RT-3020

GPS Products User Guide

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Notices

RT-3020 *GPS* Products User Guide

P/N 96-310005-3001

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Serial Number: ______________________________

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USG FAR

Technical Data Declaration (Jan 1997)

Global Positioning System

Selective availability (*S/A* code) was disabled on 2nd May 2000 at 04:05 *UTC*. The United States government has stated that present *GPS* users do so at their own risk. The US Government may at any time end or change operation of these satellites without warning.

The U.S. Department of Commerce Limits Requirements state that all exportable *GPS* products contain performance limitations so that they cannot be used to threaten the security of the United States. Access to satellite measurements and navigation results will be limited from display and recordable output when predetermined values of velocity and *altitude* are exceeded. These threshold values are far in excess of the normal and expected operational parameters of the RT-3020 *GPS* sensor.

Use of this Document

This User Guide is intended to be used by someone familiar with the concepts of *GPS* and satellite surveying equipment.

Note indicates additional information to make better use of the product.

Indicates a caution, care, and/or safety situation.

Warning indicates potentially harmful situations.

Items that have been *ITALICIZED* indicate a term or acronym that can be found in the Glossary.

Revisions to this User Guide can be obtained in a digital format from *support.navcomtech.com*

Chapter 1 Introduction

The RT-3020 *GPS* sensor delivers unmatched accuracy to the precise positioning community who need a cost-effective, high performance *GPS* sensor. This unique receiver can transmit or receive corrections via an onboard *Spread Spectrum Radio (SSR)*.

System Overview

- *GPS* Sensor

The RT-3020 sensor consists of a 10-*channel* dual frequency precision *GPS* receiver with two additional channels for receiving *Satellite Based Augmentation System (SBAS)* signals. The sensor can output proprietary raw data as fast as 50Hz (optional) and *Position Velocity Time (PVT)* data as fast as 25Hz (optional) through two 115*kbps* serial ports. The *RTK* software provides fast initialization. Testing shows that the system resolves ambiguities at start-up or on reacquisition of satellites typically within two seconds.

The RT-3020 has a built-in *Spread Spectrum Radio* providing an immediate solution for the system integrator and real time surveyor. Utilizing the built in radio for *RTK* measurements, the receivers communicate using NavCom's highly efficient proprietary *RTK* format or other *RTK* formats, such as *RTCM* and CMR. Additionally, the receivers simultaneously accept corrections for *DGPS* (*WAAS/EGNOS*) assuring seamless position output.

The RT-3020S is packaged for mobility. It can be used for construction stakeout, boundary surveys, high order control surveys and topographic surveys in rough terrain. The sensor can be carried in a backpack with the antenna either pole-mounted from the backpack or on a survey pole with a single cable connection.

The RT-3020M is a *real-time kinematic* (*RTK*) sensor specifically designed for machine control applications in construction, agriculture, mining and many other fields.

The RT-3020M is equipped with additional features allowing interconnectivity with a wide variety of antennas, vehicle data buses and other instrumentation to suit specific applications and configurations. The RT-3020M also has a 1*PPS* output port and a combined Event/*CAN Bus* interface port.

- *GPS* Antenna

Our compact *GPS* antenna with excellent tracking performance and a stable *phase center* for *GPS L1* and *L2*. The robust housing assembly features a standard 5/8" *BSW* thread for mounting directly to a surveyor's pole, tripod, or mast and is certified to 70,000' feet.

Although rated to 70K feet, this antenna is not designed for aircraft installations. E-Mail *sales@navcomtech.com* for aircraft solutions.

- Controller

The RT-3020 *GPS* sensor is designed for use with an external c*ontroller* solution connected via one of the two *COM* ports.

This may be accomplished using an IBM compatible PC, Tablet PC or *Personal Digital Assistant* (*PDA*) and a software program which implements the rich control language defined for NavCom *GPS* products. *See* the User's Guide of your *Controller* Solution for further information.

Included Items

Figure 1: RT-3020 Supplied Equipment

❶ RT-3020 *GPS* sensor
(RT-3020S *P/N* 92-310058-3001)
(RT-3020M *P/N* 92-310058-3002)

❷ Compact *L1*/*L2 GPS* Antenna
(*P/N* 82-001000-0004)

❸ *GPS* Antenna Cable (*P/N* 94-310058-3012)

❹ *SSR* 2.4GHz Radio Antenna (*P/N* 82-001000-0003)

❺ *LEMO* 7 Pin to DB9S Data Communications Cable (*P/N* 94-310059-3006)

❻ CD-Rom (*P/N* 96-310006-3001) containing User Guides to NavCom Technology, Inc. product line, brochures, software utilities, and technical papers.

❼ *LEMO* 4-Pin External Power Cable (*P/N* 94-310060-3010)

❽ RT-3020 User's Guide {Not Shown} (Hard Copy *P/N* 96-310005-3001)

❾ Ruggedized Travel Case {Not Shown} (*P/N* 79-100100-0002)

❿ *SSR* Antenna Adapter {Not Shown} (*P/N* 91-310020-3001

Applications

The RT-3020 *GPS* sensors meets the needs of a large number of applications including, but not limited to:

- Land Survey / GIS
- Asset Location
- Hydrographic Survey
- Photogrammetric Survey
- Machine Control
- Railway, Ship and Aircraft Precise Location

Unique Features

The RT-3020 *GPS* sensors have many unique features:

- Positioning Flexibility

The RT-3020 is capable of using two internal *Satellite Based Augmentation System* (*SBAS*) channels that provide *Wide Area Augmentation System (WAAS)* or *European Geostationary Navigation Overlay Service (EGNOS)* code corrections. The RT-3020 self configures itself to use the most suitable correction source available and changes as the survey dictates.

- Data Sampling

  GPS L1 and *L2* raw data is 1 to 5Hz in the standard configuration and as an optional upgrade as fast as 10, 25, and 50Hz via either of the two serial ports. The *PVT (Position, Time, & Velocity)* data is also 1 to 5Hz in the standard configuration and as an optional upgrade as fast as 10, and 25Hz for high dynamic applications.

- *GPS* Performance

  The NCT-2000D *GPS* engine at the heart of the RT-3020 incorporates several patented innovations. The receiver provides more than 50% signal to noise ratio advantage over competing technologies. The benefit to the user is improved real time positioning. Independent tests have proven the NCT-2000D to be the best receiver when facing various *multipath* environments.

- Rugged Design

  The rugged design of the RT-3020 system components provides protection against the harsh environments common to areas such as construction sites, offshore vessels, and mines.

  Units have been tested to conform to MIL-STD-810F for low pressure, solar radiation, rain, humidity, salt-fog, sand, and dust.

Chapter 2 Interfacing

This chapter details the RT-3020 *GPS* sensor connectors and status display. Appropriate sources of electrical power, and how to interface the communication ports.

Electrical Power

The electrical power input comprises of a 4-pin *LEMO* female connector located on the bottom front panel of the RT-3020, and is labeled 'DC PWR' as shown in Figure 2. The pin designations of this connector are as follows; see Figure 2 for pin rotation.

Pin	Description
1	Return
2	Return
3	Power Input 10 to 30 VDC
4	Power Input 10 to 30 VDC

Table 1: External Power Cable Pin-Out

Pins 1 and 2 are connected together inside the RT-3020 *GPS* sensor. Pins 3 and 4 are connected together inside the *GPS* sensor.

When using an external power cable longer than 5m(15ft), it is recommended that positive voltage DC be supplied on both pins 3 and 4, and return on both pins 1 and 2.

P/N 94-310060-3010 a 3m (10ft) unterminated power cable fitted with a *LEMO* plug type (Mfr. *P/N* FGG.1K.304.CLAC50Z) and red strain relief, is suitable for supplying power to the RT-3020 *GPS* sensor. This cable is supplied with the RT-3020 series of *GPS* receivers. The wiring color code and pin designations are labeled on the cable.

The *GPS* sensor is protected from reverse polarity by an inline diode. It will operate on any DC voltage between 10 and 30 VDC, which is capable of supplying the required current. The sensor typically uses:

0.67 Amps at 12VDC (8.0 Watts)
0.35 Amps at 24VDC (8.4 Watts)
0.30 Amps at 30VDC (9.0 Watts)

Voltages less than 10VDC will shut the unit down. When power is restored, the ON switch will need to be held down for more than 3 seconds.

Voltages in excess of 30VDC will damage the unit. It is extremely important to ensure that the power supply is well conditioned with surge protection. This is especially true for vehicular electrical systems, which can create voltage spikes far in excess of 30VDC.

Communication Ports

The RT-3020 *GPS* sensor is fitted with two 7-pin female *LEMO* connector communication ports labeled *COM1* and *COM2* located at the bottom front of the *GPS* sensor as shown in Figure 2. Each conforms to the EIA RS232 standard with data speeds between 1200 *bps* and 115.2kbps. The pin-outs for these connectors are described in Table 2. An interface data cable (P/N 94-310059-3006) is supplied with the RT-3020 for easy startup. The cable construction is described in Figure 4.

LEMO Pins	Signal Nomenclature [*DCE* w/respect to *DB9S*]	*DB9S* Pins
1	CTS Clear To Send	8
2	RD Receive Data	2
3	TD Transmit Data	3
4	DTR Data Terminal Ready	4
5	RTN Return [Ground]	5
6	DSR Data Set Ready	6
7	RTS Request To Send	7

Table 2: Serial Cable Pin-Outs

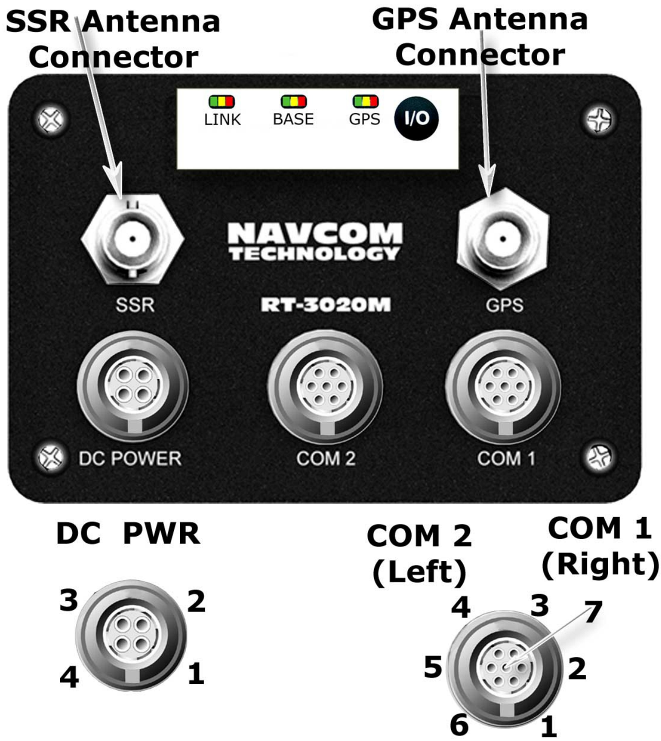


Figure 2: RT-3020 Front View

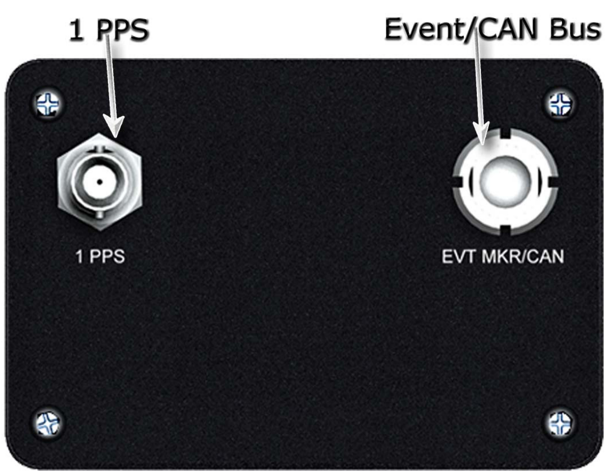


Figure 3: RT-3020M Only Back View

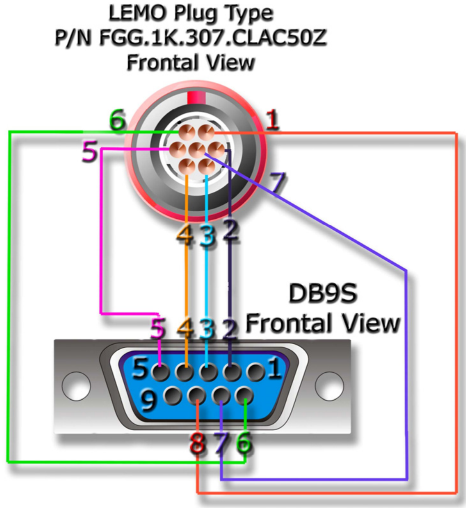


Figure 4: NavCom Serial Cable 94-310059-3006

Pin 5 should connect to shield of cable at both ends.

Indicator Panel

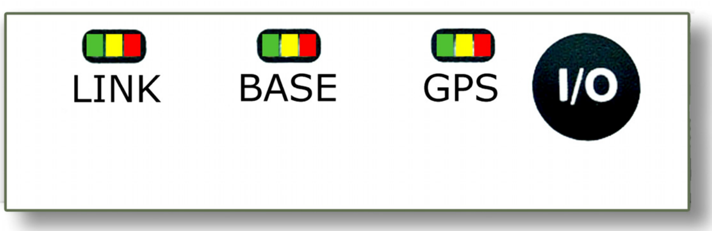


Figure 5 RT-3020 Indicator Panel

The Indicator Panel provides the on/off (I/O) switch and a quick view of the status of the RT-3020 *GPS* sensor, corrections source & type, and radio signal strength. Each of the three indicators has three *LED*s, which depict status as detailed in the following tables.

To power the unit on or off, the on/off (I/O) switch must be depressed for more than 3 seconds. During power up of the *GPS* sensor, all *LED*s will be on for a period of 3-5 seconds.

- Link LEDs

The Link lights are software configurable via the appropriate NavCom *proprietary command*. Because of the numerous scenarios available for the Link light, only the factory default configuration [*Rover* Mode] is discussed.

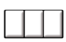
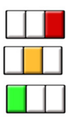
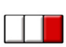
LINK	Status
	Command Mode
	Rapidly repeating Red to Amber to Green indicates Searching for base radio signal.
	Strong Signal Strength from the base radio.
	Medium Signal Strength from base radio.
	Weak Signal Strength from base radio.

Table 3: Link Light Indication

- Base LEDs

If the RT-3020 has been configured as a *Base Station*, the *LED*s indicate the type of *RTK* corrections being produced. Where the color of the *LED* will indicate the format of the correction, the blink rate indicates specifically which message is being sent. Table 4 illustrates the color, format, message, and blink rate of the *LEDs* for the type of corrections being output.

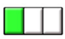
BASE	Status	Blink Rate
	Rover mode	N/A
	NCT Proprietary	5e=2Hz; 5b=1Hz; Both=5Hz
	CMR	1Hz
	*RTCM*	20,21=5Hz; 18,19=1Hz

Table 4: *Base station* Indication

- GPS LEDs

GPS	Status
	Power is off.
	Power is on. No satellites tracked.
	Tracking satellites, *position* not available yet.
	Non-differential positioning.
	Code based differential positioning.
	*Dual frequency* Phase positioning.

Table 5: *GPS* Light Indication

The *GPS LEDs* will blink at the positioning rate selected (1, 2, 5, 10 and 25 Hz).

1 PPS

The RT-3020M has the ability to output a precise pulse every second with a relative accuracy to within 12.5ns, and an absolute accuracy better than 100ns. The 1 *PPS* is 50-Ohm, TTL level. By using the appropriate NavCom *proprietary command*, the 1 *PPS* pulse width is user configurable between 0.01 and 0.50 seconds, with the default width set to 0.10 seconds. The delay default is set to 0.0 seconds from the *GPS* zero second mark and is configurable between 0.0 seconds and 0.999 seconds. This precise pulse can be used for a variety of time mark applications where precise timing is a must. The 1 *PPS* pulse is user configurable to sync on the rising or falling edge of the pulse. Connecting the 1 *PPS* output requires a cable with a BNC male connector. *P/N* 94-310050-3003 provides a 0.9m (3ft) long BNC male to BNC male connection. Detailed specifications of this pulse can be found on the NavCom website at *support.navcomtech.com*

CAN Bus/Event

The RT-3020M also employs *CAN Bus* technology. *CAN* bus is a balanced (differential) 2-wire interface, and is ISO11898 -24V compliant. The *CAN* interface uses an asynchronous transmission scheme. This interface employs a serial binary interchange and is widely used in the automotive industry. The data rate for the RT-3020M *CAN Bus* is defined as 250K*bps* maximum. Termination resistors are used at each end of the cable. This port/connector is shared with the *Event* Input.

As CAN Bus specifications are diverse, drivers for the existing hardware must be tailored to the specific manufacturer's equipment being interfaced. For further information on interfacing with theRT-3020M CAN Bus hardware e-mail NavCom Customer Support at *customersupport@navcomtech.com* .

The RT-3020M also can utilize an event input. This input pulse can be used to synchronize any external incident that requires precise *GPS* time tagging, such as aerial photography. The action of a camera's aperture could send a pulse to the *Event* port of the RT-3020M and have it output position information relative to the time the photograph was taken. It requires input impedance of 50 Ohms, 3-6vdc (60 - 120mA) for HI Level Input, 1.2vdc (24mA) Low Level Input, and a minimum pulse width of 100nSec. The Event Input latch can be configured to sync on the rising, or falling edge of the event input pulse by using the appropriate NavCom *proprietary command*. Connecting the shared EVT MKR/CAN BUS port requires a five core 5mm diameter cable fitted with a *LEMO* plug type FGG.0K.305.CLAC50Z plus strain relief. This is available as *P/N* 94-310062-3003. Detailed specifications of the *Event* Input and cable wiring can be found in Appendix C of this User Guide.

Chapter 3 Installation

This chapter provides guidance on how the hardware should be installed for optimum performance.

Tri-Mode Antenna

The antenna is fitted with a 5/8" BSW threaded mount with a depth of 16mm (0.63"). This should be used as the primary means of mounting the antenna.

It is possible to remove the 5/8" BSW threaded alloy insert to reveal the secondary means of mounting the antenna which consists of a 1-14UNS-2B thread with a depth of 16mm (0.63") typically used in the marine industry for navigation antenna.

Figure 6: Tri-Mode *GPS* Antenna

The eight Phillips screws on the base of the antenna should not be loosened or used for mounting the antenna. This will compromise the environmental seal of the antenna, may lead to internal damage and will void the equipment warranty.

There should be an unobstructed view of the sky above a 10-degree *elevation mask* for optimum *GPS* satellite visibility for *RTK* use. Any obstructions above the horizon should be mapped using a compass and clinometer and used in satellite prediction software with a recent satellite *almanac* to assess the impact on satellite visibility at that location. Potential sources of interference should be avoided where possible. Example interference sources include overhead power lines, radio transmitters and nearby electrical equipment.

Calculating the *azimuth* and *elevation* of these from a known *latitude*, *longitude* and height can be determined from [*support.navcomtech.com*](support.navcomtech.com)

GPS Sensor

The RT-3020 *GPS* sensor can be mounted to a flat surface using four screws spaced as per the following diagram of the base plate. In environments with high vibration, shock absorbers suitable for 1.8kg (4lbs) should be considered.

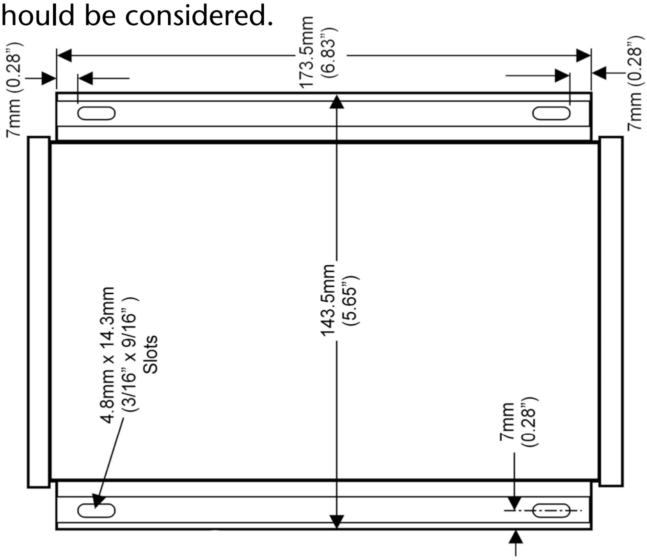


Figure 7: RT-3020 Base Plate Dimensions

The RT-3020S can be installed in a backpack for mobile surveying applications.

The sensor should not be placed in a confined space or where it may be exposed to excessive heat, moisture, or humidity.

There are no user serviceable parts inside the RT-3020 *GPS* sensor. Undoing the four screws, which secure the front end plate, and the four securing the rear end plate will void the equipment warranty.

Basics of RTK Surveying

The idea behind *RTK* surveys is to achieve the high quality, low ambiguity accuracy of post-processed position fixes, in a real time environment. In order to accomplish this task, the *GPS* data collected at the roving sensor must have its error sources inherent to *GPS* corrected as much as possible. These errors will be accounted for virtually instantaneously; thus the Real Time in *RTK*.

Setting up a *Reference (Base) Station* can minimize *GPS* errors in a roving *GPS* sensor. The reference *GPS* sensor would be set up on a known surveyed location, with this position locked in. It would then transmit its code, clock, and *reference station* coordinate information to the roving sensor. The roving sensor would use this information to correct each *GPS* measurement it receives.

In the RT-3020 this link between the *reference station* and the *rover* is achieved via a 2-way, 2.4GHz *Spread Spectrum Radio* (*SSR*) integrated into the RT-3020. This *SSR* was designed specifically with *GPS RTK* in mind. It has built in interference rejection so any extraneous radio signals will not interfere with the transmission of the correction data.

The RT-3020 when configured as a *reference station* can transmit corrections to any number of *roving receivers* capable of picking up the radio signal and decoding one of the three *GPS* correction formats [*RTCM*, CMR, or NavCom proprietary] transmitted. At 2.4Ghz, data being broadcast via modulated radio carrier frequency is limited to line of sight for error free reception. However, the signal can be received in less than ideal environments, though some data loss could occur. The *SSR* integrated into the RT-3020 has a line of sight range up to a maximum of 10km.

When setting up the reference sensor, it is best to have the *reference station* sensor elevated above the roving sensors since radio signals of such high frequency tend to travel a shorter distance than their lower frequency counterparts, and are apt not to penetrate obstructions as well over distance. This also affords the reference sensor to transmit to all *rovers* in all directions with minimal obstruction. Figure 8 & 9 illustrates a proper and improper *RTK reference station* installation.

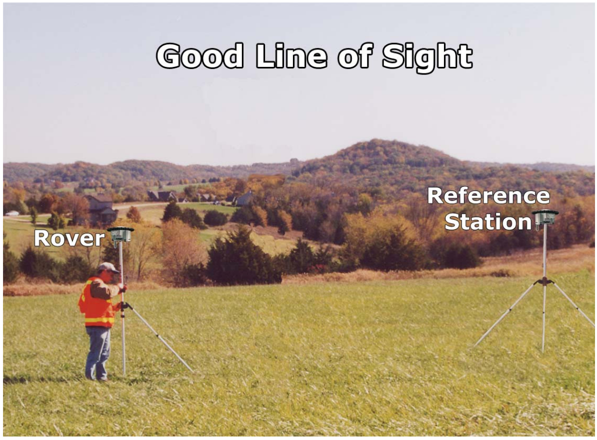


Figure 8: Good Line of Sight *RTK* setup

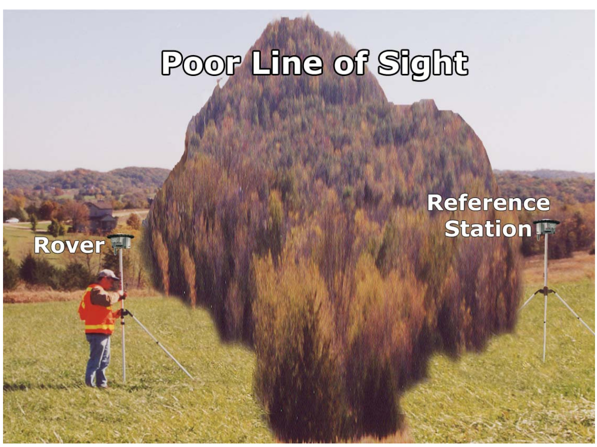


Figure 9: Poor Line of Sight *RTK* setup

Communication Ports

Connect the supplied *LEMO* 7-Pin end of the NavCom serial cable (*P/N* 94-310059-3006) to *COM 2* (factory default control port) connector of the RT-3020. Connect the DB9S end to your controlling device. Note that some devices may require an additional adaptor.

By factory default *COM 2* is designated as the control port for the RT-3020. *COM 1* can be designated as the control port by using the appropriate NavCom *proprietary commands*. Although some output data types cannot output on the controlling port.

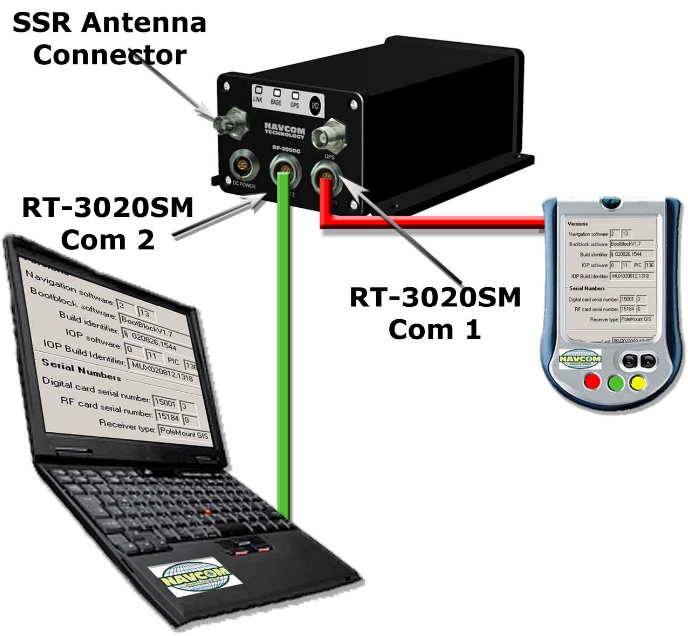


Figure 10: Communication Port Connections

GPS Antenna Connector

The connector used on the RT-3020 is a TNC female, labeled *GPS* Ant on the front panel of the sensor as shown in Figure 2.

The center pin of the TNC connector carries a voltage of 4.4 VDC (nominal), which is used to power the preamplifier in the *GPS* antenna. When the *GPS* unit is powered on, the antenna cable should not be disconnected.

The cable length between the RT-3020 and the Tri-Mode antenna should not exceed more than 10dB loss at 1.5GHz. Examples are:

Cable Type	Maximum Length
RG58/U	13.7m (45ft)
LMR400	59.7m (196ft)

NavCom cable *P/N* 94-310058-3012 provides a 3.6m (12ft) length of RG58/U cable with a right angle male TNC connector to a straight male TNC connector. This is suitable for connecting the RT-3020 *GPS* sensor to the Tri-Mode antenna.

In-line amplifiers suitable for all *GPS* frequencies may be used to increase the length of the antenna cable but care should be exercised that tracking performance is not degraded due to multiple connections and possible ingress of moisture and dust.

The antenna cable can degrade signal quality if incorrectly installed, or the cable loss exceeds NavCom specifications. Care should be taken not to kink, stretch or damage the antenna cable. Do not place the cable adjacent to cables carrying electrical power or radio frequencies.

Where the *GPS* antenna is exposed to sources of electromagnetic discharge such as lightning, an in-line electrical surge suppressor should be considered between the *GPS* sensor and antenna. Such installations should comply with local regulatory codes and practices.

Chapter 4 Configuration

The RT-3020 *GPS* sensor has a rich interface and detailed control language, which allows each unit to be tailored specifically to the required application.

Factory Default Settings

By factory default *COM 2* is designated as the Control Port. The Control Port manages the full functionality of the RT-3020. *COM 1* by factory default is designated as the data port. By factory default this port handles the non-NavCom proprietary messages that are input and/or output to/from the receiver. By factory default *NMEA* message GGA data is scheduled for output from *COM 1* at 1Hz. The *baud rate* at which *COM 1* and *COM 2* communicates is factory defaulted to 19.2k Baud. This baud rate can be changed to accommodate faster data rates.

The standard factory configuration for the RT-3020 allows for the basic operation of the system. The control port factory default NavCom Proprietary Message Blocks output is described in Table 6. These message blocks afford the novice or seasoned *GPS* user the best opportunity to get up and surveying in a minimal period of time.

The output data rate for the factory default message blocks is described in Table 6 and will remain at that rate until the user specifies otherwise by issuing the appropriate NavCom *Proprietary command*.

Message	Rate	Description
44	On Change	Packed *Almanac*
81	On Change	Packed *Ephemeris*
86	On Change	*Channel* Status
A0	On Change	Alert Text Message
AE	On Change	Identification Block
B0	On Change	Raw Measurement Data
B1	On Change	*PVT* Block

Table 6: Factory Setup Proprietary Messages *COM* 2

- 44 Packed *Almanac*: This message provides data corresponding to each satellite in the *GPS* constellation. This information includes *GPS* Week number of *almanac* collected, *GPS* Time of week [in seconds] that *almanac* was collected, *almanac* reference week, *almanac* reference time, *almanac* source, *almanac* health, pages 1-25, and subframes 4 & 5.

- 81 Packed *Ephemeris*: This message provides information as it relates to individual satellites tracked. This information includes *GPS* Week number of *ephemeris* collected, *GPS* Time of week [in seconds] that *ephemeris* was collected, IODC, and Sub-frame 1, 2, & 3 data.

- 86 *Channel* Status: Provides receiver *channel* status information and contains the *GPS* week, *GPS* Time of Week, NCT-2000D Engine status, solution status, number of satellites being tracked and the number and identity of satellites used in solution, *PDOP* and the satellite *PRN*.

- A0 Alert Text Message: Details if a message has been properly received and processed.

- AE Identification Block: Details the receiver software versions.

- B0 Raw Measurement Data: Raw Measurement Data Block that contains the *GPS* Week, *GPS* Time of Week, Time Slew Indicator and Status. Information included is *Channel* Status, CA *Pseudorange*, *L1* Phase, P1-CA *Pseudorange*, P2-CA *Pseudorange*, and *L1* Phase. This data stream is repeated for any additional satellite.

- B1 *PVT*: Provides *GPS* Week number, satellites used, latitude, longitude, navigation mode, and *DOP* information.

The term "On Change" indicates that the RT-3020 will output the specified message only when the information in the message changes. Thus in some cases, there may be an *epoch* without a message block output.

Advanced Configuration Settings

If a third party *Controller* solution was provided with your RT-3020 *GPS* sensor, please refer to that manual/user's guide.

Chapter 5 Safety Instructions

The RT-3020 *GPS* sensor is designed for precise navigation and positioning using the *Global Positioning System*. Users must be familiar with the use of portable *GPS* equipment, the limitations thereof and these safety instructions prior to use of the equipment.

FCC Notice

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Transport

The NavCom equipment should always be carried in its case. The case must be secured whilst in transit to minimize shock and vibration.

All original packaging should be used when transporting via rail, ship, or air.

Maintenance

The NavCom equipment can be cleaned using a new lint free cloth that may be moistened, but only with pure alcohol.

Connectors must be inspected, and if necessary cleaned before use. Always use the provided connector protective caps to minimize moisture and dirt ingress.

Cables should be regularly inspected for kinks and cuts as these may cause interference and equipment failure.

Damp equipment must be dried at a temperature less than +40°C (104°F), but greater than 5°C (41°F) at the earliest opportunity.

External Power Source

The RT-3020 is supplied with an external power cable (*P/N* 94-310060-3010). This must be connected to the chosen external power solution in accordance with Chapter 2 Interfacing\Electrical Power. It is important that the external power source allow sufficient current draw for proper operation. Insufficient supplied current will cause damage to your external power source.

If your chosen external power source is a disposable battery, please dispose of the battery in accordance with your local regulations.

Safety First

The owner of this equipment must ensure that all users are properly trained prior to using the equipment and are aware of the potential hazards and how to avoid them.

Other manufacturer's equipment must be used in accordance with the safety instructions issued by that manufacturer. This includes other manufacturers equipment that may be attached to NavCom Technology Inc manufactured equipment.

The equipment should always be used in accordance with local regulatory practices for safety and health at work.

There are no user serviceable parts inside the RT-3020 *GPS* sensor. Accessing the inside of the equipment will void the equipment warranty.

Typically the RT-3020 may be mounted in a backpack, the crew cab of construction machinery, or if configured as a reference station on a building top. Care should be taken to ensure that the RT-3020 does not come into contact with electrical power installations, the unit is securely fastened and there is protection against electromagnetic discharge in accordance with local regulations.

The *GPS* sensor has been tested in accordance with FCC regulations for electromagnetic interference. This does not guarantee non-interference with other equipment. Additionally, the *GPS* sensor may be adversely affected by nearby sources of electromagnetic radiation.

The *Global Positioning System* is under the control of the United States Air Force. Operation of the *GPS* satellites may be changed at any time and without warning.

A *GPS* Sensor Technical Specifications

The technical specifications of this unit are detailed below. NavCom Technology, Inc. is constantly improving, and updating our technology. For the latest technical specifications for all products go to: *support.navcomtech.com*

RT-3020S and RT-3020M

These *GPS* sensors are fitted with an internal Lithium coin cell used to maintain *GPS* time when power is removed from the unit. This allows faster satellite acquisition upon unit power up. The cell has been designed to meet over 10 years of service life before requiring replacement at a NavCom approved maintenance facility.

Features

- "All-in-view" tracking
- L1 & *L2* full wavelength carrier phase tracking
- C/A, P1 & P2 code tracking
- Proprietary RTK processing with on-the-fly initialization
- Fast ambiguity resolution
- Units are user configurable as base or rover
- User programmable output rates
- Built-in Spread Spectrum Radio (SSR)
- External 12VDC power
- 64 MB internal memory to record field data
- NavCom compact RTK format or standard RTCM v2.2 or CMR formats
- Output format NMEA 0183 or NavCom binary format

- Superior interference suppression (both in-band & out-of-band)
- Patented multipath rejection
- 2 separate WAAS/EGNOS channels
- Self-survey mode (position averaging)
- Compact Physical Size
- CAN bus interface (RT-3020M Only)
- 1PPS output (RT-3020M Only)
- Event Marker input (RT-3020M Only)

Physical and Environmental

• Size (L x W x H):	8.18″ x 5.67″ x 3.06″
• Weight:	4lbs. (1.81 kg)
• External Power:	
Input Voltage:	12 VDC nominal (10VDC to 30VDC)
Consumption:	< 10 W
• Connectors	
I/O Ports:	2 x 7-pin LEMO
DC Power:	4-pin LEMO
SSR Antenna:	BNC
GPS Antenna	TNC
CAN bus/Event Marker:	5-pin LEMO (RT-3020M Only)
1PPS Output:	BNC (RT-3020M Only)
• Temperature (ambient)	
Operating:	-40° C to +55° C
Storage:	-40° C to +85° C
• Humidity:	95% non-condensing

Measurement Performance

GPS Receiver Performance

- RTK Accuracy (RMS)*

Position (H):	< 1 cm + 1ppm
Position (V):	< 2 cm + 1ppm

- Pseudo-range Measurement Precision (RMS):

Raw C/A code :	20cm @ 42 db-hz
Raw carrier phase noise:	L1: 0.95 mm @ 42 dB-Hz
	L2: 0.85 mm @ 42 dB-Hz

- Real-time DGPS (code) Accuracy** (RMS):

Position (H):	12 cm + 2ppm
Position (V):	25 cm + 2ppm
Velocity:	0.01 m/s

- User programmable output rates:

PVT:	<1Hz, 2Hz, 5Hz Standard (10Hz, & 25Hz Optional)
Raw data:	<1Hz, 2Hz, 5Hz Standard (10Hz, 25Hz, & 50Hz Optional)

- Data Latency:

PVT:	< 20 ms at all nav rates
Raw data:	< 20 ms at all rates

- Time-to-first-fix:

Cold Start

Satellite Acquisition:	< 60seconds (typical)
Satellite Reacquisition:	< 1 second

- Dynamics:
  - Acceleration: up to 6g
  - Speed: < 300 m/s*
  - Altitude: < 60,000 ft*

- 1PPS Accuracy: 12.5nS (Relative; User Configurable) (RT-3020M Only)

*Restricted by export laws

* Up to 10 km if using receivers as base & rover.
* * Up to 200 km if using receivers as base station & mobile.

Built in Radio Performance

- Frequency Band: 2.400GHz - 2.485GHz
- Modulation: Frequency Hopping Spread Spectrum ⮝
- Data Rate: 9600bps (configurable)
- Transmit Power: 1-Watt max
- Receiver Sensitivity: -105dBm
- Range @ Max. Power: 10km Line of Sight
- Maximum EIRP: 6dBW***
- Optional Pole-Mount Antenna: 3db gain

*** Using high gain antenna
⮝EIRP and hopping bandwidth restrictions vary depending on local regions. Contact NavCom Technology, Inc. for regulations in your local area.

Connector Assignments

- Data Interfaces:
  - 2 serial ports; from 1200 bps to 115.2 kbps
  - CAN Bus I/F (RT-3020M Only)

	Event Marker I/P (RT-3020M Only)
	1PPS (RT-3020M Only)

- Com Port Functions

NCT Proprietary	Control, Data

Input/Output Data Messages

• NCT Proprietary Data:	PVT Raw Measurement Satellite Messages Nav Quality Receiver Commands
• NMEA Messages (Output Only):	ALM, GGA, GLL, GSA, GSV, RMC, VTG, ZDA, GST
• Code Corrections:	RTCM 1 or 9 WAAS/EGNOS
• RTK Correction Data:	NCT Proprietary RTCM 18/19 or 20/21 CMR (Msg. 0, 1, 2)

LED Display Functions (Default)

Link:	Base Signal Strength
Base:	Type of Correction/Rate Rover; = N/A
GPS:	Position Quality

Satellite Based Augmentation System Signals

- WAAS/EGNOS

B GPS Antenna Technical Specifications

> The standard antenna supplied with the RT-3020 *GPS* sensor is capable of Tri-Mode reception.

L1+L, L2 GPS Antenna

1525-1585 MHz	GPS L1 plus Inmarsat L Band
1217-1237 MHz	GPS L2
Polarization	Right Hand Circular (RHCP)
Finish	Fluid resistant Ultem, UV stable
Cable Connector	TNC Female
Pre–Amplifier	39dB gain (+/-2)
Input Voltage	4.2 to 15.0 VDC
Impedance	50 Ohms
VSWR	≤ 2.0:1
Band Rejection	20 dB @ 250MHz
Power Handling	1 Watt
Operating Temp	-55°C to +85°C
Altitude	70,000'

NavCom *P/N* 82-001000-0008 is an optional aircraft mount antenna, also rated to 70,000 feet.

Designed to DO-160D Standard

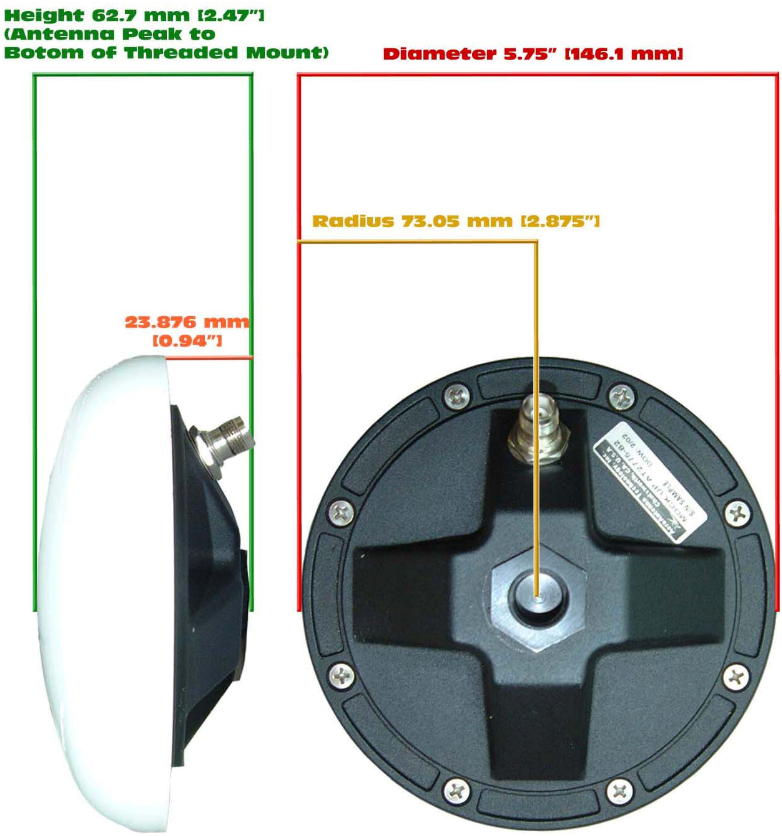


Figure B1: Tri-Mode Antenna Dimensions

In order to achieve the greatest level of accuracy, the absolute *phase center* values must be incorporated into your processing. For *phase center* information for the Tri-Mode Antenna go to support.navcomtech.com

C Event Input Configuration

Figure C1 details the wiring of the Event/Can cable assembly NavCom part number P/N 94-310062-3003. The Event Input is electrically isolated to the internal circuitry through an opto-isolator, thus a voltage of 3-6 vdc/50Ω (60 - 120mA), and a minimum pulse width of 100nSec must be sensed in order to get through the opto-isolator. Table C1 details the wiring configuration required for Event-Hi, and Event-Lo pulse sensing.

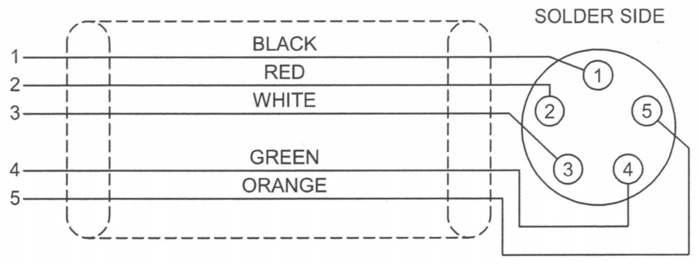


Figure C1: Event Cable Wiring Diagram

Pin #	Signal Name	Event Sync Wiring
1	Event Lo	Tie Event-Hi to Ground
2	Event Hi	Tie Event-Lo to Ground
3	Ground	N/A

Table C1: Event Wiring Connections

Once the cable is wired to correspond with the event pulse requirements, the receiver must be configured to output the message containing a time mark indicating when the event is sensed. The time will be referenced to the time kept within the NavCom receiver.

The Event Input can be triggered on the Falling, or Rising edge of the input pulse; Figure C2 shows the PPS & Event Latch window. After configuring the specifics of the input pulse, the Event Latch message (0xB4) must be enabled in the NCT 2000 Message Output list. However the Message Rate for the 0xB4 must be set to "On Trigger". The "On Trigger" message rate can be located by Right- Clicking on the Rate area adjacent to the B4 Message ID, and following the menus as seen in Figure C3. The Event Latch Message 0xB4 will only be output when the chosen pulse edge of the incoming event is sensed by the receiver.

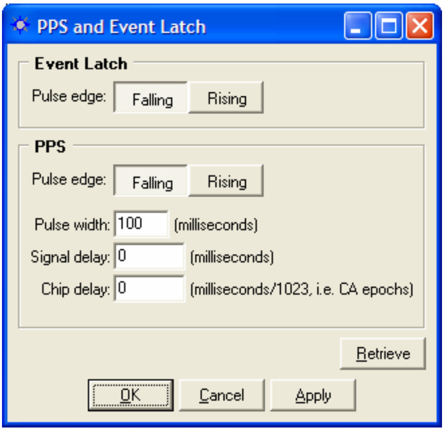


Figure C2: PPS & Event Latch Configuration

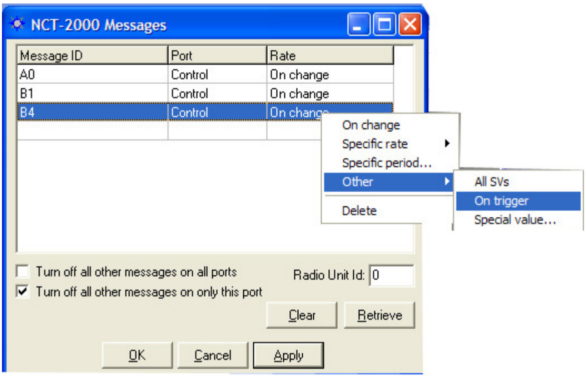


Figure C3: Event Latch Output Rate Configuration

Glossary

.yym files see meteorological files (where yy = two digit year data was collected).

.yyn files see navigation files (where yy = two digit year data was collected).

.yyo files see observation files (where yy = two digit year data was collected).

almanac files an almanac file contains orbit information, clock corrections, and atmospheric delay parameters for all satellites tracked. It is transmitted to a receiver from a satellite and is used by mission planning software.

alt see *altitude*.

altitude vertical distance above the *ellipsoid* or *geoid*. It is always stored as height above *ellipsoid* in the *GPS* receiver but can be displayed as height above *ellipsoid* (HAE) or height above *mean sea level* (*MSL*).

antenna phase center (APC) The point in an antenna where the *GPS* signal from the satellites is received. The height above ground of the APC must be measured accurately to ensure accurate *GPS* readings. The APC height can be calculated by adding the height to an easily measured point, such as the base of the antenna mount, to the known distance between this point and the APC.

APC see *antenna phase center or phase center*.

Autonomous positioning (*GPS*) a mode of operation in which a *GPS* receiver computes *position* fixes in real time from satellite data alone, without reference to data supplied by a *reference station* or orbital clock corrections. *Autonomous positioning* is typically the least precise positioning procedure a *GPS* receiver can perform, yielding *position* fixes that are precise to 100 meters with Selective Availability on, and 30 meters with S/A off.

azimuth the *azimuth* of a line is its direction as given by the angle between the *meridian* and the line measured in a clockwise direction from the north branch of the *meridian*.

base station see *reference station*.

baud rate (*bits per second*) the number of bits sent or received each second. For example, a *baud rate* of 9600 means there is a data flow of 9600 bits each second. One character roughly equals 10 bits.

bits per second see *baud rate.*

bps see *baud rate*.

BSW (British Standard Whitworth) a type of coarse screw thread. A 5/8" diameter *BSW* is the standard mount for survey instruments.

C/A code see *Coarse Acquisition code*.

CAN BUS a balanced (differential) 2-wire interface that uses an asynchronous transmission scheme. Often used for communications in vehicular applications.

channel a *channel* of a *GPS* receiver consists of the circuitry necessary to receive the signal for a single *GPS* satellite.

civilian code see *Coarse Acquisition code*.

Coarse Acquisition code (C/A or *Civilian code*) the pseudo-random code generated by *GPS* satellites. It is intended for civilian use and the accuracy of readings using this code can be degraded if *selective availability* (*S/A*) is introduced by the US Department of Defense.

COM# shortened form of the word Communications. Indicated a data communications port to/from the *GPS* sensor to a *controller* or data collection device.

controller a device consisting of hardware and software used to communicate and manipulate the I/O functions of the *GPS* sensor.

Compact Measurement Record (CMR) a standard format for *DGPS* corrections used to transmit corrections from a *reference station* to *rover* sensors.

data files files that contain Proprietary, *GPS*, NMEA, *RTCM,* or any type of data logged from a *GPS* receiver.

DB9P a type of electrical connector containing 9 contacts. The P indicates a plug pin (male).

DB9S a type of electrical connector containing 9 contacts. The S indicates a slot pin (female).

DGPS see *Differential GPS*.

Differential *GPS* (*DGPS*) a positioning procedure that uses two receivers, a *rover* at an unknown location and a *reference station* at a known, fixed location. The *reference station* computes corrections based on the actual and observed ranges to the satellites being tracked. The coordinates of the unknown location can be computed with sub-meter level precision by applying these corrections to the satellite data received by the *rover*.

Dilution of Precision (*DOP*) a class of measures of the magnitude of error in *GPS position* fixes due to the orientation of the *GPS* satellites with respect to the *GPS* receiver. There are several *DOP*s to measure different components of the error. Note: this is a unitless value. see also *PDOP*.

DOP see *Dilution of Precision*.

dual-frequency a type of *GPS* receiver that uses both L1 and L2 signals from *GPS* satellites. A *dual-frequency* receiver can compute more precise position fixes over longer distances and under more adverse conditions because it compensates for ionospheric delays. The SF-2050 is a dual frequency receiver.

dynamic mode when a *GPS* receiver operates in *dynamic mode*, it assumes that it is in motion and certain algorithms for *GPS position* fixing are enabled in order to calculate a tighter *position* fix.

EGNOS (European Geostationary Navigation Overlay Service) a European satellite system used to augment the two military satellite navigation systems now operating, the US *GPS* and Russian GLONASS systems.

elevation distance above or below Local Vertical Datum.

elevation mask the lowest *elevation*, in degrees, at which a receiver can track a satellite. Measured from the horizon to zenith, 0º to 90º.

ellipsoid a mathematical figure approximating the earth's surface, generated by rotating an ellipse on its minor axis. *GPS* positions are computed relative to the WGS-84 *ellipsoid*. An *ellipsoid* has a smooth surface, which does not match the earth's geoidal surface closely, so *GPS altitude* measurements can contain a large vertical error component. Conventionally surveyed positions usually reference a *geoid*, which has an undulating surface and approximates the earth's surface more closely to minimize *altitude* errors.

epoch literally a period of time. This period of time is defined by the length of the said period.

geoid the gravity-equipotential surface that best approximates *mean sea level* over the entire surface of the earth. The surface of a *geoid* is too irregular to use for *GPS* readings, which are measured relative to an *ellipsoid*. Conventionally surveyed positions reference a *geoid*. More accurate *GPS* readings can be obtained by calculating the distance between the *geoid* and *ellipsoid* at each *position* and subtracting this from the *GPS altitude* measurement.

GIS (Geographical Information Systems) a computer system capable of assembling, storing, manipulating, updating, analyzing and displaying geographically referenced information, i.e. data identified according to their locations. GIS technology can be used for scientific investigations, resource management, and development planning. GIS software is used to display, edit, query and analyze all the graphical objects and their associated information.

Global Positioning System (GPS) geometrically, there can only be one point in space, which is the correct distance from each of four known points. *GPS* measures the distance from a point to at least four satellites from a constellation of 24 NAVSTAR satellites orbiting the earth at a very high *altitude*. These distances are used to calculate the point's *position*.

GMT see Greenwich Mean Time.

GPS see *Global Positioning System*.

GPS time a measure of time. *GPS* time is based on *UTC*, but does not add periodic 'leap seconds' to correct for changes in the earth's period of rotation. As of September 2002 *GPS* time is 13 seconds ahead of *UTC*.

Greenwich Mean Time (*GMT*) the local time of the 0° *meridian* passing through Greenwich, England.

HAE see *altitude*, and *ellipsoid*.

JPL Jet Propulsion Laboratory.

Kbps kilobits per second.

L-Band the group of radio frequencies extending from approximately 400MHz to approximately 1600MHz. The *GPS* carrier frequencies L1 (1575.4MHz) and L2 (1227.6 MHz) are in the *L-Band* range.

L1 carrier frequency the primary *L-Band* carrier used by *GPS* satellites to transmit satellite data. The frequency is 1575.42MHz. It is modulated by *C/A code*, P-code or Y-code, and a 50 bit/second navigation message.

L2 carrier frequency the secondary *L-Band* carrier used by *GPS* satellites to transmit satellite data. The frequency is 1227.6MHz. It is modulated by *P-code* or Y-code, and a 50 bit/second navigation message.

lat see latitude.

latitude (lat) the north/south component of the coordinate of a point on the surface on the earth; expressed in angular measurement from the plane of the equator to a line from the center of the earth to the point of interest. Often abbreviated as Lat.

LED acronym for Light Emitting Diode.

LEMO a type of connector.

LES Land Earth Station the point on the earth's surface where data is up linked to a satellite.

logging interval the frequency at which positions generated by the receiver are logged to *data files.*

long see longitude.

longitude (*long*) the east/west component of the coordinate of a point on the surface of the earth; expressed as an angular measurement from the plane that passes through the earth's axis of rotation and the 0° *meridian* and the plane that passes through the axis of rotation and the point of interest. Often abbreviated as *Long*.

Mean Sea Level (*MSL*) a vertical surface that represents sea level.

meridian one of the lines joining the north and south poles at right angles to the equator, designated by degrees of longitude, from 0° at Greenwich to 180°.

meteorological (.YYm) files one of the three file types that make up the *RINEX* file format. Where YY indicates the last two digits of the year the data was collected. A meteorological file contains atmospheric information.

MSL see *Mean sea level.*

multipath error a positioning error resulting from interference between radio waves that has traveled between the transmitter and the receiver by two paths of different electrical lengths.

navigation (.YYn) files one of the three file types that make up the *RINEX* file format. Where YY indicates the last two digits of the year the data was collected. A navigation file contains satellite *position* and time information.

observation (.YYo) files one of the three file types that make up the *RINEX* file format. Where YY indicates the last two digits of the year the data was collected. An observation file contains raw *GPS position* information.

P/N Part Number.

P-code the extremely long pseudo-random code generated by a *GPS* satellite. It is intended for use only by the U.S. military, so it can be encrypted to Y-code deny unauthorized users access.

parity a method of detecting communication errors by adding an extra parity bit to a group of bits. The parity bit can be a 0 or 1 value so that every byte will add up to an odd or even number (depending on whether odd or even parity is chosen).

PDA Personal Digital Assistant.

PDOP see *Position Dilution of Precision*.

PDOP mask the highest *PDOP* value at which a receiver computes positions.

phase center the point in an antenna where the *GPS* signal from the satellites is received. The height above ground of the *phase center* must be measured accurately to ensure accurate *GPS* readings. The *phase center* height can be calculated by adding the height to an easily measured point, such as the base of the antenna mount, to the known distance between this point and the *phase center*.

Position the latitude, longitude, and *altitude* of a point. An estimate of error is often associated with a *position*.

Position Dilution of Precision (PDOP) a measure of the magnitude of Dilution of Position (*DOP*) errors in the x, y, and z coordinates.

Post-processing a method of differential data correction, which compares data logged from a known reference point to data logged by a *roving receiver* over the same period of time. Variations in the *position* reported by the *reference station* can be used to correct the positions logged by the *roving receiver*. Post-processing is performed after you have collected the data and returned to the office, rather than in real time as you log the data, so it can use complex, calculations to achieve greater accuracy.

Precise code see *P-code*.

PRN (Uppercase) typically indicates a *GPS* satellite number sequence from 1 – 32.

prn (Lower Case) see Pseudorandom Noise.

Protected code see *P-code*.

Proprietary commands those messages sent to and received from *GPS* equipment produced by NavCom Technology, Inc. own copyrighted binary language.

pseudo-random noise (*prn*) a sequence of data that appears to be randomly distributed but can be exactly reproduced. Each *GPS* satellite transmits a unique *PRN* in its signals. *GPS* receivers use *PRN*s to identify and lock onto satellites and to compute their pseudoranges.

Pseudorange the apparent distance from the *reference station*'s antenna to a satellite, calculated by multiplying the time the signal takes to reach the antenna by the speed of light (radio waves travel at the speed of light). The actual distance, or *range*, is not exactly the same because various factors cause errors in the measurement.

PVT *GPS* information depicting Position, Velocity, Time in the NCT proprietary message format.

Radio Technical Commission for Maritime Services
see *RTCM*.

range the distance between a satellite and a *GPS* receiver's antenna. The *range* is approximately equal to the *pseudorange*. However, errors can be introduced by atmospheric conditions which slow down the radio waves, clock errors, irregularities in the satellite's orbit, and other factors. A *GPS* receiver's location can be determined if you know the ranges from the receiver to at least four *GPS* satellites. Geometrically, there can only be one point in space, which is the correct distance from each of four known points.

RCP a NavCom Technology, Inc. proprietary processing technique in which carrier phase measurements, free of

Ionospheric and Troposphere effects are used for navigation.

Real-Time Kinematic (*RTK*) a *GPS* system that yields very accurate 3D *position* fixes immediately in real-time. The *base station* transmits its *GPS position* to *roving receivers* as the receiver generates them, and the *roving receivers* use the *base station* readings to differentially correct their own positions. Accuracies of a few centimeters in all three dimensions are possible. *RTK* requires *dual frequency GPS* receivers and high speed radio modems.

reference station a *reference station* collects *GPS* data for a fixed, known location. Some of the errors in the *GPS* positions for this location can be applied to positions recorded at the same time by *roving receivers* which are relatively close to the *reference station*. A *reference station* is used to improve the quality and accuracy of *GPS* data collected by *roving receivers*.

RHCP Right Hand Circular Polarization used to discriminate satellite signals. *GPS* signals are RHCP.

RINEX (Receiver Independent Exchange) is a file set of standard definitions and formats designed to be receiver or software manufacturer independent and to promote the free exchange of *GPS* data. The *RINEX* file format consists of separate files, the three most commonly used are: the observation (.YYo) file, the navigation (.YYn) file, and the meteorological (.YYm) files; where YY indicates the last two digits of the year the data was collected.

rover any mobile *GPS* receiver and field computer collecting data in the field. A *roving receiver's position* can be differentially corrected relative to a stationary reference *GPS* receiver or by using *GPS* orbit and clock corrections from a *SBAS* such as StarFire™.

roving receiver see *rover*.

RTCM
(Radio Technical Commission for Maritime Services) a standard format for *Differential GPS* corrections used to transmit corrections from a *base station* to *rovers*. RTCM allows both *real-time kinematic* (*RTK*) data collection and post-processed differential data collection. RTCM SC-104 (RTCM Special Committee 104) is the most commonly used version of RTCM message.

RTK see *Real-time kinematic*.

RTG Real Time GIPSY, a processing technique developed by NASA's Jet Propulsion Laboratory to provide a single set of real time global corrections for the *GPS* satellites.

S/A see *Selective availability*.

SBAS (Satellite Based Augmentation System) this is a more general term, which encompasses *WAAS*, *StarFire*™ and *EGNOS* type corrections.

Selective Availability (S/A) deliberate degradation of the *GPS* signal by encrypting the *P-code*. When the US Department of Defense uses *S/A*, the signal contains errors, which can cause positions to be inaccurate by as much as 100 meters.

Signal-to-Noise Ratio (*SNR*) a measure of a satellite's signal strength.

single-frequency a type of receiver that only uses the L1 *GPS* signal. There is no compensation for ionospheric effects.

SNR see *signal-to-noise* Ratio.

StarFire™ a set of real-time global orbit and clock corrections for *GPS* satellites. StarFire™ equipped receivers are capable of real-time decimeter positioning (see Appendix B).

Spread Spectrum Radio (SSR) a radio that uses wide band, noise like (pseudo-noise) signals that are hard to detect, intercept, jam, or demodulate making any data transmitted secure. Because spread spectrum signals are so wide, they can be transmitted at much lower spectral power density (Watts per Hertz), than narrow band transmitters.

SV (Space Vehicle) a *GPS* satellite.

Universal Time Coordinated (*UTC*) a time standard maintained by the US Naval Observatory, based on local solar mean time at the Greenwich *meridian*. *GPS* time is based on *UTC*.

UTC see *Universal time coordinated*.

WAAS (Wide Area Augmentation System) a set of corrections for the *GPS* satellites, which are valid for the Americas region. They incorporate satellite orbit and clock corrections.

WAD*GPS* (*Wide Area Differential GPS*) a set of corrections for the *GPS* satellites, which are valid for a wide geographic area.

WGS-84 (World Geodetic System 1984) the current standard datum for global positioning and surveying. The WGS-84 is based on the GRS-80 *ellipsoid*.

Y-code the name given to encrypted *P-code* when the U.S. Department of Defense uses *selective availability.*