SF-2050

GPS Products User Guide

find your way

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SF-2050 *GPS* Products User Guide

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StarFire™ Licensing

The *StarFire*™ signal requires a subscription that must be purchased in order to access the service. Licenses are non-transferable, and are subject to the terms of the *StarFire* Signal License agreement. For further details on the *StarFire* Signal Network, its capabilities, terms and conditions visit *www.navcomtech.com* or send an email inquiry to *sales@navcomtech.com*

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 SF-2050 *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 SF-2050 *GPS* sensor delivers unmatched accuracy to the precise positioning community who need a cost-effective, high performance *GPS* sensor. These unique receivers use the *StarFire*™ Network, NavCom's worldwide *Differential GPS* system, for instant decimeter level *position* accuracy, virtually anywhere in the world, anytime.

System Overview

- *GPS* Sensor

The SF-2050 sensor consists of a 10-*channel dual frequency* precision *GPS* sensor with two additional channels for receiving *Satellite Based Augmentation System (SBAS)* signals and an *L-Band* demodulator for reception of NavCom's *StarFire*™ Network correction service, for instant decimeter-level position accuracy, anywhere in the world, anytime. 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 115kbps serial ports. NavCom's SF-2050 model sensors deliver unmatched positioning accuracy to system integrators needing a cost-effective, high performance differential *GPS* sensor.

The SF-2050 has a built-in *L-Band* demodulator for reception of NavCom's *StarFire*™ Network correction service giving an immediate solution for the system integrator. Additionally, the sensor simultaneously accepts corrections for *DGPS (WAAS/EGNOS)* assuring seamless position output.

The SF-2050G is packaged for mobility. It can be used for *Geographical Information System (GIS)*, aerial and hydrographic surveying, and *post-processed dual-frequency* surveys. 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 SF-2050M is ideal for vehicle mounting to suit a wide variety of machine guidance and control applications in agriculture, mining, aerial, and hydrographic surveying. It is equipped with additional features allowing interconnectivity with a wide variety of antennas, vehicle data busses and other instrumentation to suit specific applications and configurations. The SF-2050M also has a 1*PPS* output port and a combined *Event/CAN Bus* interface port.

Both SF-2050 models can output proprietary raw data as fast as 50Hz (optional) and *Position Velocity Time* (*PVT*) data as fast as 25Hz (optional) through two 115kbps serial ports with less than 20ms latency. The horizontal accuracy of 1 cm or better and the vertical accuracy of 2 cm or better are maintained as each output is independently calculated based on an actual *GPS* position measurement, as opposed to an extrapolation between 1Hz measurements.

- Integrated *GPS* and Inmarsat Band 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 and is certified to 70,000 feet.

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

- Controller

The SF-2050 *GPS* sensor is designed for use with an external Controller 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: SF-2050 Supplied Equipment

❶ SF-2050 *GPS* Sensor
(SF-2050G *P/N* 92-310059-3001)
(SF-2050M *P/N* 93-310059-3002)

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

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

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

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 SF-2050 User's Guide {Not Shown}
(Hard Copy *P/N* 96-310002-3001)

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

Applications

The SF-2050 *GPS* sensors meet 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 SF-2050 *GPS* sensor has many unique features:

- *StarFire*™ [Subscription Required]

  The ability to receive NavCom's unique *StarFire*™ correction service is fully integrated within each unit. No additional equipment is required. A single set of corrections can be used globally enabling a user to achieve decimeter level positioning accuracy without the need to deploy a separate *base station*. Thus saving time and capital expenditure.

- Positioning Flexibility

  The SF-2050 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 SF-2050 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 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 25Hz for high dynamic applications.

- *GPS* Performance

The NCT-2000D *GPS* engine at the heart of the SF-2050 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 SF-2050 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 SF-2050 *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 a 4-pin *LEMO* female connector located on the bottom front panel of the SF-2050, and is labeled 'DC PWR' as shown in Figure 2. The pin designations of this connector 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 SF-2050 *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.

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 SF-2050 *GPS* sensor. This cable is supplied with the SF-2050 series of *GPS* sensors. 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:

0.87 Amps at 12VDC (10.4 Watts)
0.45 Amps at 24VDC (10.8 Watts)
0.38 Amps at 30VDC (11.4 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 SF-2050 *GPS* sensor is fitted with two 7-pin female *LEMO* connector communication ports located at the bottom front of the *GPS* sensor as shown in Figure 2 labeled *COM1* and *COM2*. 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 (NavCom P/N 94-310059-3006) is supplied with the SF-2050 for easy startup. The cable construction is described in Figure 4.

LEMO Pins	Signal Nomenclature [*DCE* w/respect to *DB9*]	*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

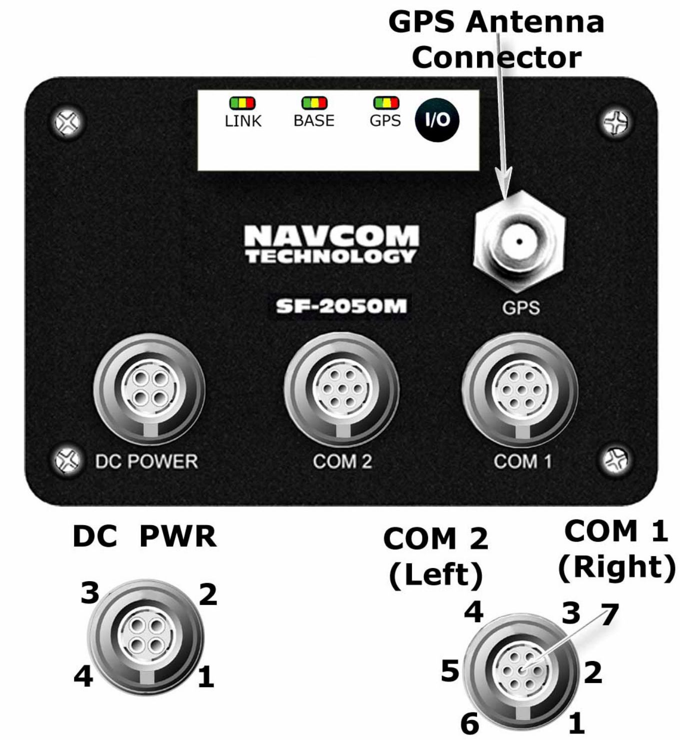


Figure 2: SF-2050 Front View

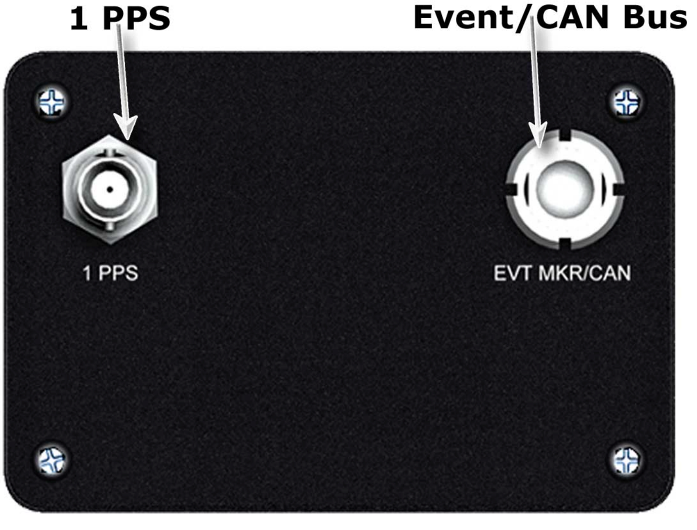


Figure 3: SF-2050M Only Back View

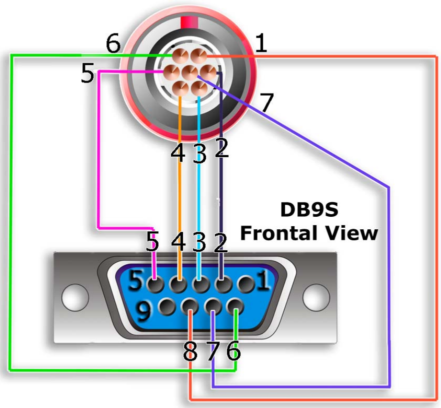


Figure 4: NavCom Serial Cable *P/N* 94-310059-3006

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

Indicator Panel

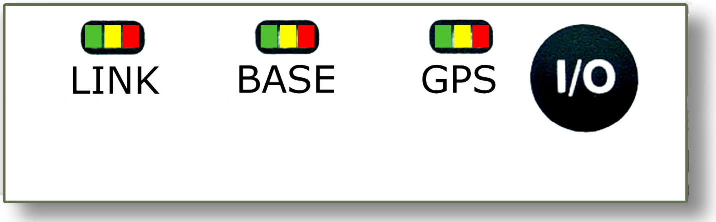


Figure 5: SF-2050 Indicator Panel

The Indicator Panel provides the on/off (I/O) switch and a quick view of the status of the SF-2050 *GPS* sensor, corrections source & type, and StarFire™ signal strength. Each of the three indicators has three LEDs, 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 LEDs 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.

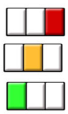
LINK	Status
	Command Mode
	Repeating Red to Amber to Green indicates Searching *StarFire*™ signal
	Strong Signal Strength from *StarFire*™
	Medium Signal Strength *StarFire*™
	Weak Signal Strength *StarFire*™

Table 3: Link Light Indication

- Base LEDs

BASE	Status
	The BASE LEDs are not utilized in the SF-2050 *GPS* sensor

Table 4: *Base station* Indication

- *GPS LED*s

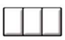
GPS	Status
	Power is off
	Power is on. No satellites tracked
	Tracking satellites, *position* not available yet
	Non-differential positioning
	Code based differential positioning
	*Dual frequency* Phase positioning

Table 5: *GPS* Light Indication

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

1 PPS

The SF-2050M 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. NavCom *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 SF-2050M 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 SF-2050M *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 *Even*t Input. Detailed specifications of the *CAN Bus* can be found on the NavCom website at *support.navcomtech.com*

The SF-2050M 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 SF-2050M and have it output position information relative to the time the photograph was taken. It requires input impedance of 50 Ohms, a minimum High Level Input of 2.5V, and a minimum Low Level Input of 1.2V. The propagation delay is less than 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 NavCom P/N 94-310062-3003. Detailed specifications of the *Event* Input can be found on the NavCom website at support.navcomtech.com

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 inch *BSW* threaded mount with a depth of 16mm (0.63 inch). This should be used as the primary means of mounting the antenna.

It is possible to remove the 5/8 inch *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 inch) typically used in the marine industry for navigation antennas.

Figure 6: Tri-Mode *GPS* Antenna

The eight Philips 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 7-degree *elevation mask* for optimum *GPS* satellite visibility. 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.

To take full advantage of the *StarFire*™ service, there needs to be a clear line of sight between the antenna and the local Inmarsat satellite. Inmarsat satellites are geo-synchronized 35,768kms above the Equator currently at Longitudes 098°West, 025°East, and 109°East.

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

GPS Sensor

The SF-2050 *GPS* sensor can be mounted to a flat surface using the four screw slots shown in Figure 7. In environments with high vibration, shock absorbers suitable for 1.8kg (4lbs) should be considered.

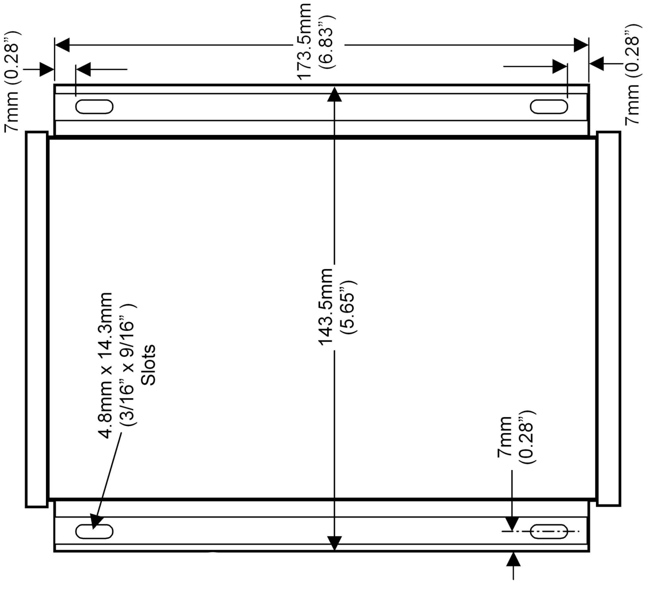


Figure 7: SF-2050 Base Plate Dimensions

The SF-2050G 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 SF-2050 *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.

Communication Ports

Connect the supplied *LEMO* 7-Pin end of the NavCom serial cable (NavCom *P/N* 94-310059-3006) to *COM 2* (factory default control port) connector of the SF-2050. 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 SF-2050. *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 8: Communication Port Connections

GPS Antenna Connector

The connector used on the SF-2050 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 (nominally), 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 SF-2050 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 SF-2050 *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, noise from the amplifier, 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 SF-2050 *GPS* sensors have 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 SF-2050. *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* communicate is factory defaulted to 19.2k Baud. This baud rate can be changed to accommodate faster data rates.

The standard factory configuration for the SF-2050 allows for the basic operation of the system. The Control Port factory default for 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
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*.

- 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 SF-2050 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 SF-2050 *GPS* sensor, please refer to that manual/user guide.

Chapter 5 Safety Instructions

The SF-2050 *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 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 SF-2050 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 case 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 SF-2050 *GPS* sensor. Accessing the inside of the equipment will void the equipment warranty.

Care should be taken to ensure that the SF-2050 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*

SF-2050G and SF-2050M

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
- Global decimeter-level accuracy using StarFire™ corrections
- Fully automatic acquisition of satellite broadcast corrections
- Rugged and lightweight package for mobile applications
- Accepts external DGPS input in RTCM v2.2 or CMR format
- L1 & L2 full wavelength carrier tracking
- C/A, P1 & P2 code tracking
- User programmable output rates:
- Minimal data latency
- 2 separate WAAS/EGNOS channels
- Superior interference suppression

- Patented multipath rejection
- Supports NMEA 0183 v3.1 messages
- Self-survey mode (position averaging)
- CAN bus interface (SF-2050M Only)
- 1PPS Output (SF-2050M Only)
- Event Marker (SF-2050M Only)

Physical and Environmental

• Size (L x W x H):	< 8.18” x 5.67” x 3.06”
• Weight:	<4 lbs (1.81 kg)
• External Power:	
Input Voltage:	10 VDC to 30 VDC
Power Consumption:	<10 W
• Connectors:	
I/O Ports:	2 x 7 pin Lemo
DC Power:	4 pin Lemo
RF Connector:	TNC (with 5 VDC bias for internal/LNA)
• Temperature (ambient):	
Operating:	-40° C to +55° C
Storage:	-40° C to +85° C
• Humidity:	95% non-condensing

Measurement Performance

• Real-time StarFire DGPS Accuracy:	
Position (H):	<15 cm
Position (V):	<30 cm
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: <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) (SF-2050M Only)

*Restricted by export laws

Connector Assignments

- Data Interfaces:
  - 2 serial ports; from 1200 bps to 115.2 kbps
  - CAN Bus I/F (SF-2050M Only)
  - Event Marker I/P (SF-2050M Only)
  - 1PPS (SF-2050M Only)

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 *StarFire*™

LED Display Functions (Default)

• Link *StarFire*™	Signal Strength (Default) (User Programmable)
• Base Station	N/A in SF-2050 (User Programmable)
• GPS Position Quality	

Satellite Based Augmentation System Signals

- WAAS/EGNOS
- *StarFire*™

B GPS Antenna Technical Specifications

The standard antenna supplied with the SF-2050 *GPS* sensor is capable of Tri-Frequency 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

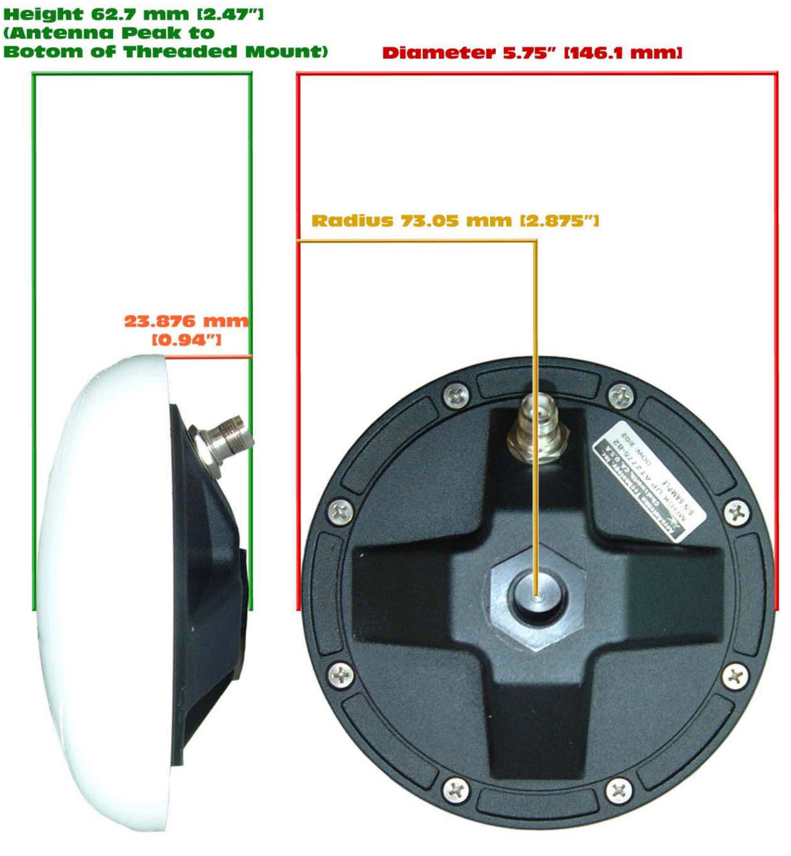


Figure 9: Tri-Mode Antenna Dimensions

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*

Description

The *StarFire*™ Network is a global system for the distribution of *Differential GPS* corrections giving the user the ability to measure his *position* anywhere in the world with exceptional reliability and unprecedented accuracy of better than 10cm (4 inches). Because the *Differential GPS* corrections are broadcast via Inmarsat geo-stationary satellites, the user needs no local *reference stations* or *post-processing* to get this exceptional accuracy. Furthermore, the same accuracy is available virtually any where on the earth's surface on land or sea from 76°N to 76°S *latitude* due to the worldwide coverage of the geo-stationary satellites.

Infrastructure

The system utilizes the *GPS* satellite system, *L-Band* communication satellites, and a worldwide network of *reference stations* to deliver real-time high precision positioning.

To provide this unique service, NavCom has built a global network of *dual-frequency reference stations*, which constantly receive signals from the *GPS* satellites as they orbit the earth. Data from these *reference stations* is fed to two USA Processing Centers in Redondo Beach, California and Moline, Illinois where they are processed to generate the differential corrections.

From the two Processing Centers, the correction data is fed via redundant and independent communication links to satellite uplink stations at Laurentides in Canada, Goonhilly in England and Auckland in New Zealand for uplink to the geo-stationary satellites.

The key to the accuracy and convenience of the *StarFire*™ system is the source of *DGPS* corrections. *GPS* satellites transmit navigation data on two *L-Band* frequencies. The *StarFire*™ *reference stations* are all equipped with geodetic-quality, *dual-frequency* receivers. These reference receivers decode *GPS* signals and send precise high quality *dual-frequency pseudorange* and carrier phase measurements back to the Processing Centers together with the data messages, which all *GPS* satellites broadcast.

At the Processing Centers, NavCom's proprietary *differential* processing techniques used to generate real time precise orbits and clock correction data for each satellite in the *GPS* constellation. This proprietary *Wide Area DGPS* (*WADGPS*) algorithm is optimized for a *dual-frequency* system such as *StarFire*™ in which *dual-*

frequency ionospheric measurements are available at both the reference receivers and the user receivers. It is the use of *dual-frequency* receivers at both the *reference stations* and the user equipment together with the advanced processing algorithms, which makes the exceptional accuracy of the *StarFire*™ system possible.

Creating the corrections is just the first part. From our two Processing Centers, the differential corrections are then sent to the Land Earth Station (*LES*) for uplink to *L-Band* communications satellites. The uplink sites for the network are equipped with NavCom-built modulation equipment, which interfaces to the satellite system transmitter and uplinks the correction data stream to the satellite that broadcasts it over the coverage area. Each *L-Band* satellite covers more than a third of the earth.

Users equipped with a *StarFire*™ precision *GPS* receiver actually have two receivers in a single package, a *GPS* receiver and an *L-Band* communications receiver, both designed by NavCom for this system. The *GPS* receiver tracks all the satellites in view and makes *pseudorange* measurements to the *GPS* satellites. Simultaneously, the *L-Band* receiver receives the correction messages broadcast via the *L-Band* satellite. When the corrections are applied to the *GPS* measurements, a *position* measurement of unprecedented real time accuracy is produced.

Reliability

The entire system meets or exceeds a target availability of 99.99%. To achieve this, every part of the infrastructure has a built-in back-up system.

All the *reference stations* are built with duplicate receivers, processors and communication interfaces, which switch automatically or in response to a remote control signal from the Processing Centers. The data links from the *reference stations* use the Internet as the primary data link and are backed up by dedicated communications lines, but in fact the network is sufficiently dense that the *reference stations* effectively act as back up for each other. If one or several fail, the net effect on the correction accuracy is not impaired.

There are two continuously running Processing Centers, each receiving all of the reference site inputs and each with redundant communications links to the uplink *Land Earth Stations* (*LES*). The *Land Earth Stations* are equipped with two complete and continuously operating sets of uplink equipment arbitrated by an automatic fail over switch. Finally, a comprehensive team of support engineers maintains round the clock monitoring and control of the system.

The network is a fully automated self-monitoring system. To ensure overall system integrity, an independent integrity monitor receiver, similar to a standard *StarFire*™ user receiver, is installed at every *reference station* to monitor service quality. Data from these integrity monitors is sent to the two independent processing hubs in Redondo Beach, California and Moline, Illinois. Through these integrity monitors the network is continuously checked for overall *DGPS* positioning accuracy, *L-Band* signal strength, data integrity and other essential operational parameters.

How to Access the *StarFire*™ Service

StarFire™ is a subscription service. The user pays a subscription, which licenses the use of the service for a predetermined period of time.

Subscriptions can be purchased for quarterly, biannual or annual periods and are available via a NavCom authorized representative, or by logging on to *support.navcomtech.com*

An authorized subscription will provide an encrypted keyword, which is specific to the Serial Number of the NavCom receiver to be authorized. This is entered into the receiver using the provided *Controller* Solution.

The only piece of equipment needed to use the *StarFire*™ system is a *StarFire*™ receiver. NavCom offers a variety of receivers configured for different applications. Details of all the *StarFire*™ receivers are available from the NavCom authorized local representative or the NavCom website at: *www.navcomtech.com*

StarFire™ receivers include a *dual-frequency GPS* receiver and an *L-Band* receiver integrated into a single unit to provide the exceptional precise positioning capability of the *StarFire*™ Network, anywhere, anytime.

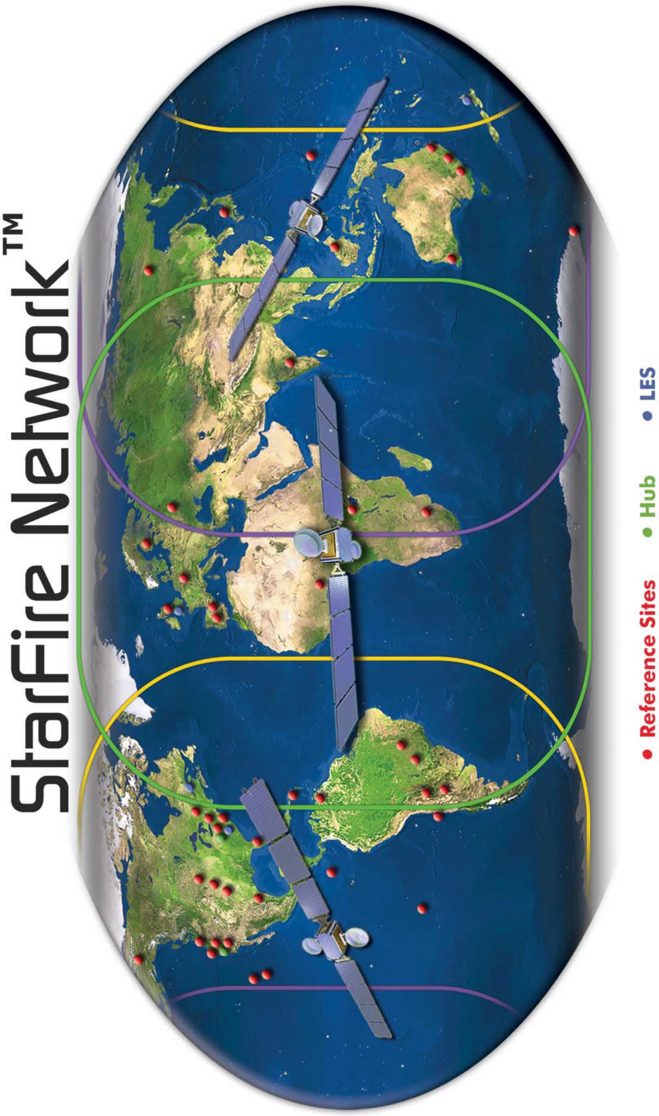


Figure 10: StarFire™ Network

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 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 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, 0° to 90°.

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 (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*.