rate of each message
- Setting the maximum differential age cut-off
- Setting the satellite elevation angle cut-off mask

4.4 Firmware

The software that runs the SXBlue GPS is often referred to as firmware since it operates at a low level. There are two types of firmware within the SXBlue GPS for the on-board digital signal processor (DSP) and the ARM processor. Each of these types of firmware may be upgraded in the field through the main serial port as new revisions become available.

The ARM processor of the SXBlue GPS engine supports two simultaneous versions of firmware. Only one of them is in operation at any given time. These two versions of firmware may have different functionality, and are also referred to as applications.

The SXBlue GPS currently ships with a SBAS (WAAS) application and the e-Dif application. Chapter 8 describes the $JAPP command used to change between the two SXBlue GPS applications. Within the WAAS application, there are two differential modes, being WAAS and external correction source. Chapter 8 describes the $JDIFF command used to change between the two differential modes.

4.5 e-Dif Operation

Operation of the SXBlue GPS unit with the optional e-Dif application requires manual sending of NMEA messages. These commands may be automatically issued through customized software or a simple terminal interface running on a PDA or data logger. Chapter 8 provides detailed information on the commands supported by the e-Dif feature.

4.5.1 Start-up

When you turn the SXBlue GPS on with the e-Dif application running, it will require a minimum of a few minutes to gather enough satellite tracking information to model the errors for the future (up to 10 minutes may be required depending on your environment). You do not have to keep the SXBlue GPS stationary for this process, but you should ensure that the SXBlue GPS maintains acquisition on the satellites available. We refer to this process of gathering information for the e-Dif application as calibration.

4.5.2 Calibration

Calibration is the process of zeroing the increasing errors in the e-Dif modeling process. Calibration can be performed either in a relative or absolute sense, depending on your positioning needs. Relative positioning will provide positions that are accurate to one another, however, there may be some offset compared to truth. Calibrating for relative positioning is easier than for absolute since any arbitrary position can be used. Calibrating for absolute positioning mode requires that you perform this task with the antenna at a known reference location.

4.5.3 e-Dif Performance

The positioning performance of the SXBlue GPS unit is dependant upon the rate at which the environmental modeling of e-Dif and the environmental errors diverge. The more that e-Dif is able to model the errors correctly, the longer that e-Dif will provide reliable, accurate positioning. As there’s no way in real-time to know the rate of divergence, a rule of thumb is to set your maximum age of differential to either 30 or 45 minutes, depending on how much error your application is able to tolerate. Testing, a sample of which is shown in Figure 1-4 has shown that accuracy will often be better than 1.0 m 95% after 30 minutes of e-Dif operation.

We suggest that you perform your own testing at your location to determine the level of performance that you would expect to see on average. When testing this feature, it’s a good idea to look at a number of e-Dif cycles per day, and monitor performance against a known coordinate. This should be done over a number of days with different states of the ionosphere.

You can monitor the energy level of the ionosphere based upon the amount of solar flare activity at the following Web sites:

iono.jpl.nasa.gov//latest.html

iono.jpl.nasa.gov//gim_dailymovie.html

www.spaceweather.com

www.maj.com/sun/noaa.html

4.6 Configuring Data Message Output

The SXBlue GPS features two primary bi-directional ports referred to as Serial and Bluetooth. GPS data messages for both ports are easily configured by sending NMEA commands to the SXBlue GPS through either of its communication ports (the output of the Serial Port can be configured through Bluetooth, for instance and vice versa). The $JASC NMEA message discussed in detail in Chapter 8 allows you to turn messages on and off as you require. Although free utilities are available to configure the SXBlue GPS, a terminal software can be used to send commands and query the receiver.

4.6.1 This Port and the Other Port

The NMEA interface for the Serial Port and the Bluetooth Port use ‘This’ and ‘Other’ terminology. When interfacing to a port for the sake of turning data messages on or off, on that same port, the port is referred to as ‘This’ port. If you wish to turn a data message on or off, on the opposite port to which you are communicating, the opposite port is referred to as the ‘Other’ port.

For example, if you are communicating with the SXBlue GPS Serial Port, and wish to turn the GPGGA message on at an update rate of 5 Hz on the Bluetooth Port, the following command would be used.

$JASC,GPGGA,5,OTHER<CR><LF>

If you wish to turn the GPGGA message on at 5 Hz on the Serial Port, you would issue the following command.

$JASC,GPGGA,5<CR><LF>

When turning a message on or off on ‘This’ port, you do not need to indicate ‘This’ at the end of the message. Consult chapter 8 for more information on NMEA messages.

4.7 Saving SXBlue GPS Configuration

Each time that you change the configuration of the SXBlue GPS, you may wish to save the new configuration so the receiver does not have to be reconfigured again for the next power cycle.

To save the settings, issue the $JSAVE command and the receiver will record the current configuration to non-volatile memory. The SXBlue GPS will let you know when the save process has been completed which can take approximately five seconds.

4.8 Using the Serial Port for RTCM Input

The SXBlue GPS Serial port can be used to accommodate externally supplied corrections input according to the RTCM SC-104 protocol.

To use the Serial port of the SXBlue GPS for correction input you must set the SXBlue GPS to operate in other differential mode using the following command while connected to the Serial port:

$JDIFF,THIS<CR><LF>

Although the following RTCM SC-104 message types don't all contain differential data, the SXBlue GPS is compatible with them.

- Type 1
- Type 2
- Type 3
- Type 5
- Type 6
- Type 7
- Type 9
- Type 16

To return to using SBAS as the correction source, send the following command to the SXBlue GPS:

$JDIFF,WAAS<CR><LF>

You will find detailed information on NMEA messages supported by the SXBlue GPS in Chapter 8 Complete NMEA 0183 Interface.

5. NMEA 0183 Message Output

The SXBlue GPS supports a selection of NMEA 0183 and proprietary binary messages. This chapter identifies only the selection of standard and proprietary NMEA 0183 Message format for the SXBlue GPS receiver. The complete NMEA interface is covered in chapters 8 and 9.

5.1 NMEA Message Elements

NMEA 0183 messages have a common structure, consisting of a message header, data fields, checksum, and carriage return/line feed message terminator. An example NMEA sentence follows:

$XXYYY,zzz,zzz,zzz…*xx<CR><LF>

The components of this generic NMEA message example are displayed in Table 5-1.

Table 5-1 NMEA Message Elements

Element	Description
$	Message header character
XX	NMEA Talker field. GP indicates a GPS talker
YYY	Type of GPS NMEA Message
zzz	Variable Length Message Fields
*xx	Checksum
<CR>	Carriage Return
<LF>	Line Feed

Null or empty fields occur when no information is available for that field.

5.2 Data Messages

The following subsections describe the NMEA data messages listed in the Table below in detail.

Table 5-2 Data Messages

Message	Max Rate	Description
GPGGA	5 Hz	Global Positioning System Fix Data
GPGLL	5 Hz	Geographic Position – Latitude/Longitude
GPGSA	1 Hz	GNSS (Global Navigation Satellite System) DOP and Active Satellites
GPGST	1 Hz	GNSS Pseudorange Error Statistics
GPGSV	1 Hz	GNSS Satellites in View
GPRMC	5 Hz	Recommended Minimum Specific GNSS Data
GPRRE	1 Hz	Range residual message
GPVTG	5Hz	Course Over Ground and Ground Speed
GPZDA	5 Hz	Time and Date
RD1	1 Hz	SBAS diagnostic information (proprietary NMEA message)

5.2.1 GGA Data Message

The GGA message contains detailed GPS position information, and is the most frequently used NMEA data message. In the table below, the GGA data message is broken down into its components. This message takes the following form:

$GPGGA,hhmmss.ss,ddmm.mmmm,s,dddmm.mmmm,s,n,qq,pp.p,saaaaa.aa,M,
±xxxx.xx,M,sss,aaaa*cc<CR><LF>

Table 5-3 GGA Data Message Defined

Field	Description
hhmmss.ss	UTC time in hours, minutes, seconds of the GPS position
ddmm.mmmmm	Latitude in degrees, minutes, and decimal minutes
s	s = N or s = S, for North or South latitude
dddmm.mmmmm	Longitude in degrees, minutes, and decimal minutes
s	s =E or s = W, for East or West longitude
n	Quality indicator, 0 = no position, 1 = undifferentially corrected position, 2 = differentially corrected position, 9= position computed using almanac
qq	Number of satellites used in position computation
pp.p	HDOP =0.0 to 9.9
saaaa.aa	Antenna altitude
M	Altitude units, M = meters
±xxxx.xx	Geoidal separation (needs geoidal height option)
M	Geoidal separation units, M = meters
sss	Age of differential corrections in seconds
aaa	Reference station identification
*cc	Checksum
<CR><LF>	Carriage return and line feed

5.2.2 GLL Data Message

The GLL message contains Latitude and Longitude. In the table below, the GLL data message is broken down into its components. This message has the following format:

$GPGLL,ddmm.mmmm,s,dddmm.mmmm,s,hhmmss.ss,s*cc<CR><LF>

Table 5-4 GLL Data Message Defined

Field	Description
ddmm.mmmmm	Latitude in degrees, minutes, and decimal minutes
s	s = N or s = S, for North or South latitude
dddmm.mmmmm	Longitude in degrees, minutes, and decimal minutes
s	s = E or s = W, for East or West longitude
hhmmss.ss	UTC time in hours, minutes, and seconds of GPS position
s	Status, s = A = valid, s = V = invalid
*cc	Checksum
<CR><LF>	Carriage return and line feed

5.2.3 GSA Data Message

The GSA message contains GPS DOP and active satellite information. Only satellites used in the position computation are present in this message. Null fields are present when data is unavailable due to the number of satellites tracked. The table below breaks down the GSA message into its components. This message has the following format:

$GPGSA,a,b,cc,dd,ee,ff,gg,hh,ii,jj,kk,mm,nn,oo,p.p,q.q,r.r *cc<CR><LF>

Table 5-5 GSA Data Message Defined

Field	Description
a	Satellite acquisition mode M = manually forced to 2D or 3D, A = automatic swap between 2D and 3D
b	Position mode, 1 = fix not available, 2 = 2D fix, 3 = 3D fix
cc to oo	Satellites used in the position solution, a null field occurs if a channel is unused
p.p	Position Dilution of Precision (PDOP) = 1.0 to 9.9
q.q	Horizontal Dilution of Precision (HDOP) = 1.0 to 9.9
r.r	Vertical Dilution of Precision (VDOP) = 1.0 to 9.9
*cc	Checksum
<CR><LF>	Carriage return and line feed

5.2.4 GST Data Message

The GST message contains Global Navigation Satellite System (GNSS) pseudorange error statistics. The table below breaks down the GST message into its components. This message has the following format:

$GPGST,hhmmss.ss,a.a,b.b,c.c,d.d,e.e,f.f,g.g *cc<CR><LF>

Table 5-6 GST Data Message Defined

Field	Description
hhmmss.ss	UTC time in hours, minutes, seconds of the GPS position
a.a	Root mean square (rms) value of the standard deviation of the range inputs to the navigation process. Range inputs include pseudoranges and differential GNSS (DGNSS) corrections
b.b	Standard deviation of semi-major axis of error ellipse (meters)
c.c	Standard deviation of semi-minor axis of error ellipse (meters)
d.d	Orientation of semi-major axis of error ellipse (degrees)
e.e	Standard deviation of latitude error (meters)
f.f	Standard deviation of longitude error (meters)
g.g	Standard deviation of altitude error (meters)
*cc	Checksum
<CR><LF>	Carriage return and line feed

5.2.5 GSV Data Message

The GSV message contains GPS satellite information. Null fields occur where data is not available due to the number of satellites tracked. The Table below breaks down the GSV data message into its components. This message has the following format:

$GPGSV,t,m,n,ii,ee,aaa,ss,…ii,ee,aaa,ss,*cc<CR><LF>

Table 5-7 GSV Data Message Defined

Field	Description
t	Total number of messages
m	Message number, m = 1 to 3
n	Total number of satellites in view
ii	Satellite number
ee	Elevation in degrees, ee = 0 to 90
aaa	Azimuth (true) in degrees, aaa = 0 to 359
ss	SNR (dB) + 30, ss = 0 to 99
*cc	Checksum
<CR><LF>	Carriage return and line feed

5.2.6 RMC Data Message

The RMC message contains recommended minimum specific GPS data. The table below breaks down the RMC data message into its components. This message has the following format:

$GPRMC,hhmmss.ss,a,ddmm.mmm,n,dddmm.mmm,w,z.z,y.y,ddmmyy,d.d,v *cc<CR><LF>

Table 5-8 RMC Data Message Defined

Field	Description
hhmmss.ss	UTC time in hours, minutes, seconds of the GPS position
a	Status is valid if a = A, status is invalid if a = V
ddmm.mmmmm	Latitude in degrees, minutes, and decimal minutes
n	S = N or s = S, for North or South latitude
dddmm.mmmmm	Longitude in degrees, minutes, and decimal minutes
w	S = E or s = W, for East or West longitude
z.z	Ground speed in knots
y.y	Track made good, referenced to true north
ddmmyy	UTC date of position fix in day, month, year
d.d	Magnetic Variation in degrees
v	Variation sense v = E = East, v = W = West
*cc	Checksum
<CR><LF>	Carriage return and line feed

5.2.7 RRE Data Message

The RRE message contains the satellite range residuals and estimated position error. The table below breaks down the RRE data message into its components. This message has the following format:

$GPRRE,n,ii,rr…ii,rr,hhh.h,vvv.v *cc<CR><LF>

Table 5-9 RRE Data Message Defined

Field	Description
n	Number of satellites used in position computation
ii	Satellite number
rr	Range residual in meters
hhh.h	Horizontal position error estimate in meters
vvv.v	Vertical position error estimate in meters
*cc	Checksum
<CR><LF>	Carriage return and line feed

5.2.8 VTG Data Message

The VTG message contains velocity and course information. The table below breaks down the VTG data message into its components. This message has the following format:

$GPVTG,ttt,c,ttt,c,ggg.gg,u,ggg,gg,u*cc<CR><LF>

Table 5-10 VTG Data Message Defined

Field	Description
ttt	True course over ground, ttt = 000 to 359, in degrees
c	True course over ground indicator, c = T always
ttt	Magnetic course over ground, ttt = 000 to 359, in degrees
c	Magnetic course over ground Indicator, always c = M
ggg.gg	Speed over ground, 000 to 999 knots
u	Speed over ground units, u = N = Nautical mile/h
ggg.gg	Speed over ground, 000 to 999 km/h
u	Speed over ground units, u = K = kilometer/h
*cc	Checksum
<CR><LF>	Carriage return and line feed

5.2.9 ZDA Data Message

The ZDA message contains Universal Time information. The table below breaks down the ZDA data message into its components. This message has the following format:

$GPZDA,hhmmss.ss,dd,mm,yyyy,xx,yy*cc<CR><LF>

Table 5-11 ZDA Data Message Defined

Field	Description
hhmmss.ss	UTC time in hours, minutes, seconds of the GPS position
dd	Day, dd = 0 to 31
mm	Month, mm = 1 to 12
yyyy	Year
xx	Local zone description in hours, xx = -13 to 13
yy	Local zone description in minutes, yy = 0 to 59
*cc	Checksum
<CR><LF>	Carriage return and line feed

5.2.10 RD1 Data Message

The RD1 message contains diagnostic information for SBAS operation. The table below breaks down the RD1 data message into its components. This message has the following format:

$RD1,SecOfWeek,WeekNum,FreqMHz,DSPLocked,BER-BER2,AGC,
DDS,Doppler,DSPStat,ARMStat,DiffStatus,NavCondition *cc<CR><LF>

Table 5-12 RD1 Data Message Defined

Field	Description
SecOfWeek	The second of GPS week (may be a couple of seconds old)
WeekNum	The GPS week number
FreqMHz	The L-band frequency in MHz (1475.4200 is used for SBAS)
DSPLocked	1 if DSPStat = 1B or 1F
BER-BER2	Bit error rate – bit error rates are given for both SBAS satellites being tracked
AGC	L-band Signal strength
DDS	0.0 for SBAS
Doppler	0 for SBAS
DSPStat	A status bit mask for the DSP tracking of SBAS
ARMStat	A status bit mask for the ARM GPS solution
DiffStatus	The SBAS PRN of the satellite in use
NavCondition	A series of hex character fields, which is read from right to left, with each field representing the number of GPS satellites satisfying a certain condition, all of which conditions are required if the satellite is to be used in the solution
*cc	Checksum
<CR><LF>	Carriage return and line feed

The following table describes the DSP status. The DSP status should be 17, 1B, or 1F when SBAS tracking has been achieved.

Table 5-13 DSP Status

Field	Description
01	Carrier lock
02	BER is ok on at least one SBAS satellite
04	Frame synchronization has been achieved on the second satellite
08	Frame synchronization has been achieved on the first satellite
10	Carrier lock

The following table describes the ARM status.

Table 5-14 ARM Status

Field	Description
01	GPS lock
02	DGPS valid data
04	The ARM processor has lock
08	DGPS solution
10	DGPS solution is good
20	Not used
40	Not used

An example of the NavCondition is presented in the following table for the 179889A value.

Table 5-15 NavCondition

Field	Description
A	The number of satellites with lock and carrier phase
9	The number of satellites with ephemeris received
8	The number of satellites with healthy ephemeris
8	The number of satellites that are tracked, have an ephemeris, which is healthy, and are above the elevation mask
9	The number of satellites above the elevation mask
7	The number of satellites with differential
1	The number of satellites with no differential

6. Frequently Asked Questions

6.1 General

Q – Are the SBAS services reliable for differential operation?

A – Yes, these services have proven themselves for some time now and have shown excellent results. As both WAAS and EGNOS are in test mode currently, they are not to be used as a sole means of navigation. Additionally, as they are under test, there may be periods of outage or times when the signal should not be used. We recommend that you refer to Appendix D - Resources of this manual for Web sites that provide details regarding the broadcast schedule of WAAS and EGNOS.

Q – Can the COAST technology work with corrections from an external source?

A – Yes, the SXBlue GPS will operate in a similar fashion with the COAST technology as when using SBAS. However, SBAS corrections have the advantage that they are separated into separate error components, allowing the SXBlue GPS to anticipate how errors will change over the coasting period with more consistent accuracy and for a longer period than regular RTCM range corrections.

Q – Is e-Dif the solution for my positioning needs?

A – It is difficult to say without knowing more about your application. e-Dif is not a different solution / replacement for everyone's application. Certain applications lend themselves to successful e-Dif operation, such as crop dusting. In this application, the aircraft must refuel and be filled with chemicals quite frequently, perhaps every 20 minutes. This allows for a new initialization when the aircraft lands. Provided that the user feels that it's efficient to do so, e-Dif can be successfully used in geographic regions where the only differential services available are subscription-based. E-Dif, in this application, would require an initialization as frequently as the user feels is necessary to maintain a level of performance that they're comfortable with. This may mean an initialization every 30 minutes or so. Also, if absolute positioning accuracy is needed as opposed to relative positioning, a point of known coordinates should be used for initializing the system. Of course, more points in the area of the system use could be used, provided that their coordinates are correctly entered into the system. This can be easily implemented through development of a custom software application running on a PDA product.

Q – How does the SXBlue GPS compare to competitor's products?

A – The SXBlue GPS is a unique solution in that it is very compact, yet offers a high degree of performance. There are a number of DGPS products on the marketplace, however, very few of these are suitable for commercial use in applications such as Agricultural Guidance or GIS & Mapping due to their positioning performance and their update rates. The SXBlue GPS is up for this task and meets the needs for these applications. The SXBlue GPS also offers the facility of outputting raw measurement data for post-processing in the office.

Q – What do I do if I want to evaluate e-Dif?

A – We suggest that you contact your dealer to see if they have a unit available with e-Dif activated for your testing.

6.2 Support and Repairs

Q - How do you recommend that I pursue support to solve a problem that I can't isolate?

A - We recommend that you contact your dealer first. With their experience with this and other products from Geneq, they're likely to help you isolate a problem. If the issue is beyond the capability or experience of your dealer, either they or you can speak with a Technical Service Representative from Geneq.

Q - Can I contact Geneq directly regarding technical problems?

A - Yes, however, we recommend that you speak to your dealer first as they would be your local support. They may be able to solve your problem more promptly than us, due to their location and experience with our equipment.

6.3 Troubleshooting

Q - What do I do initially if I have a problem with the operation of the SXBlue GPS module?

A - Try to isolate the source of the problem. Problems are likely to fall within one of the following categories. It's important to review each in detail to remove each from being a suspect source of the problem.

- Power, communication, and configuration
- GPS reception and performance
- SBAS reception and performance
- External corrections
- Installation

The questions in the following sections provide information that may help you to isolate and solve the problem that you are experiencing.

Q - What do I do if I can't resolve the problem after trying to diagnose it myself?

A - You should contact your dealer to see if they have any information that may help to solve the problem. They may be able to provide some in-person assistance too. If this either isn't viable or does not solve the problem, Geneq Technical Support is available during normal business hours to help solve the problem. You may reach Technical Support at:

Telephone number:	+1-514-354-2511
Fax number:	+1-514-354-6948
E-mail address:	support@geneq.com

Technical Support is available from 8:30 AM to 5:00 PM Eastern Time, Monday to Friday.

6.4 Power, Communication, and Configuration

Q - My SXBlue GPS system doesn't appear to be communicating, what do I do?

A - This could be one of a few issues:

1. Examine the SXBlue GPS cables and connectors for signs of damage.
2. Ensure that you are properly powering the system with the correct voltage.
3. If using the power cable, since you're required to terminate the power input with your choice of connector, ensure that you have made a good connection to the power supply.
4. Check the documentation of the receiving device, if not a PC computer, to ensure that the transmit line from the SXBlue GPS is connected to the receive line of the other device. Also ensure that the signal grounds are connected.
5. If the SXBlue GPS is connected to a custom or special device, ensure that the serial connection to it does not have any incompatible signal lines present that may not allow either to communicate properly. Try using the Serial port for communication as only pins 2, 3, and 5, which are the only pins required for communication, are connected.
6. Make sure that the baud rate of the SXBlue GPS matches the other device. The other device must also support an 8 data bit, 1 stop bit, and no parity port configuration (8-N-1). Some devices support different settings that may be user-configurable. Ensure that the settings match.
7. Consult the troubleshooting section of the other devices reference manual to determine if there may be a problem with that equipment.

Q - Am I able to configure the serial ports with different baud rates?

A - Yes, the serial and Bluetooth ports are independent. However, the Bluetooth port must be set to 9600 baud for proper operation.

Q - Am I able to have the SXBlue GPS output different NMEA messages through the two ports?

A - Yes, you may have different NMEA messages turned on for the two serial ports. Further, these NMEA messages may also be at different update rates.

Q - How can I determine the current configuration of the SXBlue GPS?

A - The $JSHOW<CR><LF> command will request the configuration information from the SXBlue GPS. The response will be similar to the following output and is described in detail in the chapter 8.

```
$>JSHOW,BAUD,19200
$>JSHOW,BIN,1,5.0
$>JSHOW,BAUD,9600,OTHER
```

$>JSHOW,ASC,GPGGA,1.0,OTHER
$>JSHOW,ASC,GPVTG,1.0,OTHER
$>JSHOW,ASC,GPGSA,1.0,OTHER
$>JSHOW,ASC,GPZDA,1.0,OTHER

Q – How can I be sure that the configuration will be saved for the subsequent power cycle?

A – The surest method is to query the receiver to make sure you're happy with the current configuration, by issuing a $JSHOW<CR><LF> command (if not, make the necessary changes and repeat). If the current configuration is acceptable, issue a $JSAVE<CR><LF> command. Wait for the receiver to indicate that the save is complete. You may power the receiver down and issue another $JSAVE if you feel it's necessary; however, it is not required.

Q - What is the best software tool to use to communicate with the SXBlue GPS and configure it?

A - We use two different software applications at Geneq for this application:

- PocketMAX - Available from Geneq. This application is a very useful tool for graphically viewing tracking performance, positioning accuracy, and more on a Pocket PC.
- HyperTerminal – Available on all Windows 95, 98, ME, 2000 and XP. This tool is useful as it allows you to easily configure the SXBlue GPS by directly typing commands into the terminal window. The output from the SXBlue GPS is shown simultaneously. Ensure that when using HyperTerminal that it is configured to use the correct PC communication port, baud rate, and that the local echo feature is on (to see what you are typing).

6.5 GPS Reception and Performance

Q - How do I know what the SXBlue GPS is doing?

A - The SXBlue GPS supports standard NMEA data messages. The $GPGSV data message contains satellite tracking information. Since the GPS automatically tracks GPS satellites when powered, this will give you information on the tracking status. If your receiver has computed a position, this will be contained within the $GPGGA data message. Additionally, the SXBlue GPS module has surface-mounted status LEDs that give indication of receiver status.

Q - Do I have to be careful when using the SXBlue GPS to ensure that it tracks properly?

A – For best performance, you have to be careful such that the hemisphere above the SXBlue GPS's antenna is unobstructed for satellite tracking. The SXBlue GPS is tolerable of a certain amount of signal blockage due to the availability of redundant satellites (only four are required for a position). However, as more satellites are blocked, the more impact this could have your positioning accuracy.

6.6 SBAS Reception and Performance

Q - How do I know if I can receive a SBAS signal in my area?

A - Refer to Appendix C that contains approximate coverage maps for both WAAS (for North America) and EGNOS (for Europe). It's important to have both signal coverage and ionospheric map coverage. In fact, it's desirable to have a few degrees of latitude and longitude of ionospheric map coverage around your location to ensure that satellites available have these correctors.

Q - How do I know if the SXBlue GPS module has acquired a SBAS signal?

A - The SXBlue GPS allows you to request the output of the $RD1 message that contains the SBAS bit error rate (BER) for both receiver channels. The BER value describes the rate of errors received from SBAS. Ideally, this should be zero; however, the SXBlue GPS should provide good performance up to a 150 BER. The PocketMAX utility discussed in the PocketMAX Manual is a useful tool that provides this information without needing to use NMEA commands.

Q - How do I know if the SXBlue GPS is offering a differentially corrected position?

A - The SXBlue GPS outputs the GGA message as the main positioning data message. This message contains a quality fix value that describes the GPS status. If this value is a 2, then the position is differentially corrected. The PocketMAX utility discussed in the PocketMAX Manual is a useful tool that provides this information without needing to use NMEA commands.

Q - Does it matter much if the SXBlue GPS is frequently losing lock on SBAS due to obstructions and the low satellite elevation angles at my geographic location?

A - No, provided that the receiver is receiving a full set of corrections relatively often. Using the COAST technology, the SXBlue GPS will be able to perform well for up to 40 minutes with old correction data (similar to e-Dif, accuracy towards the end will not be as accurate as the beginning.) In order to obtain a full set of corrections, the SXBlue GPS antenna receives the ionospheric map over a period of a few minutes. This is the minimum amount of time required to get a full set of corrections for SBAS operation. After this, the receiver can COAST until the next set of corrections have been received.

6.7 e-Dif

Q – Why was e-Dif developed?

A – Once Selective Availability was removed in May of 2000, it opened the door to develop this technology as environmental errors change much more slowly than SA did. The purpose of e-Dif was to market an alternative to users in replace of costly subscription-based differential services around the world where free services such as DGPS beacon and SBAS did not exist.

Q – Will e-Dif perform as well as other correction services?

A – e-Dif will perform with a similar level of performance as other differential services at first. There will be a slow drift to the positioning performance with increasing time. We normally allow e-Dif to age for a maximum of 30 to 40 minutes; however, it's up to you on how long you will allow it to age. A simple update to the reference position will again provide best performance.

Q – Will e-Dif correct for multipath?

A – No, there's no method of differentially correcting multipath signals. There's only ways of reducing their impact on the measurements gathered by the receiver.

6.8 External Corrections

Q - My SXBlue GPS system doesn't appear to be using corrections from an external correction source, what could be the problem?

A - This could be due to a number of issues:

- Make sure that the corrections are of an RTCM SC-104 protocol.
- Make sure that the differential source is set to receive RTCM by issuing a $JDIFF,THIS<cr><lf> on the RS-232 Serial port.
- Check to see that the baud rates of the port used by the SXBlue GPS matches that of the external correction source
- The external correction source should be using an 8 data bit, no parity, and 1 stop bit serial port configuration.
- Inspect the cable connection to ensure there's no sign of damage
- Check the pin-out information for the cables to ensure that the transmit line of the external correction source is connected to the receive line of the SXBlue GPS's serial port and that the signal grounds are connected.

6.9 Installation

Q - Does it matter where I mount the SXBlue GPS's antenna?

A - Yes, the main consideration is that it must have an open hemisphere of sky for satellite tracking. Additionally, the position that it computes is referenced to the center of the antenna. It should be placed in the location for which you would like a position. Often, this is the centerline of a vehicle or on a pole-mount for georeferencing.

Q - Can I use a vehicle's power system to operate the SXBlue GPS system or do I need a dedicated battery?

A - Yes you can for the 5V and 12 V models – For the 5V model, a cigarette lighter plug is available from your dealer or Geneq. For the 12V model, the internal power supply of the SXBlue GPS is designed for a voltage range from 9 to 18 VDC.

7. Troubleshooting

7.1 Troubleshooting Checklist

Use the following checklist to troubleshoot anomalous SXBlue GPS system operation. The following table provides a problem symptom, followed by a list of possible solutions.

Table 7-1 Troubleshooting

Symptom	Possible Solution
Receiver fails to power	• Verify polarity of power leads • Check 1.0 A in-line power cable fuse (if using the power cable) • Check integrity of power cable connections • Check power input voltage (depending on the SXBlue GPS model) • Check current restrictions imposed by power source (minimum available should be > 1.0 Amp)
No data from SXBlue GPS	• Check receiver power status (this may be done with an ammeter) • Verify that SXBlue GPS is locked to a valid DGPS signal (this can often be done on the receiving device or with the use of HyperTerminal running on a PC) • Verify that SXBlue GPS is locked to GPS satellites (this can often be done on the receiving device or with the use of HyperTerminal running on a PC) • Check integrity and connectivity of power and data cable connections
Random data from SXBlue GPS	• Verify that the RTCM or the Bin95 and Bin96 messages are not being output accidentally (send a $JSHOW command) • Verify baud rate settings of SXBlue GPS and remote device match correctly • Potentially, the volume of data requested to be output by the SXBlue GPS could be higher than the current baud rate supports. Try using 19,200 as the baud rate on the RS-232 port.
No GPS lock	• Check integrity of antenna cable • Verify antenna's unobstructed view of the sky • Verify the lock status of GPS satellites (this can often be done on the receiving device or with the use of HyperTerminal running on a PC)
No SBAS lock	• Check antenna connections • Verify antenna's unobstructed view of the sky • Verify the lock status of SBAS satellites (this can often be done on the receiving device or with the use of HyperTerminal running on a PC – monitor BER value)
No DGPS position in external RTCM mode	• Verify that the baud rate of the RTCM input port matches the baud rate of the external source • Verify the pin-out between the RTCM source and the RTCM input port (transmit from the source must go to receive of the RTCM input port and grounds must be connected - Refer to Appendix B)
Non-differential GPS output	• Verify SXBlue GPS SBAS and lock status (or external source is locked)

7.2 Using the LEDs to Troubleshoot

The SXBlue GPS receiver has 5 LED indicator lights that serve as status indicators. The first 4 lights should all be illuminated solid (non-blinking) when the receiver is powered on and has a valid GPS and differential solution. The last LED (furthest to the right) should only be illuminated solid if you are connected using Bluetooth communications. Otherwise, the lights can be in various states (blinking, on solid, or off). Table 7-2 describes the LED light operation.

Table 7-2 LED Functions

	**Power LED: (Red)** This LED should be on solid once power is applied to the receiver. This is the only LED that is not under computer control.
	**GPS LED: (Green)** This LED serves two purposes: At power-on it will blink 3 to 4 times, once per second, and then go off. If it fails to blink, the Differential processor is likely to have failed. If it does not stop blinking, the GPS processor is the likely culprit. After a minute or so, this LED should go on solid green to indicate that GPS has lock. This is true even if differential corrections are not available. If the LED is continually blinking and you have been programming your SXBlue GPS, it is possible it is still in programming mode. The SXBlue GPS will not communicate while in this state. Simply power cycle the SXBlue GPS to restore normal communications.
	**DGPS LED: (Orange)** This LED will remain off until a differentially corrected GPS solution is available. It will blink at a steady rate if the solution has not converged to the accuracy specified by the $JLIMIT command and will become solid yellow after the solution has converged. (The $JLIMIT sets the threshold for the RMS residual error and this error gives a rough indication of expected user accuracy. Note, however, that it is not a direct measure of accuracy. Factors such as constellation geometry must also be taken into account. The default value for $JLIMIT is 10 meters).
	**Differential Source LED: (Yellow)** This LED can be in several states: Off – Differential signal has not been received. Flickering on and off – the receiver is close to acquiring the differential signal. Blinking at a steady rate - Differential signal has been acquired, but the Bit-Error-Rate (BER) of the “best” signal tracked is higher than 150. Generally, this will not affect performance, but it is a warning of weak signal strength. On Solid –WAAS has been acquired and signal strength is good.
	**Bluetooth LED: (Blue)** This LED will remain off until a Bluetooth connection is established between the SXBlue GPS and the other device. It will remain on until the connection is broken.

8. Complete NMEA 0183 Interface

The SXBlue GPS supports a selection of NMEA 0183 and proprietary binary messages. The following chapter describes the NMEA interface in detail and chapter 9 defines the Binary messages. It's your choice as a systems designer to choose whether or not to support a NMEA-only software interface or a selection of both NMEA and binary messages. The SXBlue GPS is configured only using NMEA commands.

8.1 NMEA Message Elements

NMEA 0183 messages have a common structure, consisting of a message header, data fields, checksum, and carriage return/line feed message terminator. An example NMEA sentence follows:

$XXYYY,zzz,zzz,zzz…*xx<CR><LF>

The components of this generic NMEA message example are displayed in Table 8-1.

Table 8-1 NMEA Message Elements

Element	Description
$	Message header character
XX	NMEA Talker field. GP indicates a GPS talker
YYY	Type of GPS NMEA Message
zzz	Variable Length Message Fields
*xx	Checksum
<CR>	Carriage Return
<LF>	Line Feed

Null, or empty fields occur when no information is available for that field.

8.2 General Commands

This section presents various commands relating to the general operation and configuration of the SXBlue GPS.

The following table provides a brief description of the general commands supported by the SXBlue GPS receiver.

Table 8-2 General Commands

Message	Description
$JASC,Dx	Command to turn on diagnostic information.
$JAIR	This is a command to place the receiver into 'AIR' mode where the receiver will respond better to the high dynamics associated with airborne applications.
$JASC,VIRTUAL	This command is used to output RTCM data fed into the other port, through the current port
$JALT	This command is used to set the altitude aiding mode of the GPS inside the SXBlue GPS
$JLIMIT	This command is used to set the threshold of estimated horizontal performance.
$JAPP	This command is used to query the current applications and also choose the current application.
$JBAUD	Baud rate change command for the SXBlue GPS.
$JCONN	Virtual circuit command used to interface to communicate with the menu system microprocessor.
$JDIFF	This command is used to set the differential mode.
$JK	This command is used to subscribe certain features of use of the SXBlue GPS.
$JPOS	This command is used to provide the SXBlue GPS with a seed position to acquire a SBAS signal more quickly upon start-up. This is not normally needed.
$JQUERY,GUIDE	This command is used to poll the SXBlue GPS for its opinion on whether or not it is providing suitable accuracy after the both SBAS and GPS have been acquired (up to 5 min)
$JRESET	This command is used to reset the configuration of the SXBlue GPS.
$JSAVE	This command is used to save the configuration of the SXBlue GPS.
$JSHOW	This command is used to query the SXBlue GPS receiver for its configuration.
$JT	This command is used to poll the SXBlue GPS for its receiver type

The following subsections provide detailed information relating to the use of each command.

Note - Please ensure that you save any changes that you wish to survive beyond the current power-up by using the $JSAVE command and wait for the '$> Save Complete' response.

8.2.1 $JASC,D1

This command allows you to adjust the output of the RD1 diagnostic information message from the SXBlue GPS receiver.

This command has the following structure:

$JASC,D1,r[,OTHER]<CR><LF>

Currently, only the RD1 message is defined, with x = 1. The message status variable 'r' may be one of the following values:

r	Description
0	ON
1	OFF

When the ',OTHER' data field is specified (without the square brackets), this command will enact a change in the RD1 message on the other port.

8.2.2 $JAIR

This command allows you to place the SXBlue GPS into AIR mode, where the receiver is optimized for the high dynamic environment associated with airborne platforms.

The format of this command follows:

$JAIR,r<CR><LF>

Where feature status variable, 'r', may be one of the following values:

r	Description
0	ON
1	OFF

The SXBlue GPS will reply with the following response:

$>

8.2.3 $JASC,VIRTUAL

When using an external correction source, this command is used to 'daisy chain' RTCM data from being input from one port and output through the other. For example, if RTCM is input on Port B, this data will correct the SXBlue GPS position and also be output through Port A. The SXBlue GPS acts as a pass-through for the RTCM data. Either port may be configured to accept RTCM data input and this command then allows the opposite port to output the RTCM data. To configure the SXBlue GPS to output RTCM data on the current port from data input on the other port, issue the following command:

$JASC,VIRTUAL,r<CR><LF>

To configure the SXBlue GPS to output RTCM data on the other port from RTCM data input on the current port, issue the following command:

$JASC,VIRTUAL,r,OTHER<CR><LF>

Where the message status variable, 'r', may be one of the following:

r	Description
0	ON
1	OFF

The SXBlue GPS will reply with the following response:

$>

8.2.4 $JALT

This command turns altitude aiding on or off for the SXBlue GPS. When set to on, altitude aiding uses a fixed altitude instead of using one satellite's observations to calculate the altitude. The advantage of this feature, when operating in an application where a fixed altitude is acceptable, is that the extra satellite's observations can be used to betterment of the latitude, longitude, and time offset calculations, resulting in improved accuracy and integrity. Marine markets, for example, may be well suited for use of this feature.

This command has the following layout:

$JALT,c,v[,GEOID] <CR><LF>

Where feature status variable, 'c', and threshold variable, 'v', may be one of the following:

c	Description
NEVER	This is the default mode of operation where altitude aiding is not used.
SOMETIMES	Setting this feature to SOMETIMES allows the receiver to use altitude aiding, dependent upon the PDOP threshold, specified by 'v'
ALWAYS	Setting this feature to ALWAYS allow the receiver to use altitude aiding regardless of a variable. In this case, you may specify the ellipsoidal altitude, 'v' that the receiver should use. Optionally, if you specify the ',GEOID' field, the receiver will use the GEOID as its reference.

The SXBlue GPS will reply with the following response:

$>

8.2.5 $JLIMIT

This command is used to change the threshold of estimated horizontal performance for which the DGPS position LED is illuminated. The default value for this parameter is a conservative 10.0 meters. This command has the following format:

$JLIMIT,limit<CR><LF>

Where 'Limit' is the new limit in meters.

The receiver will respond with the following message:

$>

If you wish to verify the current $JLIMIT threshold, the response to the $JSHOW command provides this information.

8.2.6 $JAPP

This command allows you to request the SXBlue GPS for the currently installed applications and to choose which application to use. The SXBlue GPS by default comes pre-installed with WAAS (SBAS) with a second, empty application.

To poll the receiver for the current applications, send the following message:

$JAPP<CR><LF>

There are no data fields to specify in this message. The receiver will respond with the following message:

$>JAPP,current,other

Where 'current' indicates the current application in use and 'other' indicates the secondary application that is not in use currently. Available applications follow:

Applications
WAAS
AUTODIF (e-Dif)

For the sake of the application names, the SBAS application is referred to as WAAS by the SXBlue GPS' internal software.

To change from the current application to the other application (when two applications are present), issue the following command:

$JAPP,OTHER<CR><LF>

or

$JAPP,app<CR><LF>

Where 'app' may be one of the following by name:

app	Description
waas	This will change to the SBAS application
Autodif	This will change to the e-Dif application (referred to as autodif in the firmware)

Note – Other derivatives of the $JAPP command are the $JAPP,1<CR><LF> and $JAPP,2<CR><LF> commands that can be used to set the SXBlue GPS to use the first and second application. It's best to follow up the sending of these commands with a $JAPP query to see which application is 1 or 2. These two commands are best used when upgrading the firmware inside the SXBlue GPS, as

the firmware upgrading utility uses the application number to designate which application to overwrite.

8.2.7 $JBAUD

This command is used to configure the baud rates of the SXBlue GPS.

This command has the following structure:

$JBAUD,r[,OTHER] <CR><LF>

Where 'r' may be one of the following baud rates:

Baud Rates
4800
9600
19200

When this command has been issued without the ',OTHER' data field, the baud rate of the current port will be changed accordingly. When the ',OTHER' data field is specified (without the square brackets), a baud rate change will occur for the other port. Note that the Bluetooth port only supports 9600 baud. The Bluetooth baud rate can only be modified by Geneq.

The SXBlue GPS will reply with the following response:

$>

8.2.8 $JCONN

This command is used to create a virtual circuit between the A and B port, if needed. This allows you to through the SXBlue GPS to the device on the opposite port.

The virtual circuit command has the following form:

$JCONN,p<CR><LF>

Where the connection type, 'p', may be one of the following:

p	Description
AB	Specify 'AB' in order to connect the A port to the B port
X	Once a virtual circuit has been established, to remove the virtual circuit, specify 'X' in this command to return the current port to normal

8.2.9 $JDIFF

This command is used to change the differential mode of the SXBlue GPS receiver.

The structure of this command follows:

$JDIFF,diff<CR><LF>

Where the differential mode variable, 'diff', has one of the following values:

diff	Description
OTHER	Specifying OTHER instructs the SXBlue GPS to use external corrections input through the opposite port from which you are communicating
WAAS	Specifying WAAS instructs the SXBlue GPS to use SBAS corrections
NONE	In order for the SXBlue GPS to operate in autonomous mode, the NONE argument may be specified in this command.

8.2.10 $JK

This command is used by the SXBlue GPS to enable the e-Dif option.

This command will have the following format:

$JK,x…<CR><LF>

Where 'x…' is the subscription key provided by Geneq and is 10 characters in length. If you send the $JK command without a subscription key as follows, it will return the expiry date of the subscription.

$JK<CR><LF>

Reply:

$>JK,12/31/2003,1

8.2.11 $JPOS

This command is used to speed up the initial acquisition when changing continents with the SXBlue GPS (for example, powering it for the first time in Europe after it has been tested in Canada). This will allow it to begin the acquisition process for the closest SBAS spot beams. This will save some time with acquisition of the SBAS service, however, use of this message is typically not required due to the quick overall startup time of the SXBlue GPS receiver.

This command has the following layout:

$JPOS,lat,lon<CR><LF>

Where 'lat' and 'lon' have the following requirements:

Position Component	Description
lat	Latitude component must be entered in decimal degrees. This component does not have to be more accurate than half a degree.
lon	Longitude component must be entered in decimal degrees. This component does not have to be more accurate than approximately half a degree.

Note – this command is not normally required for operation of the SXBlue GPS.

8.2.12 $JQUERY,GUIDE

This command is used to poll the SXBlue GPS for its opinion on whether or not it is providing suitable accuracy after the both SBAS and GPS have been acquired (up to 5 min). This feature takes into consider the download status of the SBAS ionospheric map and also the carrier phase smoothing of the unit.

This command has the following format:

$JQUERY,GUIDE<CR><LF>

If the SXBlue GPS is ready for use with navigation or positioning with optimum performance, it will return the following message:

$>JQUERY,GUIDE,YES<CR><LF>

Otherwise, it will return the following message:

$>JQUERY,GUIDE,NO<CR><LF>

8.2.13 $JRESET

This command is used to reset the GPS engine inside the SXBlue GPS to its default operating parameters.

This message has the following format:

$JRESET[,ALL] <CR><LF>

The '[,ALL]' field is optional. When this command is issued without this field present, the configuration only is defaulted. Please note that the default of the GPS engine does not necessarily correspond with the factory setup of the SXBlue GPS.

When the ',ALL' field is present (without the square brackets), the almanac is also defaulted. Issuing this command with this optional data field is not usually necessary.

Caution – We do not recommend the issue of the $JRESET,ALL<CR><LF> command under most circumstances as it will erase any feature subscriptions from memory of the SXBlue GPS.

8.2.14 $JSAVE

Sending this command is required after making changes to the operating mode of the SXBlue GPS receiver. It is possible, however, that after making changes to the operating mode through the serial port, and later using the menu system, that the mode becomes saved. This could occur as changes through the menu system automatically invokes the $JSAVE command. However, do not rely on this feature to save your changes.

This command has the following structure:

$JSAVE<CR><LF>

The SXBlue GPS will reply with the following two messages. Ensure that the receiver indicates that the save process is complete before turning the receiver off or changing the configuration further.

$> Saving Configuration. Please Wait...

$> Save Complete

No data fields are required. The receiver will indicate that the configuration is being saved and will notify you when the save is complete.

8.2.15 $JSHOW

This command is used to poll the SXBlue GPS for the current operating configuration of its internal GPS receiver.

This command has the following structure:

$JSHOW[,subset] <CR><LF>

Using the $JSHOW command without the optional ',subset' field will provide a complete response from the receiver. An example of this response follows:

```
$>JSHOW,BAUD,9600                    (1)
$>JSHOW,BAUD,9600,OTHER              (2)
$>JSHOW,ASC,GPGGA,1.0,OTHER          (3)
$>JSHOW,ASC,GPVTG,1.0,OTHER          (4)
$>JSHOW,ASC,GPGSV,1.0,OTHER          (5)
$>JSHOW,ASC,GPGST,1.0,OTHER          (6)
$>JSHOW,ASC,D1,1,OTHER               (7)
$>JSHOW,DIFF,WAAS                    (8)
$>JSHOW,ALT,NEVER                    (9)
$>JSHOW,LIMIT,10.0                   (10)
$>JSHOW,MASK,10                      (11)
$>JSHOW,POS,51.0,-114.0              (12)
$>JSHOW,AIR,AUTO,OFF                 (13)
$>JSHOW,FREQ,1575.4200,250           (14)
$>JSHOW,AGE,3600                     (15)
```

This example response is summarized in the following table:

Line	Description
1	This line indicates that the current port is set to a baud rate of 9600.
2	This line indicates that the other port is set to a baud rate of 9600.
3	This line indicates that GPGGA is output at a rate of 1 Hz from the other port.
4	This line indicates that GPVTG is output at a rate of 1 Hz from the other port.
5	This line indicates that GPGSV is output at a rate of 1 Hz from the other port.
6	This line indicates that GPGST is output at a rate of 1 Hz from the other port.

7	This line indicates that D1 is output at a rate of 1 Hz from the other.
8	This line indicates that the current differential mode is WAAS
9	This line indicates the status of the altitude aiding feature.
10	This indicates the threshold of horizontal performance.
11	This line indicates the current elevation mask cutoff angle, in degrees.
12	This line indicates the current seed position used for startup, in decimal degrees.
13	This line indicates the current status of the AIR mode.
14	This line indicates the current frequency of the L-band receiver
15	This line indicates the current maximum acceptable differential age in seconds.

When issuing this command with the optional ',subset' data field (without the square brackets), a one-line response is provided. The subset field may be either CONF or GP. When CONF is specified for 'subset', the following response is provided:

$>JSHOW,CONF,N,0.0,10.0,5,A,60W

This response is summarized in the following table:

Message Component	Description
$>JSHOW,CONF	Message header
N	'N' indicates no altitude aiding
0.0	'0.0' indicates the aiding value, if specified (either specified height or PDOP threshold)
10.0	Residual limit for the $JLIMIT command, which is not supported by the SXBlue GPS.
5	Elevation mask cutoff angle, in degrees
A	AIR mode indication
60	Maximum acceptable age of correction data in seconds
W	Current differential mode, 'W' indicates WAAS mode.

When GP is specified for 'subset', the following is an example response provided:

$>JSHOW,GP,GGA,1.0

This response will provide the >$JSHOW,GP message header, followed by each message currently being output through the current port and also the update rate for that message.

8.2.16 $JT

This command displays the type of receiver engine within the SXBlue GPS and has the following format:

$JT<CR><LF>

The receiver will return the following response, indicating that the receiver is an SX1g ('g' for global differential operation) when in SBAS mode and SX1i when in e-Dif mode ('i' for internal differential operation):

$>JT,SX1g

8.2.17 $JBIN

This command allows you to request the output of the various binary messages, but most notably, the Bin95 and Bin96 messages. These latter two messages contain all information required for post processing. Refer to chapter 9 for a complete binary message structure.

This message has the following structure:

$JBIN,msg,r

Where 'msg' is the message name and 'r' is the message rate as shown in the table below.

msg	r (Hz)	Description
Bin1	5, 1, 0, or .2	Binary GPS position message.
Bin2	5, 1, 0, or .2	Binary message containing GPS DOP's.
Bin80	1 or 0	Binary message containing SBAS information.
Bin95	1 or 0	Binary message containing ephemeris information.
Bin96	1 or 0	Binary message containing code and carrier phase information.
Bin97	5, 1, 0, or .2	Binary message containing process statistics
Bin98	1 or 0	Binary message containing satellite and almanac information.
Bin99	5, 1, 0, or .2	Binary message containing GPS diagnostic information.

The SXBlue GPS will reply with the following response:

$>

8.3 GPS Commands

This section describes the selection of commands specific to the configuration and operation of the SXBlue GPS' internal GPS engine.

The following table provides a brief description of the commands supported by the GPS engine for its configuration and operation.

Table 8-3 GPS Commands

Message	Description
$JASC,GP	This command is used to configure the NMEA message output of the GPS engine
$JAGE	A command used to configure the maximum age of DGPS corrections
$JOFF	This command is used to turn off all data output by the GPS engine
$JMASK	This command allows you to modify the cut-off angle for tracking of GPS satellites
$J4STRING	This command allows you to configure the GPS for output of the GPGGA, GPGSA, GPVTG, and GPZDA messages at a specific baud rate

The following subsections provide detailed information relating to the use of each command.

Note - Please ensure that you save any changes that you wish to survive beyond the current power-up by using the $JSAVE command and wait for the '$> Save Complete' response.

8.3.1 $JASC

Using this command, you may turn GPS data messages on at a particular update rate or off. When turning messages on, you have the choice of various update rates available, depending on what your requirements are.

This command has the following layout:

$JASC,GPmsg,r[,OTHER]<CR><LF>

Where 'msg' is the name of the data message and 'r' is the message rate, as shown in the table below. Sending the command without the optional [,OTHER] data field (without the square braces) will enact a change on the current port.

A message is turned off by sending a command with a zero value for the 'r' field.

msg	r (Hz)	Description
GPGGA	5, 1, 0, or .2	Global Positioning System Fix Data
GPGLL	5, 1, 0, or .2	Geographic Position – Latitude/Longitude
GPGSA	1 or 0	GNSS (Global Navigation Satellite System) DOP and Active Satellites
GPGST	1 or 0	GNSS Pseudorange Error Statistics
GPGSV	1 or 0	GNSS Satellites in View
GPRMC	5, 1, 0, or .2	Recommended Minimum Specific GNSS Data
GPRRE	1 or 0	Range residual message
GPVTG	5, 1, 0, or .2	Course Over Ground and Ground Speed
GPZDA	5, 1, 0, or .2	Time and Date

When the ',OTHER' data field is specified (without the square brackets), this command will enact a change in the $GPmsg message on the other port.

The SXBlue GPS will reply with the following response:

$>

8.3.2 $JAGE,age

This command allows you to choose the maximum allowable age for correction data. The default setting for the SXBlue GPS is 3600 seconds; however, you may change this value as you feel appropriate.

Using COAST technology, the SXBlue GPS is able to use old correction data for extended periods of time. If you choose to use a maximum correction age older than 1800 seconds, we recommend that you consider testing the receiver to ensure that the new setting meets your requirements as accuracy will slowly drift with increasing time.

This command has the following structure:

$JAGE,age<CR><LF>

Where maximum differential age timeout variable, 'age', may be a value from 6 to 8100 seconds.

The SXBlue GPS will reply with the following response:

$>

8.3.3 $JOFF

This command allows you to turn off all data messages being output through the current or other port, including any binary messages, such as Bin95 and Bin96, etc.

This command has the following definition:

$JOFF[,OTHER]<CR><LF>

When the ',OTHER' data field is specified (without the square brackets), this command will turn on the four NMEA messages on the other port.

There are no variable data fields for this message. The SXBlue GPS will reply with the following response:

$>

8.3.4 $JMASK

This command allows you to change the elevation cutoff mask angle for the GPS engine. Any satellites below this mask angle will be ignored, even if available. The default angle is 10 degrees, as satellites available below this angle will have significant tropospheric refraction errors.

This message has the following format:

$JMASK,e<CR><LF>

Where the elevation mask cutoff angle, 'e', may be a value from 0 to 60 degrees.

The SXBlue GPS will reply with the following response:

$>

8.3.5 $J4STRING

This command allows the GPGGA, GPVTG, GPGSA, and GPZDA messages to all be output with the issue of a single command. The output rate of each message is limited to 1 Hz, however, you may choose the set the baud rate of the current or other port at the same time.

This command has the following definition:

$J4STRING[,r][,OTHER] <CR><LF>

Where ‘r’ may be one of the following baud rates:

Baud Rates
4800
9600

When the ‘,OTHER’ data field is specified (without the square brackets), this command will turn on the four NMEA messages on the other port.

The SXBlue GPS will reply with the following response:

$>

8.4 SBAS Commands

This section details the NMEA messages accepted by the internal SBAS engine of the SXBlue GPS receiver. The following table provides a brief description of the commands supported by the SBAS demodulator for its control and operation.

Table 8-4 SBAS Commands

Message	Description
$JWAASPRN	This message is used to reconfigure the WAAS PRN numbers for use with other Space Based Augmentation Systems (SBAS)
$JGEO	This command is used to poll the WAAS demodulator for information relating to your current location and WAAS satellites
$JRD1	This command is used to poll the SXBlue GPS for SBAS diagnostic information
$JASC,RTCM	This feature allows you to configure the SXBlue GPS to output RTCM data from the WAAS demodulator

The following subsections provide detailed information relating to the use of each command.

Note - Please ensure that you save any changes that you wish to survive beyond the current power-up by using the $JSAVE command and wait for the ‘$> Save Complete’ response.

8.4.1 $JWAASPRN

This command allows you to both poll the GPS engine for the SBAS PRN’s in memory, and change them, if desired.

To poll the receiver for the current SBAS PRN’s, send the following message:

$JWAASPRN<CR><LF>

There are no data fields to specify in this message. The receiver will respond with the following message:

$>JWAASPRN,prn1,prn2

Where 'prn1' indicates the first PRN number and 'prn2' indicates the second PRN number. The PRN numbers for WAAS are 122 and 134. EGNOS is currently using PRN 120 but also has PRN 131.

To change from the current PRN numbers, the following message should be used:

$JWAASPRN[,sv1[,sv2]] <CR><LF>

Where 'sv1' is the PRN number of the first SBAS satellite and 'sv2' is the PRN number of the second SBAS satellite. Either 'sv1' or both 'sv1' and 'sv2' may be specified.

The SXBlue GPS will reply with the following response:

$>

If you wish to return the unit to automatic SBAS tracking, the following command should be sent to the receiver:

$JWAASPRN,,,AUTO <CR><LF>

The SXBlue GPS will reply with the following response:

$>

8.4.2 $JGEO

This message is used to display information related to the current frequency of SBAS, and its location in relation to the SXBlue GPS' antenna.

To query the SXBlue GPS for the currently used SBAS satellite information, use the following query:

$JGEO<CR><LF>

The receiver will respond with the following data message:

$>JGEO,Sent=1575.4200,Used=1575.4200,PRN=prn,Lon=lon,El=ele,Az=az

This message response is summarized in the following table:

Data Field	Description
$>JGEO	Message header.
Sent=1575.4200	Frequency sent to the digital signal processor
Used=1575.4200	Frequency currently used by the digital signal processor
PRN=prn	WAAS satellite PRN number
Lon=-lon	Longitude of the satellite
El=ele	Elevation angle from the SXBlue GPS antenna to the WAAS satellite, referenced to the horizon.
Az=az	Azimuth from the SXBlue GPS antenna to the WAAS satellite, referenced to the horizon.

To monitor this information for dual SBAS satellites, add the ',ALL' variable to the $JGEO message as follows:

$JGEO[,ALL] <CR><LF>

This will result in the following output messages:

$>JGEO,Sent=1575.4200,Used=1575.4200,PRN=122,Lon=-54,El=9.7,Az=114.0

$>JGEO,Sent=1575.4200,Used=1575.4200,PRN=134,Lon=178,El=5.0,Az=252.6

As can be seen from this output, the first message is identical to the output from the $JGEO query, however, the second message provides information on the WAAS satellite not being currently used. Both outputs follow the format in the previous table for the $JGEO query.

8.4.3 $JRD1

This command is used to request diagnostic information from the SXBlue GPS.

To command the SXBlue GPS to output the diagnostic information message for the currently used SBAS satellites at a rate of 1 Hz, use the following query:

$JASC,D1,1[,OTHER]<CR><LF>

The receiver will respond with the following data message:

$>

This message may be turned off by setting the update rate to zero as follows:

$JASC,D1,0<CR><LF>

8.4.4 $JASC,RTCM

This command allows you to configure the SXBlue GPS to output RTCM corrections from SBAS through either SXBlue GPS serial port. The correction data output is RTCM SC-104 even though SBAS uses a different over-the-air protocol (RTCA).

To have the SXBlue GPS output RTCM corrections, send the following command to the receiver:

$JASC,RTCM,r[,OTHER]<CR><LF>

The message status variable 'r' may be one of the following values:

r	Description
0	ON
1	OFF

When the ',OTHER' data field is specified (without the square brackets), this command will turn RTCM data on or off on the other port.

The SXBlue GPS will reply with the following response:

$>

8.5 e-Dif Commands

This section provides information related to the NMEA messages accepted by the SXBlue GPS' optional e-Dif application. The following table provides a brief description of the commands supported by the e-Dif application for its control and operation.

Table 8-5 e-Dif Commands

Message	Description
$RAD,1	This command is used to display the current reference position
$JRAD,1,P	Store present position as reference
$JRAD,1,lat,lon,alt	Store entered position as reference
$RAD,2	Use reference position as base
$JRAD,3	Use current position as base

The following subsections provide detailed information relating to the use of each command.

Note - Please ensure that you save any changes that you wish to survive beyond the current power-up by using the $JSAVE command and wait for the '$> Save Complete' response.

8.5.1 $JRAD,1

This command is used to display the current reference position.

This command has the following format:

$JRAD,1<CR><LF>

The SXBlue GPS will reply with a response similar to the following:

$>JRAD,1,51.00233513,-114.08232345,1050.212

Upon startup of the SXBlue GPS with the e-Dif application running (as opposed to the SBAS application), no reference position will be present in memory. If you attempt to query for the reference position, the SXBlue GPS will respond with the following message:

$>JRAD,1,FAILED,Present Location Not Stable

8.5.2 $JRAD,1,P

This command records the current position as the reference with which to compute e-Dif corrections. This would be used in relative mode, as no absolute point information is specified.

This command has the following format:

$JRAD,1,P<CR><LF>

The SXBlue GPS will reply with the following response:

$>JRAD,1P,OK

8.5.3 $JRAD,1,lat,lon,alt

This command is a derivative of the $JRAD,1,P command and is used when absolute positioning is desired.

This command has the following layout:

$JRAD,1,lat,lon,alt<CR><LF>

Where the data fields in this command are described in the following table.

Data Field	Description
lat	This is the latitude of the reference point in degrees decimal degrees.
lon	This is the longitude of the reference point in degrees decimal degrees.
alt	This is the altitude of the reference point in m.

The SXBlue GPS will reply with the following response:

$>JRAD,lat,lon,alt

Note - Both latitude and longitude must be entered as values with a decimal place. The receiver will not accept the command if there are no decimal places.

8.5.4 $JRAD,2

This command is used to force the receiver to use the new reference point. This command is normally used following a $JRAD,1 type command.

This command has the following format:

$JRAD,2<CR><LF>

The SXBlue GPS will reply with the following response:

$>JRAD,2,OK

8.5.5 $JRAD,3

This command is used for two primary purposes. The first is to invoke the e-Dif function once the unit has started up (with the e-Dif application active). The second purpose is to update the e-Dif solution (calibration) using the current position as opposed to the reference position used by the $JRAD,2 command. This command has the following format:

$JRAD,2<CR><LF>

The receiver will respond with the following command if it has tracked enough satellites for a long enough period before you sent the command. This period of time can be from 3 to 10 minutes long and is used for modeling errors going forward.

$>JRAD,3,OK<CR><LF>

If the e-Dif algorithms do not find that there has been sufficient data collected, the SXBlue GPS will send the following response:

$>JRAD,3,FAILED,Not Enough Stable Satellite Tracks

If you receive the failure message after a few minutes of operation, try again shortly until the 'OK' acknowledgement message is sent. The e-Dif application will begin operating as soon as the $JRAD,3,OK message has been sent, however, you will still need to define a reference position for e-Dif, unless relative positioning is sufficient for your needs.

8.6 Data Messages

(This section is the same as section 5.2 and is repeated here for providing a complete reference of NMEA messages). The following subsections describe the NMEA data messages listed in the Table below in detail.

Table 8-6 Data Messages

Message	Max Rate	Description
GPGGA	5 Hz	Global Positioning System Fix Data
GPGLL	5 Hz	Geographic Position – Latitude/Longitude
GPGSA	1 Hz	GNSS (Global Navigation Satellite System) DOP and Active Satellites
GPGST	1 Hz	GNSS Pseudorange Error Statistics
GPGSV	1 Hz	GNSS Satellites in View
GPRMC	5 Hz	Recommended Minimum Specific GNSS Data
GPRRE	1 Hz	Range residual message
GPVTG	5Hz	Course Over Ground and Ground Speed
GPZDA	5 Hz	Time and Date
RD1	1 Hz	SBAS diagnostic information (proprietary NMEA message)

8.6.1 GGA Data Message

The GGA message contains detailed GPS position information, and is the most frequently used NMEA data message. In the table below, the GGA data message is broken down into its components. This message takes the following form:

$GPGGA,hhmmss.ss,ddmm.mmmm,s,dddmm.mmmm,s,n,qq,pp.p,saaaaa.aa,M,
±xxxx.xx,M,sss,aaaa*cc<CR><LF>

Table 8-7 GGA Data Message Defined

Field	Description
hhmmss.ss	UTC time in hours, minutes, seconds of the GPS position
ddmm.mmmmm	Latitude in degrees, minutes, and decimal minutes
s	s = N or s = S, for North or South latitude
dddmm.mmmmm	Longitude in degrees, minutes, and decimal minutes
s	s =E or s = W, for East or West longitude
n	Quality indicator, 0 = no position, 1 = undifferentially corrected position, 2 = differentially corrected position, 9= position computed using almanac
qq	Number of satellites used in position computation
pp.p	HDOP =0.0 to 9.9
saaaa.aa	Antenna altitude
M	Altitude units, M = meters
±xxxx.xx	Geoidal separation (needs geoidal height option)
M	Geoidal separation units, M = meters
sss	Age of differential corrections in seconds
aaa	Reference station identification
*cc	Checksum
<CR><LF>	Carriage return and line feed

8.6.2 GLL Data Message

The GLL message contains Latitude and Longitude. In the table below, the GLL data message is broken down into its components. This message has the following format:

$GPGLL,ddmm.mmmm,s,dddmm.mmmm,s,hhmmss.ss,s*cc<CR><LF>

Table 8-8 GLL Data Message Defined

Field	Description
ddmm.mmmmm	Latitude in degrees, minutes, and decimal minutes
s	s = N or s = S, for North or South latitude
dddmm.mmmmm	Longitude in degrees, minutes, and decimal minutes
s	s = E or s = W, for East or West longitude
hhmmss.ss	UTC time in hours, minutes, and seconds of GPS position
s	Status, s = A = valid, s = V = invalid
*cc	Checksum
<CR><LF>	Carriage return and line feed

8.6.3 GSA Data Message

The GSA message contains GPS DOP and active satellite information. Only satellites used in the position computation are present in this message. Null fields are present when data is unavailable due to the number of satellites tracked. The table below breaks down the GSA message into its components. This message has the following format:

$GPGSA,a,b,cc,dd,ee,ff,gg,hh,ii,jj,kk,mm,nn,oo,p.p,q.q,r.r *cc<CR><LF>

Table 8-9 GSA Data Message Defined

Field	Description
a	Satellite acquisition mode M = manually forced to 2D or 3D, A = automatic swap between 2D and 3D
b	Position mode, 1 = fix not available, 2 = 2D fix, 3 = 3D fix
cc to oo	Satellites used in the position solution, a null field occurs if a channel is unused
p.p	Position Dilution of Precision (PDOP) = 1.0 to 9.9
q.q	Horizontal Dilution of Precision (HDOP) = 1.0 to 9.9
r.r	Vertical Dilution of Precision (VDOP) = 1.0 to 9.9
*cc	Checksum
<CR><LF>	Carriage return and line feed

8.6.4 GST Data Message

The GST message contains Global Navigation Satellite System (GNSS) pseudorange error statistics. The table below breaks down the GST message into its components. This message has the following format:

$GPGST,hhmmss.ss,a.a,b.b,c.c,d.d,e.e,f.f,g.g *cc<CR><LF>

Table 8-10 GST Data Message Defined

Field	Description
hhmmss.ss	UTC time in hours, minutes, seconds of the GPS position
a.a	Root mean square (rms) value of the standard deviation of the range inputs to the navigation process. Range inputs include pseudoranges and differential GNSS (DGNSS) corrections
b.b	Standard deviation of semi-major axis of error ellipse (meters)
c.c	Standard deviation of semi-minor axis of error ellipse (meters)
d.d	Orientation of semi-major axis of error ellipse (degrees)
e.e	Standard deviation of latitude error (meters)
f.f	Standard deviation of longitude error (meters)
g.g	Standard deviation of altitude error (meters)
*cc	Checksum
<CR><LF>	Carriage return and line feed

8.6.5 GSV Data Message

The GSV message contains GPS satellite information. Null fields occur where data is not available due to the number of satellites tracked. The Table below breaks down the GSV data message into its components. This message has the following format:

$GPGSV,t,m,n,ii,ee,aaa,ss,…ii,ee,aaa,ss,*cc<CR><LF>

Table 8-11 GSV Data Message Defined

Field	Description
t	Total number of messages
m	Message number, m = 1 to 3
n	Total number of satellites in view
ii	Satellite number
ee	Elevation in degrees, ee = 0 to 90
aaa	Azimuth (true) in degrees, aaa = 0 to 359
ss	SNR (dB) + 30, ss = 0 to 99
*cc	Checksum
<CR><LF>	Carriage return and line feed

8.6.6 RMC Data Message

The RMC message contains recommended minimum specific GPS data. The table below breaks down the RMC data message into its components. This message has the following format:

$GPRMC,hhmmss.ss,a,ddmm.mmm,n,dddmm.mmm,w,z.z,y.y,ddmmyy,d.d,v *cc<CR><LF>

Table 8-12 RMC Data Message Defined

Field	Description
hhmmss.ss	UTC time in hours, minutes, seconds of the GPS position
a	Status is valid if a = A, status is invalid if a = V
ddmm.mmmmm	Latitude in degrees, minutes, and decimal minutes
n	S = N or s = S, for North or South latitude
dddmm.mmmmm	Longitude in degrees, minutes, and decimal minutes
w	S = E or s = W, for East or West longitude
z.z	Ground speed in knots
y.y	Track made good, referenced to true north
ddmmyy	UTC date of position fix in day, month, year
d.d	Magnetic Variation in degrees
v	Variation sense v = E = East, v = W = West
*cc	Checksum
<CR><LF>	Carriage return and line feed

8.6.7 RRE Data Message

The RRE message contains the satellite range residuals and estimated position error. The table below breaks down the RRE data message into its components. This message has the following format:

$GPRRE,n,ii,rr…ii,rr,hhh.h,vvv.v *cc<CR><LF>

Table 8-13 RRE Data Message Defined

Field	Description
n	Number of satellites used in position computation
ii	Satellite number
rr	Range residual in meters
hhh.h	Horizontal position error estimate in meters
vvv.v	Vertical position error estimate in meters
*cc	Checksum
<CR><LF>	Carriage return and line feed

8.6.8 VTG Data Message

The VTG message contains velocity and course information. The table below breaks down the VTG data message into its components. This message has the following format:

$GPVTG,ttt,c,ttt,c,ggg.gg,u,ggg,gg,u*cc<CR><LF>

Table 8-14 VTG Data Message Defined

Field	Description
ttt	True course over ground, ttt = 000 to 359, in degrees
c	True course over ground indicator, c = T always
ttt	Magnetic course over ground, ttt = 000 to 359, in degrees
c	Magnetic course over ground Indicator, always c = M
ggg.gg	Speed over ground, 000 to 999 knots
u	Speed over ground units, u = N = Nautical mile/h
ggg.gg	Speed over ground, 000 to 999 km/h
u	Speed over ground units, u = K = kilometer/h
*cc	Checksum
<CR><LF>	Carriage return and line feed

8.6.9 ZDA Data Message

The ZDA message contains Universal Time information. The table below breaks down the ZDA data message into its components. This message has the following format:

$GPZDA,hhmmss.ss,dd,mm,yyyy,xx,yy*cc<CR><LF>

Table 8-15 ZDA Data Message Defined

Field	Description
hhmmss.ss	UTC time in hours, minutes, seconds of the GPS position
dd	Day, dd = 0 to 31
mm	Month, mm = 1 to 12
yyyy	Year
xx	Local zone description in hours, xx = -13 to 13
yy	Local zone description in minutes, yy = 0 to 59
*cc	Checksum
<CR><LF>	Carriage return and line feed

8.6.10 RD1 Data Message

The RD1 message contains diagnostic information for SBAS operation. The table below breaks down the RD1 data message into its components. This message has the following format:

$RD1,SecOfWeek,WeekNum,FreqMHz,DSPLocked,BER-BER2,AGC,
DDS,Doppler,DSPStat,ARMStat,DiffStatus,NavCondition *cc<CR><LF>

Table 8-16 RD1 Data Message Defined

Field	Description
SecOfWeek	The second of GPS week (may be a couple of seconds old)
WeekNum	The GPS week number
FreqMHz	The L-band frequency in MHz (1475.4200 is used for SBAS)
DSPLocked	1 if DSPStat = 1B or 1F
BER-BER2	Bit error rate – bit error rates are given for both SBAS satellites being tracked
AGC	L-band Signal strength
DDS	0.0 for SBAS
Doppler	0 for SBAS
DSPStat	A status bit mask for the DSP tracking of SBAS
ARMStat	A status bit mask for the ARM GPS solution
DiffStatus	The SBAS PRN of the satellite in use
NavCondition	A series of hex character fields, which is read from right to left, with each field representing the number of GPS satellites satisfying a certain condition, all of which conditions are required if the satellite is to be used in the solution
*cc	Checksum
<CR><LF>	Carriage return and line feed

The following table describes the DSP status. The DSP status should be 17, 1B, or 1F when SBAS tracking has been achieved.

Table 8-17 DSP Status

Field	Description
01	Carrier lock
02	BER is ok on at least one SBAS satellite
04	Frame synchronization has been achieved on the second satellite
08	Frame synchronization has been achieved on the first satellite
10	Carrier lock

The following table describes the ARM status.

Table 8-18 ARM Status

Field	Description
01	GPS lock
02	DGPS valid data
04	The ARM processor has lock
08	DGPS solution
10	DGPS solution is good
20	Not used
40	Not used

An example of the NavCondition is presented in the following table for the 179889A value.

Table 8-19 NavCondition

Field	Description
A	The number of satellites with lock and carrier phase
9	The number of satellites with ephemeris received
8	The number of satellites with healthy ephemeris
8	The number of satellites that are tracked, have an ephemeris, which is healthy, and are above the elevation mask
9	The number of satellites above the elevation mask
7	The number of satellites with differential
1	The number of satellites with no differential

9. Binary Data

The SXBlue GPS supports a selection of binary data messages that provide improved communication port efficiency.

9.1 Binary Message Structure

The Binary messages supported by the SXBlue GPS are in an Intel Little Endian format for direct read in a PC environment. You can find more information on this format at the following Web site.

www.cs.umass.edu/~verts/cs32/endian.html

Each binary message begins with an 8-byte header and ends with a carriage return line-feed pair (0x0D, 0x0A). The first four characters of the header is the ASCII sequence $BIN.

The following table provides the general binary message structure.

Table 9-1 Binary Message Structure

Group	Components	Type	Bytes	Value
Header	Synchronization String	4 byte string	4	$BIN
	BlockID – a number which tells the type of binary message	Unsigned short	2	1, 2, 80, 93, 94, 95, 96, 97, 98, or 99
	DataLength – the length of the binary messages	Unsigned short	2	52, 16, 40, 56, 96, 128, 300, 28, 68, or 304
Data	Data Binary Data – varying fields of data with a total length of DataLength bytes	Mixed fields	Varies – see message tables	52, 16, 40, 56, 96, 128, 300, 28, 68, or 304
Epilogue	Checksum – sum of all bytes of the data (all DataLength bytes). The sum is placed in a 2-byte Integer	Unsigned Short	2	Sum of data bytes
	CR – Carriage return	Byte	1	0D hex
	LF – Line feed	Byte	1	0A hex

The total length of the binary message packet is DataLength plus 12 (8 byte header, 2 byte checksum, and 2 bytes for CR, LF).

9.1.1 Bin 1

This message has a BlockID of 1 and is 52 bytes excluding the header and epilogue. It consists of GPS position and velocity data. It is the only binary message that can be output at a rate of 5 Hz. The following table describes the content of this message.

Table 9-2 Bin 1 Message

Group	Components	Type	Bytes	Value
AgeOfDiff	Age of differential, seconds. Use Extended AgeOfDiff first. If both = 0 then no differential	Byte	1	0 to 255
NumOfSats	Number of satellites used in the GPS solution	Byte	1	0 to 12
GPSWeek	GPS week associated with this message	Unsigned Short	2	0 to 65536
GPSTimeOfWeek	GPS tow (sec) associated with this message	Double	8	0.0 to 604800.0
Latitude	Latitude in degrees North	Double	8	-90.0 to 90.0
Longitude	Longitude in degrees East	Double	8	-180.0 to 180.0
Height	Altitude above the ellipsoid in meters	Float	4	
VNorth	Velocity north in m/s	Float	4	
VEast	Velocity East in n/s	Float	4	
VUp	Velocity up in m/s	Float	4	Positive
NavMode	Navigation mode: 0 = No fix 1 = 2D no diff 2 = 3D no diff 3 = 2D with diff 4, 5, or 6 = 3D with diff If bit 7 is set (left-most bit), then this is a manual mark position	Unsigned short	2	Bits 0 through 6 = Navmode Bit 7 = Manual mark
Extended	Extended age of differential, seconds. If 0, use 1 byte AgeOfDiff listed above	Unsigned short	2	0 to 65536

9.1.2 Bin 2

This message has a BlockID of 2 and is 16 bytes excluding the header and epilogue. This message contains various quantities that are related to the GPS solution. The following table describes the details of this message in order.

Table 9-3 Bin 2 Message

Group	Components	Type	Bytes	Value
MaskSatsTracked	A mask of satellites tracked by the GPS. Bit 0 corresponds to the GPS satellite with PRN 1.	Unsigned long	4	Individual bits represent satellites
MaskSatsUsed	A mask of satellites used in the GPS solution. Bit 0 corresponds to the GPS satellite with PRN 1.	Unsigned long	4	Individual bits represent satellites
GPSUtcDiff	Whole seconds between UTC and GPS time (GPS minus UTC)	Unsigned short	2	Positive
HDOPTimes10	Horizontal Dilution of precision scaled by 10 (0.1 units)	Unsigned short	2	Positive
VDOPTimes10	Vertical Dilution of precision scaled by 10 (0.1 units)	Unsigned short	2	Positive
WAAS PRN Bitmask	PRN and tracked or used status masks	Unsigned short	2	See below

WAAS PRN bit mask:

- Bit 00 Mask of satellites tracked by first WAAS satellite
- Bit 01 Mask of satellites tracked by second WAAS satellite
- Bit 02 Mask of satellites used by first WAAS satellite
- Bit 03 Mask of satellites used by second WAAS satellite
- Bit 04 Unused
- Bit 05-09 Value used to find PRN of first WAAS satellite (This value +120 = PRN)
- Bit 10-14 Value used to find PRN of second WAAS satellite (This value + 120 = PRN)
- Bit 15 Unused

9.1.3 Bin 80

This message has a BlockID of 80 and is 40 bytes excluding the header and epilogue. This message contains the WAAS message. The following table describes the constituents of this message in order.

Table 9-4 Bin 80 Message

Group	Components	Type	Bytes	Value
PRN	Broadcast PRN	Unsigned short	2	
Spare	Not used at this time	Unsigned short	2	Future use
MsgSecOfWeek	Seconds of week for message	Unsigned long	4	
WaasMsg[8]	250 bit WAAS message (RTCA DO-229). 8 unsigned longs with most significant bit received first	Unsigned long	4 x 8 = 32	

9.1.4 Bin 93

This message has a BlockID of 93 and is 45 bytes excluding the header and epilogue. This message contains information relating to the WAAS ephemeris. The following table describes the contents of this message in order.

Table 9-5 Bin 93 Message

Group	Components	Type	Bytes	Value
SV	Satellite to which this data belongs	Unsigned short	2	
Spare	Not used at this time	Unsigned short	2	Future use
TOWSecOfWeek	Time at which this arrived (LSB = 1 sec)	Unsigned long	4	
IODE		Unsigned short	2	
URA	Consult the ICD-GPS-200 for definition in Appendix D – Resources	Unsigned short	2	
T0	Bit 0 = 1 sec	Long	4	
XG	Bit 0 = 0.08 m	Long	4	
YG	Bit 0 = 0.08 m	Long	4	
ZG	Bit 0 = 0.4 m	Long	4	

XGDot	Bit 0 = 0.000625 m/s	Long	4	
YXDot	Bit 0 = 0.000625 m/s	Long	4	
ZGDot	Bit 0 = 0.004 m/s	Long	4	
XGDotDot	Bit 0 = 0.0000125 m/s2	Long	4	
YGDotDot	Bit 0 = 0.0000125 m/s2	Long	4	
ZGDotDot	Bit 0 = 0.0000625 m/s2	Long	4	
Gf0	Bit 0 = 2**-31 s	Unsigned short	2	
Gf0Dot	Bit0 = 2**-40 s/s	Unsigned short	2	

9.1.5 Bin 94

This message has a BlockID of 94 and is 96 bytes excluding the header and epilogue. This message contains ionospheric and UTC conversion parameters. The following table describes the details of this message in order.

Table 9-6 Bin 94 Message

Group	Components	Type	Bytes	Value
a0,a1,a2,a3	AFCRL alpha parameters	Double	8 x 4 = 32	
b0,b1,b2,b3	AFCRL beta parameters	Double	8 x 4 = 32	
A0,A1	Coefficients for determining UTC time	Double	8 x 2 = 16	
tot	Reference time for A0 and A1, second of GPS week	Unsigned long	4	
wnt	Current UTC reference week	Unsigned short	2	
wnlsf	Week number when dtlsf becomes effective	Unsigned short	2	
dn	Day of week (1-7) when dtlsf becomes effective	Unsigned short	2	
dtls	Cumulative past leap	Short	2	
dtlsf	Scheduled future leap	Short	2	
Spare	Not used at this time	Unsigned short	2	Future use

9.1.6 Bin 95

This message has a BlockID of 95 and is 128 bits excluding the header and epilogue. This message contains ephemeris data of all 12 channels. The following table describes the contents of this message in order.

Table 9-7 Bin 95 Message

Group	Components	Type	Bytes	Value
SV	The satellite to which this data belongs	Unsigned short	2	
Spare1	Not used at this time	Unsigned short	2	Future use
SecOfWeek	Time at which this arrived (LSB = 6)	Unsigned long	4	
SF1words[10]	Unparsed SF 1 message	Unsigned long	4 x 10 = 40	
SF2words[10]	Unparsed SF 2 message	Unsigned long	4 x 10 = 40	
SF3words[10]	Unparsed SF 3 message	Unsigned long	4 x 10 = 40	

9.1.7 Bin 96

This message has a BlockID of 96 and is 300 bytes excluding the header and epilogue. This message contains phase and code data. The following table describes the constituents of this message in order.

Table 9-8 Bin 96 Message

Group	Components	Type	Bytes	Value
Spare1	Not used at this time	Unsigned short	2	Future use
Week	GPS week number	Unsigned short	2	
TOW	Predicted GPS time in seconds	Double	8	
UICS_TT_SNR_PRN[12]	See below	Unsigned long	4 x 12 = 48	
UIDoppler_FL[12]	See below	Unsigned long	4 x 12 = 48	
PseudoRange[12]	Pseudoranges	Double	8 x 12 = 96	
Phase[12]	Phase (m) L1 wave = 0.190293672798365m	Double	8 x 12 = 96	

Where:

UICS_TT_SNR_PRN

- Bits 0-7: PRN (PRN is 0 if no data)
- Bits 8-15: SNR value (SNR= 10.0 * $\log_{10}$ * (0.8192 * SNR value))
- Bits 16-23: Phase Track Time in units of 1/10 second, range = 0 to 25.5 seconds (see next word)
- Bits 24-31: Cycle Slip Counter (Increments by 1 every cycle slip with natural rollover after 255)

UIDoppler_FL

- Bit 0: 1 if Valid Phase, 0 otherwise
- Bit 1: 1 if Track Time > 25.5 seconds, 0 otherwise
- Bits 2-3: Unused
- Bits 4-31: Signed (two's compliment) Doppler in units of m/sec x 4096. (i.e. LSB=1/4096), range = +/- 32768 m/sec. Computed as phase change over 1/10 sec.

9.1.8 Bin 97

This message has a BlockID of 97 and is 28 bytes excluding the header and epilogue. This message contains statistics for processor utilization. The following table describes the details of this message in order.

Table 9-9 Bin 97 Message

Group	Components	Type	Bytes	Value
CPUFactor	CPU utilization factor. Multiply by 450e-06 to get percentage of spare CPU that is available	Unsigned long	4	Positive
MissedSubFrame	The total number of missed sub frames in the navigation message since power on	Unsigned short	2	Positive
MaxSubFramePnd	Max sub frames queued	Unsigned short	2	Positive
MissedAccum	The total number of missed code accumulation measurements in the channeltracking loop	Unsigned short	2	Positive
MissedMeas	The total number of missed pseudorange measurements	Unsigned short	2	Positive
Spare 1 Spare 2 Spare 3	Not used at this time Not used at this time Not used at this time	All Unsigned long	4 4 4	Future use Future use Future use
Spare 4 Spare 5	Not used at this time Not used at this time	All Unsigned short	2 2	Future use Future use

9.1.9 Bin 98

This message has a BlockID of 98 and is 68 bytes excluding the header and epilogue. This message contains data derived from the satellite almanacs. The following table describes the contents of this message in order.

Table 9-10 Bin 98 Message

Group	Components	Type	Bytes	Value
AlmanData	Almanac-derived-data, 8 satellites at a time	Structure array	8 x 8 =64	See the following table
LastAlman	Last almanac processed	Byte	1	0 to 31
IonoUTCVFlag	Flag that is set when ionosphere modeling data is extracted from the GPS sub frame 4	Byte	1	0 = not logged 2 = valid
Spare	Not used at this time	Unsigned short	2	Future use

AlmanData Structure Array

Group	Components	Type	Bytes	Value
DoppHz	Predicted Doppler in Hz for the satellite in question (assuming a stationary satellite).	Short	2	
CountUpdate	Number of times the almanac has changed for this satellite since the receiver was turned on	Byte	1	Positive
Svindex	Channel number (groups of 8)	Byte	1	0 to 7 8 to 15 16 to 23 24 to 31
AlmVFlag	Almanac valid flag	Byte	1	0 = not logged 1 = invalid 2 = valid 3 = has data (not yet validated)
AlmHealth	Almanac health from sub frame 4 of the GPS message	Byte	1	See ICD-GPS-200
Elev	Elevation angle in degrees	Char	1	-90 to 90
Azimuth	½ the azimuth in degrees	Byte	1	0 to 180 represents 360 degrees

9.1.10 Bin 99

This message has a BlockID of 99 and is 304 bytes excluding the header and epilogue. This message contains quantities related to the tracking of the individual GPS satellites along with some other relevant data. The following table describes the constituents of this message in order.

Table 9-11 Bin 99 Message

Group	Components	Type	Bytes	Value
NavMode2	Navigation mode data (lower 3 bits hold the GPS mode, upper bit set if differential is available).	Byte	1	Lower 3 bits take on the values 0 = time not valid 1 = no fix 2 = 2D fix 3 = 3D fix Upper bit (bit 7) is 1 if differential is Available
UTCTimeDiff	Whole seconds between UTC and GPS time (GPS minus UTC)	Byte	1	Positive
GPSWeek	GPS week associated with this message	Unsigned short	2	0 to 65536
GPSTimeOfWeek	GPS tow (sec) associated with this message	Double	8	0.0 to 604800.0
ChannelData	12 structures (see below) containing tracking data for each of the 12 receiver channels	Structure array	12x24 =288	See following table
ClockErrAtL1	The clock error of the GPS clock oscillator at L1 frequency in Hz	Short	2	-32768 to 32768
Spare	Not used at this time	Unsigned short	2	Future use

ChannelData Array

Group	Components	Type	Bytes	Value
Channel	Channel number	Byte	1	0 to 12
SV	Satellite being tracked, 0 == not tracked	Byte	1	0 to 32
Status	Status bit mask (code carrier bit frame)	Byte	1	Bit 0 = code lock 1 = carrier lock 2 = bit lock 3 = frame sync 4 = frame sync and new epoch 5 = channel reset 6 = phase lock 7 = spare

LastSubFrame	Last sub frame processed in the GPS message	Byte	1	1 to 5
EphmVFlag	Ephemeris valid flag	Byte	1	0 = not logged 1 = invalid 2 = valid 3 = has data (not yet validated)
EphmHealth	Satellite health from sub frame 1 of the GPS message	Byte	1	See ICD-GPS-200
AlmVFlag	Almanac valid flag	Byte	1	0 = not logged 1 = invalid 2 = valid 3 = has data (not yet validated)
AlmHealth	Almanac health from sub frame 4 of the GPS message	Byte	1	See ICD-GPS-200
Elev	Elevation angle in degrees	Char	1	-90 to 90
Azimuth	½ the azimuth in degrees	Byte	1	0 to 180 represents 0 to 360 degrees
URA	User range error from sub frame 1 of the GPS message	Byte	1	See ICD-GPS-200
Spare	Not used at this time	Byte	1	Future use
CliForSNR	Code lock indicator for SNR. SNR = 10.0 * 4096 CliForSNR/ Nose_floor) where Nose_floor = 80000.0	Unsigned short	2	Positive
DiffCorr	100 times the differential correction for this channel's pseudorange	Short	2	
PosResid	10 times the position residual from the GPS solution for this channel	Short	2	
VelResid	10 times the velocity residual from the GPS solution for this channel	Short	2	
DoppHZ	Expected Doppler for this channel in Hz	Short	2	
NCOHz	Carrier track offset for this channel in Hz	Short	2	

Appendix A - Specifications

This appendix provides the operational, mechanical, electrical, physical, and environmental specifications of the SXBlue GPS receiver.

Table A-1 SXBlue GPS Receiver Specifications

Internal GPS Engine Operational Specifications	
Item	**Specification**
Frequency	1.575 GHz
Channels	12 parallel tracking
Horizontal accuracy	< 1 m 95%
Max Position update rate	Up to 5 Hz

Serial Interface Specifications (standard cable)	
Item	**Specification**
Serial port interface level	RS-232C
Data Port	3-pin Socket
Data Port available baud rates	4800, 9600, 19200 and 38400 Baud
Output protocol	NMEA 0183, proprietary binary
Input protocol	NMEA 0183
External correction input protocol	RTCM SC-104

Power Specifications	
Item	**Specification**
Input voltages (depends on model)	4.5 to 9, 9 to 18 or 18 to 36 VDC
Power consumption	<3 W Nominal

Mechanical Characteristics	
Item	**Specification**
Enclosure	Powder coated aluminum enclosure
Length	11.26 cm (4.43") excluding connectors
Width	8.54 cm (3.36")
Height	3.53 cm (1.39")
Weight	268 g (.6 lb)

Environmental Specifications	
Item	**Specification**
Storage temperature	-40°C to 85°C
Operating temperature	-40°C to 70°C
Humidity	95% Non-Condensing

Appendix B – Interface

This appendix provides information on interfacing the main aspects of your SXBlue GPS.

The main purpose of the SXBlue GPS is to provide differentially corrected position and related information to a data logging or navigation device in the standard NMEA format. In addition to the SXBlue GPS operating as a positioning sensor, you may also have a use for the correction data received by the internal SBAS demodulator.

The following sections detail how to interface your SXBlue GPS depending on your application.

GPS NMEA Output

When operating the SXBlue GPS as a differential positioning tool, the data output from either SXBlue GPS communication port (Serial or Bluetooth) is NMEA data that provides a variety of information, such as position, speed, satellites tracked, and more. This is the normal data output and mode of operating the SXBlue GPS.

To establish communications between the SXBlue GPS receiver and your data logging or navigation device in this mode of operation, you must:

- Connect Pin-2 - transmit (TX) of the supplied SXBlue GPS Serial cable to the receive pin (RX) of the data logging or navigation device.
- Connect Pin-3 - receive (RX) of the SXBlue GPS Serial cable to transmit pin (TX) of the other device if it is able to configure the SXBlue GPS. Otherwise, this connection is optional.
- Connect Pin-5 - signal ground of the SXBlue GPS Serial Port to the signal return or ground of the external device.

Figure B-1 illustrates the required interface between the SXBlue GPS and an external device using the serial cable:

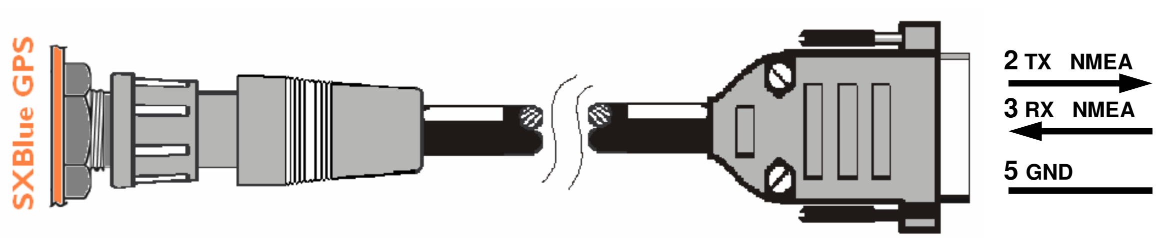

Figure B-1 Serial Interface

Note - For successful communications, the baud rate of the SXBlue GPS port must be set to match that of the data logging or monitoring device. The SXBlue GPS only supports an RS-232C serial port. Refer to the chapter 8 for instructions related to setting the SXBlue GPS baud rate.

RTCM Data Output

To output only RTCM correction data from the internal SBAS correction source from the Serial or Bluetooth ports of the SXBlue GPS, use the following procedure:

- Turn off all NMEA and binary messages using the $JOFF<CR><LF> command
- Turn RTCM on using the $JRTCM,1<CR><LF> command

To establish communications between the SXBlue GPS and an external GPS receiver, you must:

- Connect Pin-2-transmit (TX) of the serial cable to the receive pin (RX) of the separate GPS receiver or logging device.
- Connect Pin-5-Common Ground of the serial cable to the signal return or common ground of the separate GPS receiver.

Figure B-2 illustrates the required interface between the SXBlue GPS and device that receives position information:

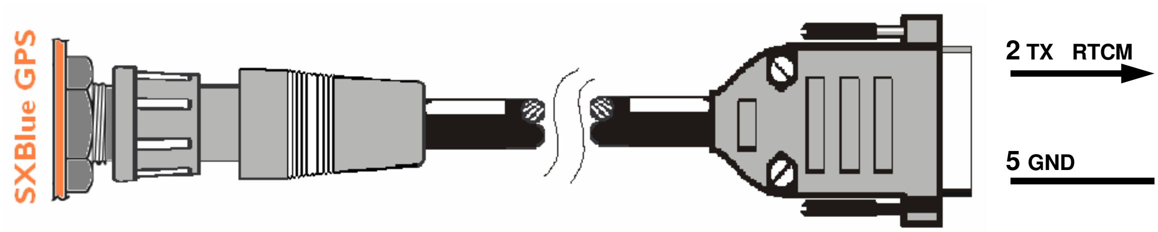

Figure B-2 RTCM Data Output From Serial Port

Note - For successful communications, the baud rate of the SXBlue GPS Serial port must be set to match that of the separate GPS receiver. Additionally, you must interface the SXBlue GPS to an RS-232C serial port of the separate GPS receiver. Refer to chapter 8 for instructions related to setting the SXBlue GPS baud rate.

External Correction Input

In this operating mode, an external correction device inputs RTCM correction data through the Serial port. In order to accomplish this, the SXBlue GPS must be commanded to use external corrections using the $JDIFF command.

To configure external correction input on the Serial port you must:

- Communicate with the SXBlue GPS on the Serial Port. Ensure that the baud rate of the Serial Port and the external correction source match by issuing the appropriate $JBAUD command.
- Issue a $JDIFF,THIS<CR><LF> command through the Serial port.

To establish communications between the SXBlue GPS and an external GPS receiver, you must:

- Connect Pin-3-receive (RX) of the serial cable to transmit pin (TX) of the external correction source
- Connect Pin-5-Common Ground of the serial cable to the signal return or common ground of the external correction source

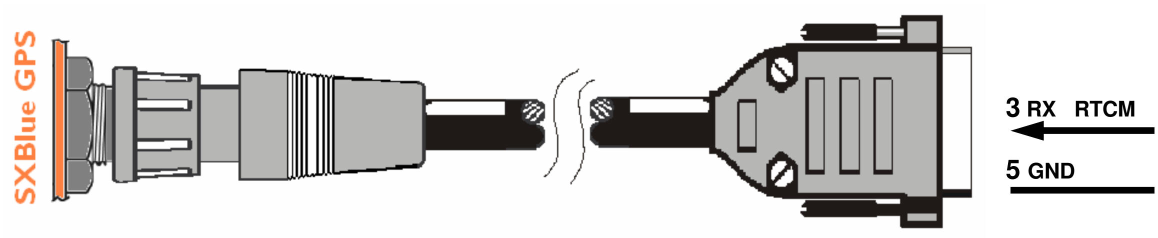

Figure B-3 RTCM Data Input to Serial Port

Note - For successful communications, the baud rate of the SXBlue GPS differential port must be set to match that of the external correction source. The correction source must support an RS-232 interface level and the baud rates between each device must match.

Appendix C – Introduction to GPS, SBAS and Beacon

This chapter provides a brief overview of GPS, differential GPS, Space Based Augmentation Systems (SBAS) such as WAAS / EGNOS / MSAS / GAGAN and radiobeacon.

GPS

The United States Department of Defense (DoD) operates a reliable, 24 hour a day, all weather Global Positioning System (GPS).

Navstar, the original name given to this geographic positioning and navigation tool, includes a constellation of 24 satellites (plus active spares) orbiting the Earth at an altitude of approximately 22,000 km.

How it Works

These satellites transmit coded information to GPS users at UHF (1.575 GHz) frequencies that allows user equipment to calculate a range to each satellite. GPS is essentially a timing system - ranges are calculated by timing how long it takes for the coded GPS signal to reach the user's GPS antenna.

To calculate a geographic position, the GPS receiver uses a complex algorithm incorporating satellite coordinates and ranges to each satellite. Reception of any four or more of these signals allows a GPS receiver to compute 3D coordinates. Tracking of only three satellites reduces the position fix to 2D coordinates (horizontal with fixed vertical).

The GPS receiver calculates its position with respect to the phase center of the GPS antenna. The latitude, longitude, and altitude of the antenna are referenced according to the World Geodetic System 1984 ellipsoid (WGS-84).

GPS Services

The positioning accuracy offered by GPS varies depending upon the type of service and equipment available. For security reasons, two GPS services exist: the Standard Positioning Service (SPS) and the Precise Positioning Service (PPS). The SPS uses a code modulated onto the signal for measurements and is referred to as the Coarse Acquisition code (C/A code). The US Department of Defense (DoD) reserves the PPS for use by its personnel and authorized partners. The PPS uses a different code than the SPS, referred to as the Precise Code (P-code) and contains more resolution than the C/A code. The DoD provides the SPS free of charge, worldwide, to all civilian users.

In order to maintain a strategic advantage, the US DoD used to artificially degrade the performance of the SPS so that the positioning accuracy was limited to 100 meters 95% of the time. This intentional degradation is called Selective Availability (SA). The effect of SA has been turned to zero since mid-2000, however, it has not been officially ‘turned off’.

Currently, autonomous GPS is able to provide accuracy on the order of 10 meters, depending on the sophistication of the GPS engine. For many positioning and navigation applications, this level of accuracy is not sufficient, and differential techniques must be employed.

Differential GPS

The primary sources of errors that degrade GPS performance include SA (currently set to a zero effect), atmospheric errors, timing errors, satellite orbit errors, and multipath. Differential GPS (DGPS) is essentially a differencing process that removes sources of error from the GPS position solution and improves the integrity of the GPS position solution. There are a number of methods of differential measurement correction:

- Conventional real-time differential – This is the most common form of correcting GPS errors in real-time with corrections sent to the rover GPS receiver by some form of communications equipment. Conventional real-time differential uses C/A code range measurements and their associated corrections. Carrier phase corrections are not used with this form of differential technique.
- Post processing – This method is often used when either higher accuracy than achievable through conventional differential is needed, or a conventional form of real-time corrections is not available in the region where the rover receiver is being operated. Depending on receiver hardware and the methodology used for post process, performance can be from many centimeters to millimeter precision. A variety of 3rd party software packages are available to post process GPS raw measurement data. The SXBlue GPS can be configured to output raw measurement data at rates of up to 5 Hz in a proprietary format. This data can be converted to an industry standard RINEX format if needed.
- Real-Time Kinematic – This method uses more sophisticated techniques to resolve the number of wavelengths between the satellite and the user, to provide centimeter-level positioning (or better) in real-time. This technique uses high-end receiver hardware, antennas, and internal operating software to compute accurate position solutions. The compromise with this method of differential correction is increased system complexity, cost, and operating constraints.

The SXBlue GPS includes a primary source of conventional real-time corrections – Space-Based Augmentation System (SBAS). External corrections may also be input to the SXBlue GPS for situations where either internal correction services is not available or an external source is preferential.

In addition to the conventional differential positioning with internal sources of corrections, the SXBlue GPS also has a documented binary raw measurement protocol. A RINEX translator is available from Geneq in the event that this may be useful, in addition to some C code snippets to aid in integrating the binary format itself into your own application.

For heading determination, the SXBlue GPS uses a moving base station RTK solution. This allows for a very precise computation of heading regardless of whether or not the receiver is in differential mode using either internal source of corrections or those from an external source.

Conventional Real-Time Differential

The majority of GPS navigation and positioning uses this form of positioning. Conventional real-time differential techniques are more robust in their usage and versatility than post processing or RTK solutions. They are tolerant to errors in communication of the real-time corrections from the base station or correction network, provide a reasonable amount of accuracy (sub-meter accuracy is best-case), and can be simply turned on and used without too much regard other than ensuring a lock to GPS satellite signals and the correction communication link.

How it Works

Conventional DGPS involves setting up a reference GPS receiver at a point of known coordinates. This receiver makes distance measurements, in real-time, to each of the GPS satellites. The measured ranges include the errors present in the system. The base station receiver calculates what the true range, without errors, knowing its coordinates and those of each satellite. The difference between the known and measured range for each satellite is the range error. This error is the amount that needs to be removed from each satellite distance measurement in order to correct for errors present in the system.

The base station transmits the range error corrections to remote receivers in real-time. The remote receiver corrects its satellite range measurements using these differential corrections, yielding a much more accurate position. This is the predominant DGPS strategy used for a majority of real-time applications. Positioning using corrections generated by DGPS radiobeacons will provide a horizontal accuracy of 1 to 5 meters with a 95% confidence. More sophisticated, short-range DGPS systems (10 to 15 km) can achieve centimeter-level accuracy, but are expensive and often limited to precise survey applications due to technical constraints on their use.

DGPS Format

For manufacturers of GPS equipment, commonality is essential to maximize the utility and compatibility of a product. The governing standard associated with GPS is the Interface Control Document, ICD-GPS-200, maintained by the US DoD. This document provides the message and signal structure information required to access GPS.

Like GPS, DGPS data and broadcast standards exist to ensure compatibility between DGPS services and associated hardware and software. The Radio Technical Commission for Maritime Services Special Committee 104 has developed the primary DGPS standard associated with conventional DGPS, designated RTCM SC-104 V2.2. This correction standard is used by many correction services, including many private reference stations and DGPS beacon systems. The SXBlue GPS supports this correction protocol via either of its two serial ports.

In addition to the RTCM standard, the Radio Technical Commission for Aeronautics has a differential service intended for wide area correction services, designated RTCM SC-159. The United States Federal Aviation Administration's Wide Area Augmentation System (WAAS) and other compatible Space Based Augmentation Systems (SBAS) such as the European Geostationary Navigation Overlay System (EGNOS) and the

Japanese MT-SAT Satellite-based Augmentation System (MSAS) use this data format. The SXBlue GPS receiver is compatible with each of these differential services.

Note – When using a differential correction service, the resultant position may be referenced to a local datum rather than the WGS-84 ellipsoid. Please refer to your signal provider for more information.

Post Processing

Post processing is a method to compute accurate positions in post mission by logging raw measurement data at the base station and the rover simultaneously. The differential processing can then be performed later in the office using sophisticated processing software tools. There are a small variety of methodologies available to the operator, such as static, rapid static, kinematic, etc.

Describing in detail the various post processing techniques is beyond the scope of this document, however, generally, post processing is more complicated from a procedural perspective and requires more skill to successfully operate than real-time systems.

Factors Affecting DGPS Accuracy

Many factors affect the positioning accuracy that a user may expect from a DGPS system. The most significant of these influences include:

- Proximity of the remote user to the reference station (atmospheric and orbit errors)
- Age of the received differential corrections
- Atmospheric conditions at the beacon and remote user locations
- Satellite constellation geometry, often expressed as a Dilution of Precision (DOP)
- Magnitude of GPS signal multipath present at the remote station
- Quality of the GPS receiver being used at both the reference and remote stations

Proximity of the Reference Station

The distance between a remote user and the reference station can sometimes be considerable, such as when using 300 kHz DGPS radiobeacons. Consequently, some of the errors associated with GPS at the base station differ somewhat from those at the remote user's location. This spatial decorrelation of errors can result in a relative position offset from the absolute coordinates of the remote receiver. This offset may be as much as one meter for every 100 km (62 miles) between the base station and remote receiver.

The causes of decorrelation are:

- GPS satellite orbit errors (significant)
- Ionospheric errors (potential to be most significant depending on level of activity)
- Tropospheric errors (less significant)

GPS satellite orbit errors are typically a greater problem with local area differential systems, such as that of radiobeacons. The decorrelation effect is such that the satellite's orbit error projects onto the reference receiver and remote receiver's range measurements differently. As the separation between the receivers increases, the orbit error will not project onto the ranges in the same manner, and will then not cancel out of the measurement differencing process completely. SBAS networks, with the use of multiple base stations, are able to accurately compute the orbit vector of each satellite. The resulting corrector is geographically independent, so minimal decorrelation occurs with respect to position within the network.

The ionosphere and the troposphere both induce measurement errors on the signals being received from GPS. The troposphere is the humid portion of the atmosphere closest to the ground. Due to it humidity, refraction of GPS signals at lower elevations can distort the measurements to satellites. This error source is rather easily modeled within the GPS receiver and doesn't constitute a significant problem.

The error induced by the ionosphere is more significant, however, is not as simple a task to correct. The ionosphere is charged layer of the atmosphere responsible for the Northern Lights. Charged particles from the sun ionize this portion of the atmosphere, resulting in an electrically active atmospheric layer. This charged activity affects the GPS signals that penetrate this layer, affecting the measured ranges. The difficulty in removing the effect of the ionosphere is that it varies from day to day, and even hour to hour due to the sun's 11-year solar cycle and the rotation of the earth, respectively. During the summer of 2001, the sun's solar cycle reached an 11-year high and going forward we will see a general cooling trend of the ionosphere over the next few years thus reducing ionospheric activity.

Removing the effect of the ionosphere depends on the architecture of the differential network. DGPS radiobeacons, for example, use a more conventional approach that WAAS or SBAS in general. DGPS beacons make use of a single reference station, which provides real-time GPS error corrections based upon measurements that it makes at its location. It's possible that the state of the ionosphere differs between the remote user and the single reference station. This can lead to incompletely corrected error source that could degrade positioning accuracy with increased distance from the base station.

WAAS and SBAS use a different approach, using a network of reference stations in strategic locations to take measurements and model the real-time ionosphere. Updates the ionospheric map are sent on a continual basis to ensure that as the activity of the ionosphere changes with time, the user's positioning accuracy will be maintained. Compared to using a DGPS beacon, the effect of geographic proximity to a single reference station is minimized resulting in more consistent system performance throughout all locations within the network.

Correction Latency

The latency of differential corrections to a lesser extent affects the achievable positioning accuracy at the remote receiver since the magnitude of SA was turned to zero in year 2000. Latency is a function of the following:

- The time it takes the base station to calculate corrections
- The data rate of the radio link
- The time it takes the signal to reach the user

- The time required for the remote differential receiver to demodulate the signal and communicate it to the GPS receiver.
- Any data loss that occurs through reception problems

Most of these delays require less than a second, though in some instances, depending upon the amount of information being transferred, overall delays of three to five seconds may occur. The effect of latency is mitigated by new COAST technology within the SXBlue GPS. This technology is especially valuable in conditions of DGPS signal loss where the age of corrections increases for each second of signal loss. Consult Section 1.7 for further information on COAST.

Satellite Constellation Geometry

The number of satellites visible and their geometry in the sky influences positioning accuracy. The Dilution of Precision (DOP) describes the strength of location and number of satellites in view of the receiver. A low DOP indicates a strong potential for better accuracy than a high DOP. Generally, more satellites visible to both the reference and remote receivers will provide a lower DOP (any satellites seen by one receiver and not the other, are not used in the position solution). Additionally, if the satellites are evenly spread around the receiver, rather than grouped in a few regions of the sky, a lower DOP (stronger solution) will result.

GPS Signal Multipath

Satellite signals received by the GPS receiver by a reflection from an object can decrease positioning accuracy. These multipath signals increase the measured range to a satellite as the signal takes a longer route to the GPS antenna. Certain precautions will minimize GPS antenna sensitivity to these reflected signals. Operating away from large reflective structures such as buildings or using special antennas and GPS equipment can help to reduce the impact of multipath. For most consumer-level applications, a small amount of multipath is tolerable.

GPS Receiver Quality

The quality of a GPS receiver has a dramatic influence on positioning accuracy. Consumer-based GPS products, such as many affordable handheld and fixed-mount receivers, typically operate with an accuracy of 3 to 5 meters horizontally 95% of the time. The accuracy of a particular product depends on the specific receiver’s performance characteristics. Higher accuracy GPS receivers are able to achieve sub-1 meter horizontal accuracy 95% of the time using real-time DGPS transmissions. The SXBlue GPS falls in to this latter category.

Space Based Augmentation Systems

The US Federal Aviation Administration is in the process of developing a Wide Area Augmentation System (WAAS) for the purpose of providing accurate positioning to the aviation industry. In addition to providing a high quality, accurate service for this industry, this service is available free of charge to all other civilian users and markets in North America. This service falls into the greater category of Space Based Augmentation System (SBAS).

Upon the successful completion of a 21-day test on August 24, 2000, the FAA announced that WAAS would be running 24 hours per day, seven days per week from then on. Testing has shown since that this signal is accurate and reliable, however, since no official statement on it's Initial Operating Capability has been issued, this signal is to used at your risk.

Other government agencies are in the process of developing compatible SBAS systems for their respective geographic regions. In Europe, the European Space Agency, the European Commission, and EUROCONTROL are jointly developing the European Geostationary Overlay System (EGNOS). In Japan, the MTSAT Satellite-based Augmentation System (MSAS) is in progress of development by the Japan Civil Aviation Bureau (JCAB). China has a similar program for a SBAS and the service is named the Chinese Satellite Navigation Augmentation System (SNAS). The SXBlue GPS is capable of receiving correction data from all compatible SBAS.

EGNOS is currently in a prototyping phase, referred to as the EGNOS System Test Bed (ESTB) and which has been broadcasting a test signal since February 2000. EGNOS should be used at your risk only. MSAS has yet to begin transmitting data publicly. SNAS is transmitting correction data currently on a military communication channel and is expected to become publicly available in the near future.

Warning – Although WAAS has successfully passed a 21-day test, and is publicly available; its use is at your risk and discretion. EGNOS is not currently broadcasting with any form of certification or approval. It may produce misleading information, and its use is entirely at your risk and discretion.

MSAS may begin broadcasting a preliminary signal as early as the end of 2002.

How it Works

A SBAS incorporates a modular architecture, similar to GPS, comprised of a Ground Segment, Space Segment, and User Segment:

- The Ground Segment includes reference stations, processing centers, a communication network, and Navigation Land Earth Stations (NELS)
- The Space Segment includes geostationary satellites (For example, WAAS and EGNOS use Inmarsat-III transponders).
- The user segment consists of the user equipment, such as a SXBlue GPS receiver and antenna

A SBAS uses a state-based approach in their software architecture. This means that a separate correction is made available for each error source rather than the sum effect of errors on the user equipment's range measurements. This more effectively manages the issue of spatial decorrelation than some other techniques, resulting in a more consistent system performance regardless of geographic location with respect to reference stations. Specifically, SBAS calculates separate errors for the following:

- The ionospheric error
- GPS satellite timing errors
- GPS satellite orbit errors

Provided that a GPS satellite is available to the SBAS reference station network for tracking purposes, orbit and timing error corrections will be available for that satellite. Ionospheric corrections for that satellite are only available if the signal passes through the ionospheric map provided by SBAS (for example, the WAAS ionospheric map covers the majority of North America). As an example, if a satellite is South of your current location at a low elevation angle, the pierce point of the ionosphere will be considerably South of your location since the ionosphere is at an altitude of approximately 60 km. There must be sufficient ionospheric map coverage beyond your location in order to have ionospheric correctors for all satellites.

To enhance the information provided by SBAS, the SXBlue GPS extrapolates the ionospheric information beyond the broadcast information. This increases the usable geography for WAAS. This feature helps to improve the usable coverage area of a SBAS service.

Signal Information

A SBAS transmits correction data on the same frequency as GPS from a geostationary satellite (the space segment), allowing the use of the same receiver equipment used for GPS. Another advantage of having SBAS transmit on the same frequency is that only one antenna is required.

Reception

Since SBAS broadcast in the L-band, the signal requires a line of sight in the same manner as GPS to maintain signal acquisition.

Currently, two commercial marine communication satellites are transmitting WAAS data for public use, and one each is located above both the Pacific Ocean and Northern Brazil. Due to their location, these satellites may appear lower on the horizon, depending on your geographic position on land. In regions where the satellites appear lower on the horizon, they may be more prone to being masked by terrain, foliage, buildings or objects, resulting in signal loss. The further that you are away from the equator and the satellite's longitude will cause the satellite to appear lower on the horizon. Fortunately, the COAST Technology helps alleviate this problem by maintaining system performance when WAAS (SBAS) signal loss occurs for extended periods of time. More information on COAST is provided in Section 2.3.

The EGNOS System Test Bed (ESTB), also referred to as EGNOS in this document, uses two geostationary satellites (separate from WAAS), however, in this case, they are located over the Atlantic and Indian Oceans. Similar to WAAS, the satellites may appear lower on the horizon, depending on your geographic position on land. The further that you are away from the equator and the satellite's longitude will cause the satellite to appear lower on the horizon. If the EGNOS signal becomes unavailable due to obstruction, COAST technology helps to maintain system performance during times of differential outage.

When using SBAS correction data, the SXBlue GPS is able to provide you with the azimuth and elevation of the SBAS available satellites via a NMEA serial port command to aid in determining their position with respect to the built-in antenna. More about this feature is described in Section 5.2.5.

WAAS and ESTB Coverage

Figure C-1 depicts the current WAAS coverage as provided by the currently leased Inmarsat Atlantic Ocean Region - West (AOR-W) and Pacific Ocean Region (POR) geostationary satellites. This figure approximates signal coverage with white shading where each satellite is 5° elevation or greater. Figure C-1 also shows additional contours for 10°, 15°, and 20° elevations. Within the white shaded coverage area, at least one of the two satellites is available by line of sight. Within the overlap area, both satellites may be accessible. Although there is geographic coverage at higher latitudes, practical usage of WAAS will be limited to environments where a relatively consistent line of sight to either of the Inmarsat satellites from the SXBlue GPS system.

Figure C-2 presents approximate EGNOS System Test Bed coverage provided by the leased Inmarsat Atlantic Ocean Region - East (AOR-E) and Indian Ocean Region (IOR) satellites. This figure approximates signal coverage with white shading where each satellite is 5° elevation or greater. Figure C-2 also shows additional contours for 10°, 15°, and 20° elevations. Within the white shaded coverage area, at least one of the two satellites is available by line of sight. Within the overlap area, both satellites may be accessible. Virtually all of Europe, part of northern Africa, and into the Middle East is covered with at least one signal. Most of Europe is covered by two signals.

Note - Currently, we recommend using only the AOR-E satellite (prn 120) and the IOR-W satellite (prn 126). Refer to Appendix D – Resources for information on how to monitor the status of the ESTB.

Note - The satellite elevation angle lowers with increasing distance away from the equator and from the satellite's longitude. Although a good amount of signal coverage is shown in Northern latitudes for both WAAS and EGNOS, it may not be usable due to its low elevation angle and the potential for it to be obstructed. Ideally, testing of the system in the area of its use is recommended to ensure that the signal is sufficiently available.

Note - The SBAS signal coverage may be present in some areas without either sufficient ionospheric map coverage or satellites with valid orbit and clock correctors. In such a case, differential positioning with SBAS may not be desirable or possible, as four or greater satellites (with correctors) must be available to compute a DGPS position. The next section provides further information on the ionospheric map features of SBAS and the SXBlue GPS receiver.

Figure C-1 WAAS Coverage

Figure C-2 EGNOS Coverage

SBAS Ionospheric Map Extrapolation

To improve upon the ionospheric map provided by SBAS, the SXBlue GPS receiver extrapolates a larger ionospheric map from the broadcast coverage map, extending its effective coverage. This allows the SXBlue GPS to be used successfully in regions that competitive products may not.

For WAAS, this is especially important in Canada for regions north of approximately 54° N latitude and east of 110° W longitude. Extrapolation also provides enhanced coverage throughout much of the Gulf of Mexico.

Please note that the process of estimating ionospheric corrections beyond the WAAS broadcast map would not be as good as having an extended WAAS map in the first place. This difference may lead to minor accuracy degradation.

Figures C-3 and C-4 depict the broadcast WAAS ionospheric map extent and the extrapolated version, respectively. As can be seen from Figure C-3, the coverage compared to Figure C-1 extends further in all directions, enhancing usable coverage.

Similar to the WAAS ionospheric map extrapolation, Figures C-5 and C-6 depict the broadcast EGNOS ionospheric map extent and the extrapolated version, respectively. As can be seen from Figure C-6, the coverage compared to Figure C-5 extends further in all directions, enhancing usable coverage.

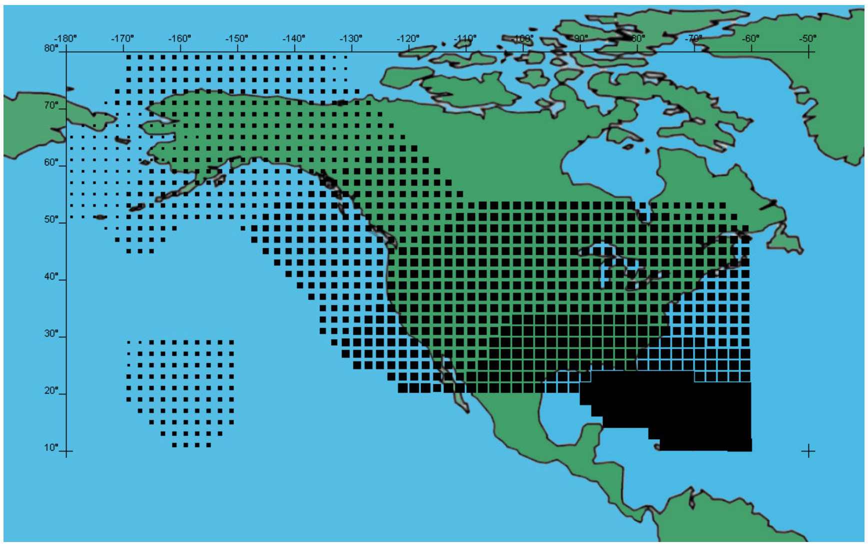

Figure C-3 Broadcast WAAS Ionospheric Correction Map

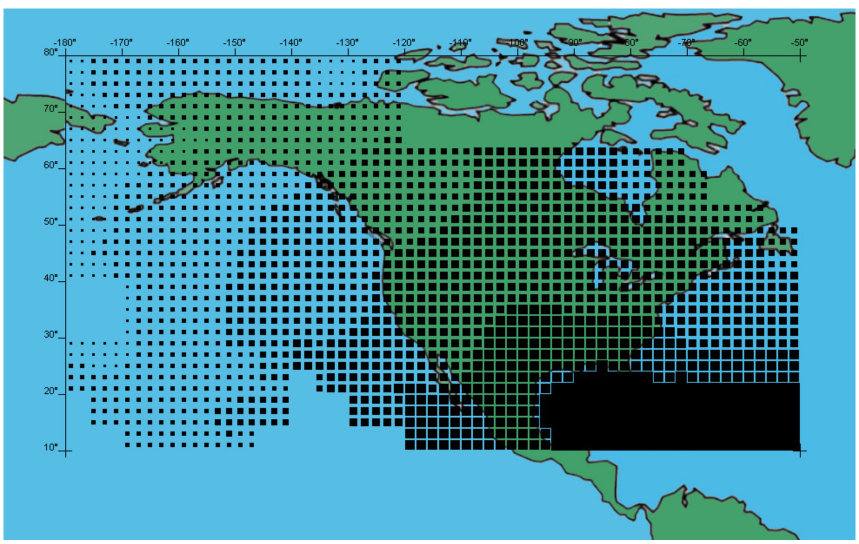

Figure C-4 Extrapolated WAAS Ionospheric Correction Map

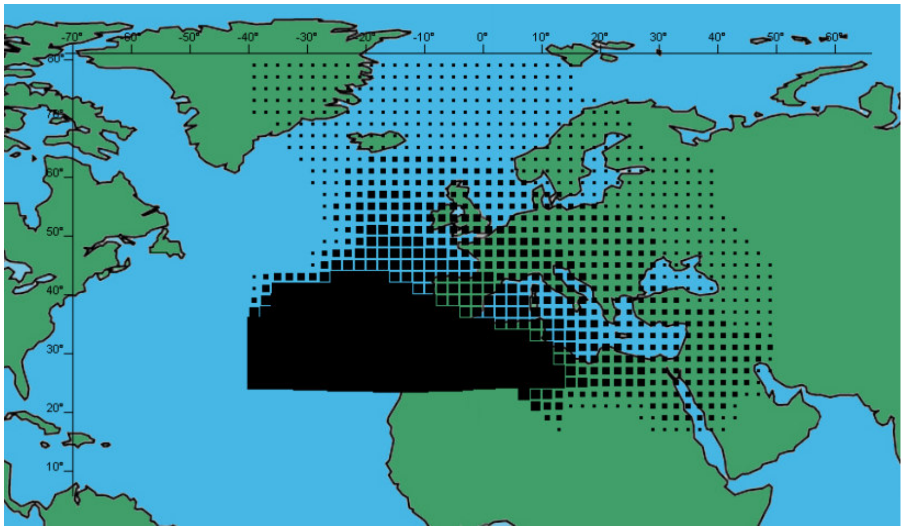

Figure C-5 Broadcast EGNOS Ionospheric Correction Map

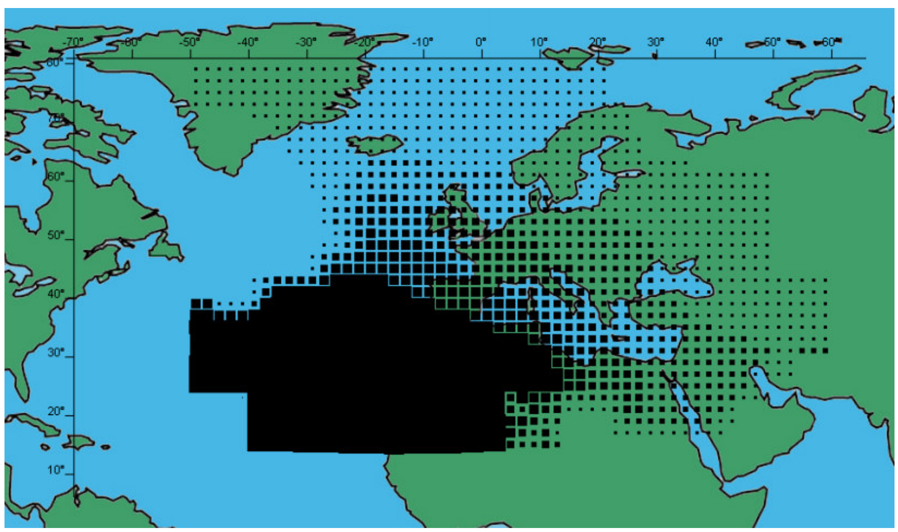

Figure C-6 Extrapolated EGNOS Ionospheric Correction Map

Radiobeacon DGPS

Radiobeacon Range

The broadcasting range of a 300 kHz beacon is dependent upon a number of factors including transmission power, free space loss, ionospheric state, surface conductivity, ambient noise, and atmospheric losses.

The strength of a signal decreases with distance from the transmitting station, due in large part to spreading loss. This loss is a result of the signal's power being distributed over an increasing surface area as the signal radiates away from the transmitting antenna.

The expected range of a broadcast also depends upon the conductivity of the surface over which it travels. A signal will propagate further over a surface with high conductivity than over a surface with low conductivity. Lower conductivity surfaces such as dry, infertile soil absorb the power of the transmission more than higher conductivity surfaces, such as sea water or arable land.

A radiobeacon transmission has three components: a direct line of sight wave, a ground wave, and a sky wave. The line of sight wave is not significant beyond visual range of the transmitting tower, and does not have a substantial impact upon signal reception.

The ground wave portion of the signal propagates along the surface of the earth, losing strength due to spreading loss, atmospheric refraction and diffraction, and attenuation by the surface over which it travels (dependent upon conductivity).

The portion of the beacon signal broadcast skywards is known as the sky wave. Depending on its reflectance, the sky wave may bounce off the ionosphere and back to Earth causing reception of the ground wave to fade. Fading occurs when the ground and sky waves interfere with each other. The effect of fading is that reception may fade in and out. However, this problem usually occurs in the evening when the ionosphere becomes more reflective and usually on the edge of coverage areas. Fading is not usually an issue with overlapping coverage areas of beacons and their large overall range.

Atmospheric attenuation plays a minor part in signal transmission range, as it absorbs and scatters the signal. This type of loss is the least significant of those described.

Radiobeacon Reception

Various sources of noise affect beacon reception, and include:

- Engine noise
- Alternator noise
- Noise from Power lines
- DC to AC inverting equipment
- Electric devices such as CRT’s electric motors, and solenoids

Noise generated by this type of equipment can mask the beacon signal, reducing or impairing reception.

Radiobeacon Coverage

The Figure below shows the approximate radiobeacon coverage throughout the world. In this figure, light shaded regions note current coverage, with beacon stations symbolized as white circles.

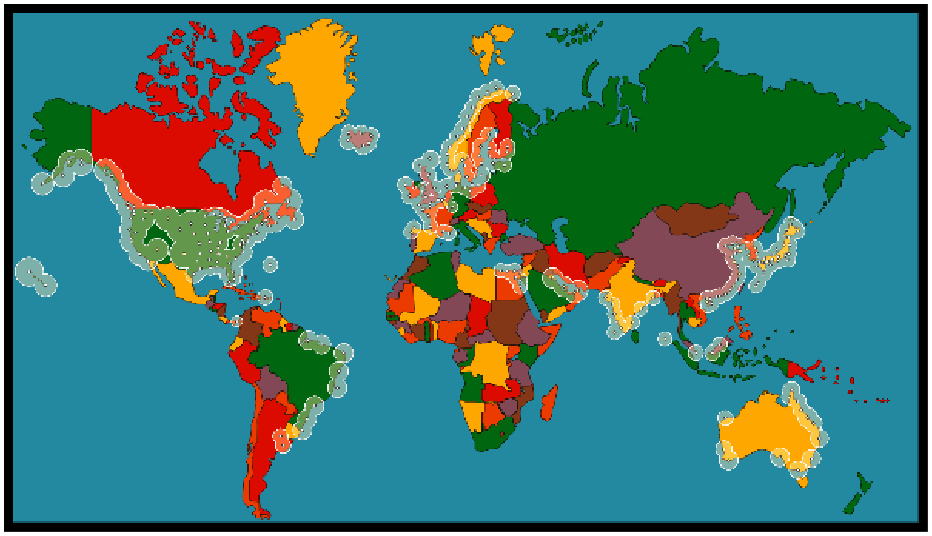

Figure C-7 World DGPS Radiobeacon Coverage

The world beacon networks continue to expand.

Appendix D – Resources

Reference Documents

National Marine Electronics Association, National Marine Electronics Association (NMEA 0183) Standard for Interfacing Marine Electronic Devices, Version 2.1, October 15, NMEA 1995, PO Box 50040, Mobile Alabama, 36605 USA, Tel: +1-205-473-1793, Fax: +1-205-473-1669

Radio Technical Commission for Maritime Services, RTCM Recommended Standards for Differential NAVSTAR GPS Service, Version 2.2, Developed by Special Committee No. 104, RTCM 1998, 1800 Diagonal Rd, Suite 600, Alexandria, VA, 22314-2840 USA, Tel: +1-703-684-4481, Fax: +1-703-836-4429

Radio Technical Commission for Aeronautics, Minimum Operational Performance Standards (MOPS) for Global Positioning System/Wide Area Augmentation System Airborne Equipment, Document RTCA DO-229A, Special Committee No. 159, RTCA 1998, 1828 L Street, NW, Suite 805, Washington, DC, 20036 USA, Tel: +1-202-833-9339

ARIC Research Corporation, Interface Control Document, Navstar GPS Space Segment / Navigation User Interfaces, ICD-GPS-200, April 12, 2000, 2250 E. Imperial Highway, Suite 450, El Segundo, CA 90245-3509, www.navcen.uscg.gov/gps/geninfo/default.htm

Geneq Web Site

This following address is the Geneq Web site which provides detailed information on all products offered by Geneq. www.geneq.com

FAA WAAS Web Site

This site offers general information on the WAAS service provided by the U.S. FAA. gps.faa.gov/Programs/WAAS/waas.htm

ESA EGNOS System Test Bed Web Site

This site contains information relating to past performance, real-time performance, and broadcast schedule of EGNOS www.esa.int/export/esaEG/estb.html

Solar and Ionospheric Activity Web Sites

The following sites are useful in providing details regarding solar and ionospheric activity. iono.jpl.nasa.gov//latest.html, iono.jpl.nasa.gov//gim_dailymovie.html, www.spaceweather.com, http://www.n3kl.org/sun/noaa.html

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