RT-3010

GPS Products User Guide

find your way

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RT-3010 *GPS* Products User Guide

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Serial Number: ______________________________

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Technical Data Declaration (Jan 1997)

The Contractor, NavCom Technology, Inc., hereby declares that, to the best of its knowledge and belief, the technical data delivered herewith under Government contract (and subcontracts, if appropriate) are complete, accurate, and comply with the requirements of the contract concerning such technical data.

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-3010 *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-3010 *GPS* sensor delivers unmatched accuracy to the precise positioning community who need a cost-effective, high performance *GPS* sensor. This unique sensor can transmit or receive corrections via an onboard *Spread Spectrum Radio (SSR)*.

System Overview

GPS Sensor

The RT-3010 sensor consists of a 12-channel *dual frequency* precision *GPS* sensor 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 RT-3010 is designed to integrate easily into *RTK*, field data verification, topographical surveys, and a wide variety of surveying applications. Testing shows that the system resolves ambiguities at startup or on satellite reacquisition typically within 2 seconds.

The RT-3010 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 sensors communicate using NavCom's highly efficient proprietary *RTK* format or other *RTK* formats, such as *RTCM* and *CMR*. Additionally, the sensor simultaneously accepts corrections for *DGPS (WAAS/EGNOS)* assuring seamless position output.

GPS Antenna

The all-in-one housing incorporates 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.

Controller

The RT-3010 *GPS* sensor is designed for use with an external Controller Solution connected via one of two serial *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-3010 Supplied Equipment

❶ RT-3010 *GPS* Sensor (*P/N* 92-310053-3001)

❷ *LEMO* 7 Pin to *DB9S* Data Communications Cable Supplied Coily Cable P/N 94-310090-3003 (Straight Cable P/N 94-310059-3006 shown in photo)

❸ Battery Charger (*P/N* 92-310046-3001)

❹ AC/DC Adapter for Battery Charger (*P/N* 82-020003-5001)

❺ 2 Lithium Ion Batteries
(1 Battery Each = *P/N* 59-020101-0001)

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

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

❽ RT-3010 User's Guide {Not Shown}
(Hard Copy *P/N* 96-310004-3001)

❾ Ruggedized Travel Case {Not Shown}
(*P/N* 79-100100-0001)

Applications

The RT-3010 *GPS* sensor meets the needs of a large number of applications including, but not limited to:

- High-Order Control Survey
- Construction Stakeout
- Boundary Survey
- Topographical Survey
- Machine Control

Unique Features

The **RT-3010** *GPS* sensor has many unique features:

- **Positioning Flexibility**

  The RT-3010 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-3010 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 5 Hz 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 5 Hz in the standard configuration and as an optional upgrade as fast as 10 and 25 Hz for high dynamic applications.

■ *GPS* Performance

The NCT-2100 *GPS* engine at the heart of the RT-3010 incorporates several patented innovations. The sensor provides more than 50% signal to noise ratio advantage over competing technologies. The benefit to the user is improved real time positioning with independent tests proving the NCT-2100 to be the best receiver when facing various *multipath* environments.

■ Rugged Design

The rugged design of the RT-3010 system components provides protection against the harsh environments common to areas such as construction sites and can withstand a 2-meter drop onto a flat hard surface.

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-3010 *GPS* sensor connectors and status display appropriate sources of electrical power, and how to interface with communication ports.

Electrical Power

Electrical power is input thru a 4-pin *LEMO* female connector located on the front panel of the RT-3010, and labeled 'DC PWR.' The pin designations are shown in Table 1; see Figure 2 for pin rotation on unit.

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-3010 *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 applied on both pins 3 and 4, and return on both pins 1 and 2

The optional Navcom P/N 82-020002-5001 Universal AC/DC 12 V 2 Amp Power Adapter can be used to supply DC voltage wherever an AC outlet is available for the RT-3010 GPS receiver. Another optional external power cable, NavCom *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-3010 *GPS* sensor. The wiring color code and pin designations are labeled on this optional cable assembly.

The *GPS* sensor is protected from reverse polarity by an inline diode. It will operate on any DC voltage between 10 and 30 VDC, capable of supplying the required current, typically. Power Consumption of the RT-3010 is typically 5 Watts Maximum.

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.

The RT-3010 comes equipped with 2 removable Lithium Ion battery packs that provide secondary power when the primary external voltage is not available. Each of the two battery packs is designed to last ~4 hours on a single charge [conditions vary with use]. The smart battery interface allows the batteries to be hot-swapped on the fly. When battery 1 voltage level is sensed to be between 7.5vdc to 8.2vdc, the sensor will automatically switch over to battery 2 without the loss of a single observation. A third battery (not supplied) could then replace battery 1, and the process would reverse.

When **external power** is applied, it has precedence over the batteries, but **will not charge the batteries**. Detailed information on the battery *LED*s, batteries, and battery charger can be found in Chapter 2 Interfacing, Chapter 3 Installation, and Chapter 5 Safety.

Communication Ports

The RT-3010 *GPS* sensor is fitted with two 7-pin female *LEMO* connector communication ports located at the bottom of the Indicator Panel labeled *COM1* and *COM2* as shown in Figure 2. Each conforms to the EIA RS232 standard with data speeds between 1200 *bps* and 115.2*kbps*. The pin-outs for these connectors are described in Table 2. An interface data cable (*P/N* 94-310090-3003) is supplied with the RT-3010 for easy startup. The cable construction is described in Figure 3.

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

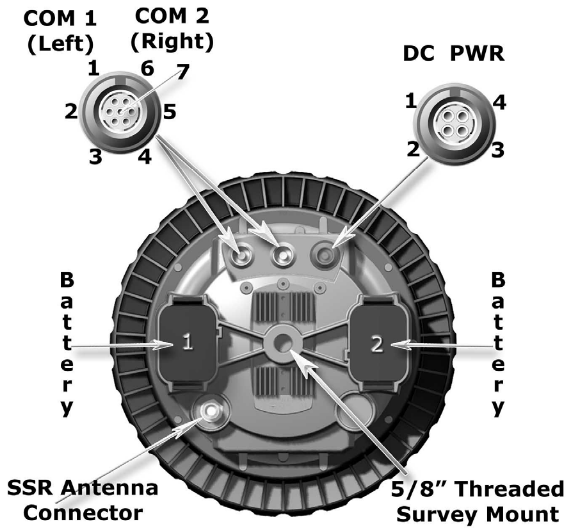


Figure 2: RT-3010 Viewed From Bottom

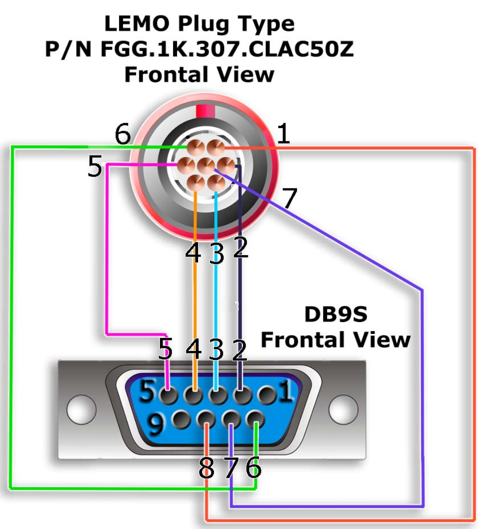


Figure 3: NavCom Serial Cable *P/N* 94-310090-3003

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

Indicator Panel

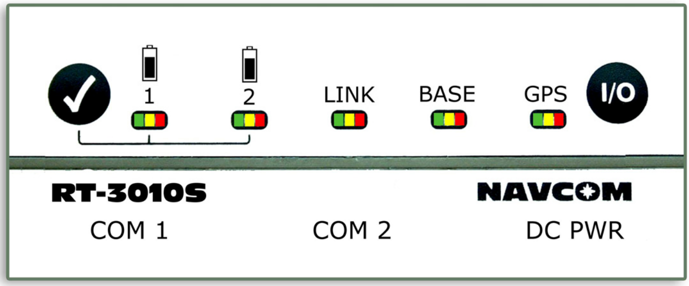


Figure 4: RT-3010 Indicator Panel

The Indicator Panel provides the on/off (I/O) switch and a quick view of the status of the RT-3010 *GPS* sensor, corrections source, and batteries. Each of the five indicators has three *LED*s, which depict status as detailed in the tables below.

To power the unit on or off, the 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

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

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.

Base LEDs

If the RT-3010 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 *LED*s for the type of corrections being output.

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

Table 4: *Base station* Indication

GPS LEDs

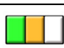
GPS	Status
	Power is off.
	Power is on, No satellites tracked.
	Tracking satellites, *position* not available yet.
	Non-differential positioning.
	Code based differential positioning.
	*Dual frequency* Phase positioning.

Table 5: *GPS* Light Indication

The *GPS LED*s will blink at the PVT positioning rate selected.

Battery LEDs

A fully charged battery indication is a GREEN light, and an extremely low battery is indicated by a RED light. Different combinations of the three *LED* colors indicate various battery levels. Table 6 illustrates the possible scenarios and the estimated voltage level (as a percentage) remaining in the battery. The battery *LED*s will blink at 5Hz for the battery in use, and 1Hz for the battery in reserve (see Table 6 Blink Rate).

The indicator panel has a Battery Test button, indicated by a √. Depressing this button will give an indication of the battery status as per Table 6, typically for duration of 20 to 30 seconds.

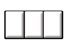
Battery	Status
	Battery Not Installed, or Battery Installed but drained.
	Greater Than 80% Remaining
	60% - 80% Remaining
	40% - 60% Remaining
	20% - 40% Remaining
	Less Than 20% (Solid; No Blink Rate)
In Use	*LED*(s) Blink Rate at 5Hz
Not In Use	*LED*(s) Blink Rate at 1Hz

Table 6: Battery Status *LED* Indicator

The Battery lights are software configurable via the appropriate NavCom *proprietary command*. The factory default *LED* states are described in Table 7.

Batteries are NOT charged in the unit! If external power is applied, the battery light will indicate the status of the batteries and NOT the external power source.

Chapter 3 Installation

This chapter provides guidance on hardware installation for optimum performance.

Preparation

Charging The Batteries

The batteries (*P/N* 59-020101-0001) will be in a partially charged state when you receive your RT-3010. It is recommended that you complete one full charge cycle (approximately 10 hours) before attempting to use the batteries. Only use the supplied battery charger (*P/N* 92-310046-3001) and Universal AC/DC adapter (*P/N* 82-020003-5001) to charge the batteries otherwise damage to the batteries could occur.

The charger can accommodate 4 batteries and has independent charging bays for simultaneous charging. The battery charger has a GREEN *LED* to indicate that power is applied to the charger. Adjacent to each battery bay, is a RED *LED* and a GREEN *LED* that indicates the charge state of each battery. A GREEN light indicates the charging of the battery is complete, and a RED light indicates the battery is in the process of being charged.

Batteries should not be stored in the charger for periods greater than 5 days. This will cause the charging indicator *LED*s to shut off giving a false indication of a defective battery. If this occurs, place the battery in the RT-3010 and power on for ~10-15 minutes in order to slightly discharge the battery.

To charge the batteries follow the procedure below:

- Connect the Universal AC/DC adapter (*P/N* 82-020003-5001) to the battery charger assembly (*P/N* 92-310046-3001).

- Plug the opposite end of the Universal AC/DC power adapter into an AC receptacle. The GREEN POWER *LED* should light up.

- Insert each battery into a battery bay. The RED *LED* adjacent to that bay will light.

- One full charge cycle takes ~8 to ~10 hours to complete.

Installing/Removing the Batteries

The batteries are Lithium Ion type, which have none of the memory effects seen in NiCad rechargeables. Batteries are shipped in a partially charged state. Batteries should receive one full charge cycle before use.

The batteries should be removed from the RT-3010 if the unit will not be used for >1 week, see Chapter 5 Safety Instructions/Battery.

Warning: Lithium Ion Battery Pack should be used with designated charger only (*P/N* 92-310046-3001)! Do Not short circuit battery contacts. Do Not store above 60 deg C (140 deg F). Do Not disassemble battery. Do Not expose to fire, explosive hazard. DO dispose of the battery in accordance with the manufacturer's specifications or your local regulations (See Chapter 5 Safety Instructions).

- **Battery Installation:**

  The batteries are keyed so as to prevent inverse installation. There are two locking clips on either side of the end of the battery as shown in Figure 5. Slide the battery into its chamber. Press each end firmly until a "snap" or "click" sound is heard. Repeat for the other end.

- **Battery Removal:**

  Using the thumb and the middle finger, depress the two locking clips firmly. The battery should pop out enough to be pulled free of the chamber.

Care should be exercised when removing the batteries. If the battery is in an inverted state, it may fall free to the ground when the locking clips are depressed.

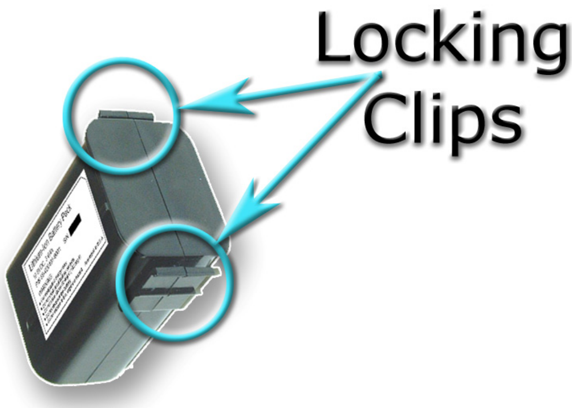


Figure 5: Battery Locking Clips

Mounting the RT-3010

The RT-3010 housing is fitted with a female 5/8" *BSW* threaded mount with a depth of 16mm (0.63"). This is the means of mounting the RT-3010 to the surveyor's pole, or any apparatus that accepts the thread size, as seen in Figure 2.

Communications Ports

Connect the supplied *LEMO* 7-Pin end of the NavCom serial cable (NavCom *P/N* 94-310090-3003) to *COM 2* (factory default Control Port) connector of the RT-3010. Connect the *DB9S* end to your controlling device. Note that some devices may require an additional adaptor, as the receiver is configured as a DCE device.

By factory default *COM 2* is the control port for the RT-3010. *COM 1* can be designated as the control port by using the appropriate NavCom *proprietary commands*. NOTE: Some output data types, such as NMEA messages, cannot output on the Control Port.

Figure 6: Communications Port Interface

If you desire to provide external power to the RT-3010, you will need an optional NavCom External Power cable (*P/N* 94-310060-3010). Construction specifications are detailed in Chapter 2 Interfacing.

GPS Sensor

The all in one construction of the *GPS* sensor allows it to be mounted on a surveyor's pole or any apparatus via the female 5/8" thread mounting receptacle on the bottom of the housing. (See Figure 2) The sensor should be stored in its ruggedized storage case when not in use. It should not be placed in a space where it may be exposed to excessive heat, moisture, or humidity.

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.

There are no user serviceable parts inside the RT-3010 *GPS* sensor. Opening the unit will compromise the environmental seal and 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-3010 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-3010. 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 reception or transmission of the correction data.

The RT-3010 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-3010 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 7 & 8 illustrates a proper and improper *RTK reference station* installation.

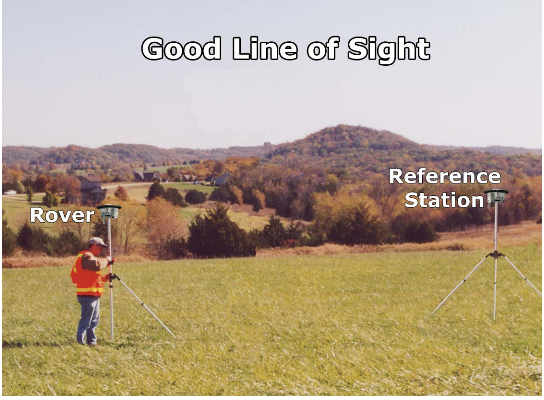


Figure 7: Good Line of Sight *RTK* setup

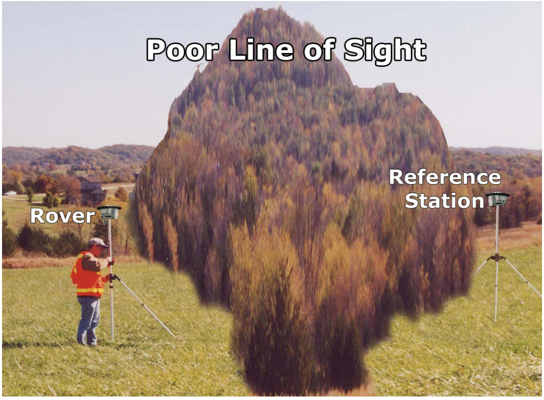


Figure 8: Poor Line of Sight *RTK* setup

Chapter 4 Configuration

The RT-3010 *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

COM1

Configuration - Data port

Rate – 19.2Kbps

Output of NMEA messages GGA & VTG scheduled @ 1Hz rate

COM2

Configuration - Control Port

Rate – 19.2Kbps

Input/output of Navcom Proprietary messages used for Navigation and receiver setup. Table 7 describes the default messages that provide the user the best opportunity to initiate surveying with minimal effort.

The user has full control over the types of messages utilized and their associated rates by using either Navcom Technologies StarUtil or a third party software/Utility.

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	600 Seconds	Identification Block
B0	On Change	Raw Measurement Data
B1	On Change	*PVT* Block

Table 7: Factory Setup Proprietary Messages *COM* 2

The term "On Change" indicates that the RT-3010 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.

- 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, including *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-2100 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, Status, *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.

Advanced Configuration Settings

If a third party *Controller* Solution was provided with your RT-3010 *GPS* sensor, please refer to that manual/user's guide.

Chapter 5 Safety Instructions

The RT-3010 *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 this 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.

RF Exposure Compliance

The RT-3010 complies with the FCC exposure limits. Users and bystanders are required to be a minimum of 20 cm away from the *SSR* transmitting antenna when used in the basic configuration. If transmitting system is modified from basic setup, check FCC regulations for compliance with exposure limits.

Maintenance

The NavCom equipment may be cleaned using a new lint free cloth moistened 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

If the RT-3010 is used 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.

Battery

The battery pack contains Lithium Ion cells and should be used with the supplied charger only (*P/N* 92-310046-3001). Any short circuit battery contacts could result in an explosion, and the release of toxic fumes.

Do Not store above 40°C (104° F) or below 0°C (32° F). Do Not disassemble battery; there are no user serviceable parts inside. Do Not expose to fire, this could result in an explosion, and the release of toxic fumes. DO dispose of the battery properly; cover the contacts with a non-conductive material and recycle.

The Lithium Ion battery packs are classified by the United States Federal Government as non-hazardous waste and are safe for disposal in the normal municipal waste stream per your local regulations. These batteries, however, do contain recyclable materials and are accepted for recycling by the Rechargeable Battery Recycling Corporation's (RBRC) Battery Recycling Program. Go to the RBRC website at *www.rbrc.org/* for additional information.

Outside the USA, used Lithium Ion batteries must be disposed of in accordance with local regulations.

Please follow these Warnings and Cautions.

WARNING

When Using the Battery

(1) Misusing the battery may cause the battery to get hot, explode, or ignite and cause serious injury. Be sure to follow the safety rules listed below:

- Do not place the battery in fire or heat the battery.
- Do not install the battery backwards so that the polarity is reversed.
- Do not connect the positive terminal and the negative terminal of the battery to each other with any metal object (such as wire).
- Do not carry or store the batteries together with necklaces, hairpins, or other metal objects.

- Do not pierce the battery with nails, strike the battery with a hammer, step on the battery, or otherwise subject it to strong impacts or shocks.
- Do not solder directly onto the battery.
- Do not expose the battery to water or salt water, or allow the battery to get wet.

(2) Do not disassemble or modify the battery. The battery contains safety and protection devices, which if damaged, may cause the battery to generate heat, explode or ignite.

(3) Do not place the battery on or near fires, stoves, or other high-temperature locations. Do not place the battery in direct sunshine or use or store the battery inside cars in hot weather. Doing so may cause the battery to generate heat, explode, or ignite. Using the battery in this manner may also result in a loss of performance and a shortened life expectancy.

CAUTION

(1) This device is NOT to be used by small children.

(2) When the battery is worn out, insulate the terminals with adhesive tape or similar materials before disposal.

(3) Immediately discontinue use of the battery if, while using, charging, or storing the battery, the battery emits an unusual smell, feels hot, changes color, changes shape, or appears abnormal in any other way.

(4) Do not place the batteries in microwave ovens, high-pressure containers, or on induction cookware.

(5) In the event that the battery leaks and the fluid get into one's eye, do not rub the eye. Rinse well with water and immediately seek medical care. If left untreated the battery fluid could cause damage to the eye.

(6) If the RT-3010 is to be stored unused for a period >1 (one) week, the batteries should be removed as the sensor will draw current from the batteries even when turned off.

WARNING

While Charging the Battery

(1) Be sure to follow the rules listed below while charging the battery. Failure to do so may cause the battery to become hot, explode, or ignite and cause serious injury.

- When charging the battery, use only the specified battery charger (*P/N* 92-310046-3001), and Universal AC/DC adapter (*P/N* 82-020003-5001)
- Do not attach the batteries to a power supply plug or directly to a car's cigarette lighter.
- Do not place the batteries in or near fire, or into direct sunlight. When the battery becomes hot, the built-in safety equipment is activated; preventing the battery from charging further, and heating the battery can destroy the safety equipment and can cause additional heating, breaking, explosion, or ignition of the battery.

(2) Do not continue charging the battery if it does not recharge within the specified charging time. Doing so may cause the battery to become hot,

explode, or ignite. The temperature range over which the battery can be charged is 0°C to 45°C. Charging the battery at temperatures outside of this range may cause the battery to become hot or to break. Charging the battery outside of this temperature range may also harm the performance of the battery or reduce the battery's life expectancy.

WARNING

When Discharging the Battery

Do not discharge the battery using any device except for the specified device. When the battery is used in devices aside from the specified device it may damage the performance of the battery or reduce its life expectancy, and if the device causes an abnormal current to flow, it may cause the battery to become hot, explode, or ignite and cause serious injury.

CAUTION

The temperature range over which the battery can be discharged is 0°C to +40°C. Use of the battery outside of this temperature range may damage the performance of the battery or may reduce its life expectancy.

CAUTION

Batteries should not be stored in the charger for periods greater than 5 days. This will cause the charging indicator *LED*s to shut off giving a false indication of a defective battery. If this occurs, place the battery in the RT-3010 and power on for ~10-15 minutes in order to slightly discharge the battery.

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 manufacturer's 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-3010 *GPS* sensor. Accessing the inside of the equipment will void the equipment warranty.

Typically the RT-3010 may be mounted on a pole, tripod, or if configured as a *reference station*, a building top. Care should be taken to ensure that the RT-3010 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-3010

The RT-3010 *GPS* is 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 with 26 channels (12 L1 GPS + 12 L2 GPS + 2 SBAS)
- 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)
- Operates from internal batteries or external power
- Automatic power management
- Internal memory to record field data (64 Mbytes)
- NavCom compact RTK or standard RTCM v2.2 or CMR

- 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)

Physical and Environmental

• Size:	10.4"W x 5.5"H (264mm x 140mm)
• Weight:	5.5lb. (2.5kg)
• External Power:	
Input Voltage:	12 VDC nominal 10 VDC to 30 VDC
Consumption:	< 5 W
• Connectors:	
I/O Ports:	2 x 7 pin LEMO
DC Power:	4 pin LEMO
SSR Antenna:	TNC-F
• Temperature (ambient):	
Operating:	-40° C to +55° C
Storage:	-40° C to +85° C [w/o Batteries] 0° C to +60° C [with Batteries]
• Humidity:	95% non-condensing

Measurement Performance

• RTK Accuracy (RMS):	
Position (H):	< 1 cm + 1ppm
Position (V):	< 2 cm + 1ppm
• Real-time DGPS (code) Accuracy (RMS)	
Position (H):	12 cm + 2ppm
Position (V):	25 cm + 2ppm
Velocity:	0.01 m/s

- 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

- User programmable output rates:
  - PVT: 1, 2, 5Hz Standard
    Optional, 10 & 25Hz
  - Raw data: 1, 2, 5Hz Standard
    Optional, 10, 25, & 50Hz

- Up to 10 km if using NCT Base & Rover
- Up to 200 km if using receiver as base station and mobile.

- Data Latency:
  - PVT: < 20 ms at all nav rates
  - Raw data: < 20 ms at all rates
- Time-to-first-fix:
  - Cold Start, Satellite Acquisition: < 60 Seconds (typical)
  - Satellite Reacquisition: < 1 Second
  - Ambiguity Resolution: < 2 Seconds (90% of time)
- Dynamics:
  - Acceleration: up to 6g ➢
  - Speed: < 515 m/s ➢
  - Altitude: < 60,000ft

➢ Export laws restrict speed & altitude

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; 1200 bps to 115.2 kbps

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
Proprietary NMEA Type (Output Only)	SET
• Code Corrections:	RTCM 1 or 9 WAAS/EGNOS

• RTK Correction Data (I/O) v.2.2: NCT Proprietary
RTCM 18,19 or 20,
CMR+ CMR (Msg. 0, 1, 2)

LED Display Functions (Default)

Battery 1 & 2:	Status
Link:	Base Radio Signal Strength
Base:	Type of Correction/Rate
	Rover; = N/A
GPS:	Position Quality

Satellite Based Augmentation System Signals

- WAAS/EGNOS
- WCT (proprietary)

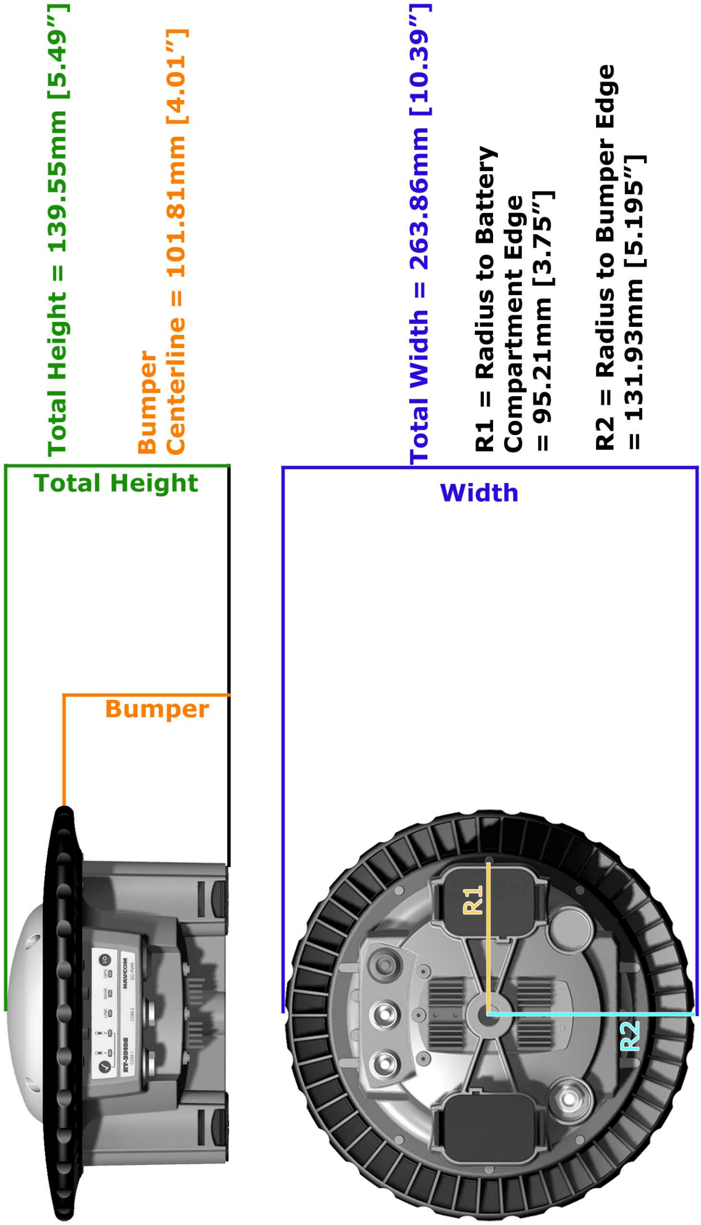


Figure A1: RT-3010 Dimensions

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.

datum A reference datum is a known and constant surface which can be used to describe the location of unknown points. Geodetic datums define the size and shape of the earth and the origin and orientation of the coordinate systems used to map the earth.

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 unit less 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 RT-3010 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 400 MHz to approximately 1600 MHz. The *GPS* carrier frequencies L1 (1575.4 MHz) 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

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*.