DGPS Receiver

DGPS-220-PC

(USCG/IALA Beacon compatible)

User Manual

Version A

Please read this manual before operating the unit

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Content

Chapter 1 Overview

Congratulations on the purchase of **DGPS-220-PC**, a new member of our successful DGPS-220 receiver family. You will find the device an ***accurate***, ***reliable*** and ***useful*** aid to your positioning pursuits.

Before introducing you our new receiver, we would like to give you some basic background knowledge about GPS and DGPS, which should be helpful for you to better understand your DGPS-220-PC.

1.1 What is GPS?

GPS (Global Positioning System) is a satellite-based global navigation system created and operated by the United States Department of Defense (DOD). Originally intended solely to enhance military defense capabilities, GPS capabilities have expanded to provide highly accurate position and timing information for many civilian applications.

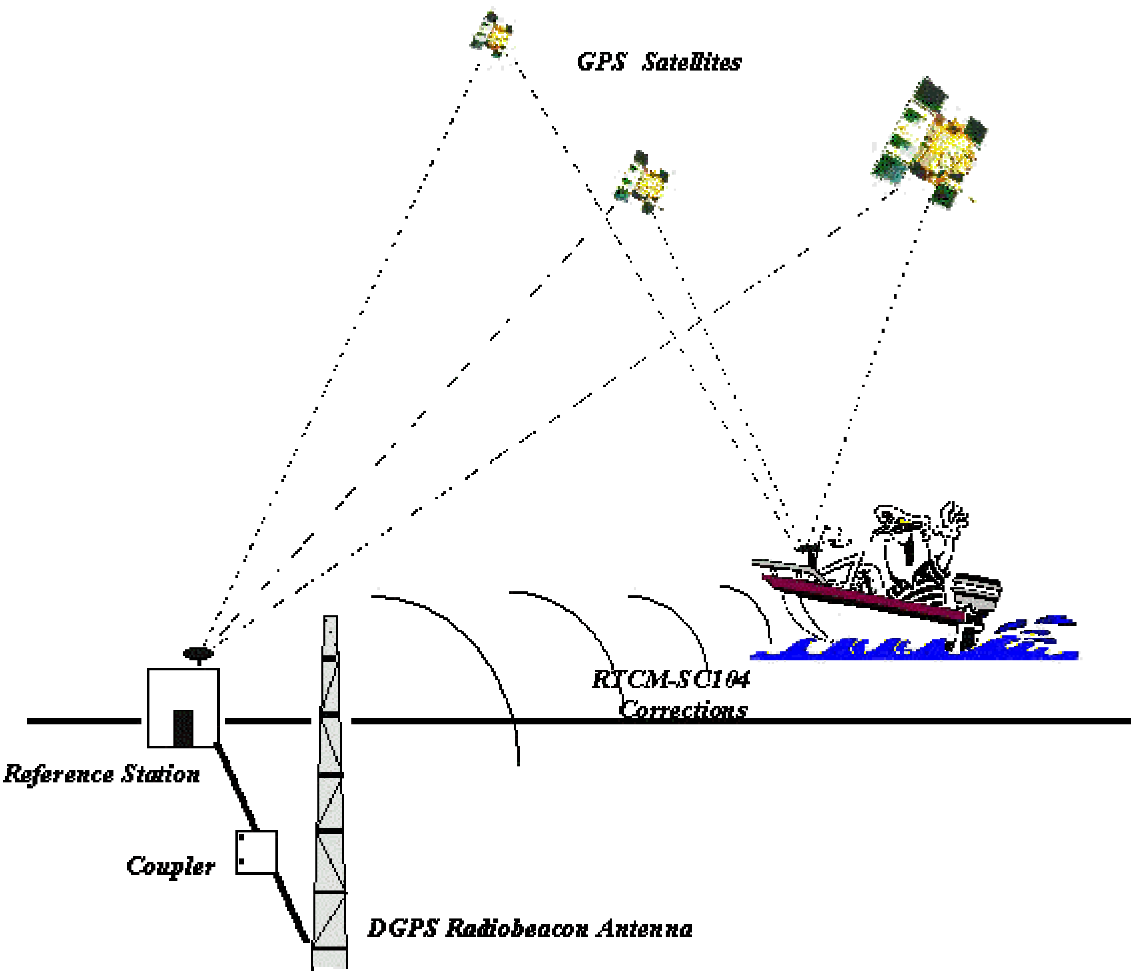
An in-depth study of GPS is required to fully understand how it works, but simply stated: Twenty four satellites in six orbital paths circle the earth twice each day at an inclination angle of approximately 55 degrees to the equator. This constellation of satellites continuously transmit coded positional and timing information at high frequencies in the 1500 Megahertz range. GPS receivers with antennas located in a position to clearly view the satellites, pick up these signals and use the coded information to calculate a position in an earth coordinate system.

GPS is the navigation system of choice for today and many years to come. While GPS is clearly the most accurate worldwide all-weather navigation system yet developed, it still can exhibit significant errors. GPS receivers determine position by calculating the time it takes for the radio signals transmitted from each satellite to reach earth. It's that old "Distance = Rate x Time" equation. Radio waves travel at the speed of light (Rate). Time is determined using an ingenious code matching technique within the GPS receiver. With time determined, and the fact that the satellite's position is reported in each coded navigation message, by using a little trigonometry the receiver can determine its location on earth.

Position accuracy depends on the receiver's ability to accurately calculate the time it takes for each satellite signal to travel to earth. This is where the problem lies. There are primarily five sources of errors which can affect the receiver's calculation. These errors consist of (1) ionosphere and troposphere delays on the radio signal, (2) signal multi-path, (3) receiver clock biases, (4) orbital errors, also known as ephemeris errors of the satellite's exact location, and (5) the intentional degradation of the satellite signal by the DOD. This intentional degradation of the signal is known as "Selective Availability (SA)" and is intended to prevent adversaries from exploiting highly accurate GPS signals and using them against the United States or its allies. However, on May 1, 2000, U.S. President Bill Clinton ordered Selective Availability (SA) turned off at midnight (Coordinated Universal Time). Now, civilian GPS users around the world will no longer experience the up to 100 meter (approximate 300 feet) random errors that SA added to keep GPS a more powerful tool for the military. Today, GPS units are accurate to within 20 meters (approximately 60 feet); although in good conditions, units should display an error of less than 10 meters. The combination of these errors in conjunction with poor satellite geometry can limit GPS accuracy to 100 meters 95% of the time and up to 300 meters 5% of the time. Fortunately, many of these errors can be reduced or eliminated through a technique known as "Differential."

1.2 What is DGPS?

DGPS works by placing a high-performance GPS receiver (reference station) at a known location. Since the receiver knows its exact location, it can determine the errors in the satellite signals. It does this by measuring the ranges to each satellite using the signals received and comparing these measured ranges to the actual ranges calculated from its known position. The difference between the measured and calculated range is the total error. The error data for each tracked satellite is formatted into a correction message and transmitted to GPS users. The correction message format follows the standard established by the Radio Technical Commission for Maritime Services, Special Committee 104 (RTCM-SC104) These differential corrections are then applied to the GPS calculations, thus removing most of the satellite signal error and improving accuracy. The level of accuracy obtained is a function of the GPS receiver.



Differential GPS Broadcast Site

1.3 Why use DGPS?

DGPS accuracy and integrity are better than GPS:

- Accuracy improvement (2drms): Positions of 10 meters or better are achievable using DGPS (USCG signals) vs. 100 meters or better for GPS (Standard Positioning Service)

- Integrity improvement: Provides an independent check of each GPS satellite's signal, and reports whether it's good or bad.

1.4 How is DGPS used?

DGPS receivers collect navigational signals from all GPS satellites in view, plus differential corrections from a nearby DGPS site. (Many DGPS receivers consist of two units: a GPS receiver, with a data "port" for DGPS corrections, directly connected to a radio receiver.) DGPS receivers display position, velocity, time, etc., as needed for their marine, terrestrial, or aeronautical applications.

Chapter 2 Introduction of DGPS-220-PC

2.1 What Makes DGPS-220-PC Different:

It is the availability of host-based operation that makes **DGPS-220-PC** different from its predecessor **DGPS-220**, which features automatic search for beacon stations. In addition to the automatic mode, **DGPS-220-PC** now offers a manual mode, an extra feature that allows users themselves to set up in their computing devices the frequencies and baud rates for beacon stations. This feature is designed mainly to provide users with enhanced flexibility in positioning without scarifying accuracy.

As part of effort to free manual-operating users from the hassle of finding beacon stations available for their locations, **DGPS-220-PC** is shipped with a list of beacon stations located worldwide.

Essentially, **DGPS-220-PC** is an integrated GPS/Beacon receiver with built-in antennas, providing differential GPS corrections in NMEA-0183 format for navigation requiring high degree of accuracy.

DGPS-220-PC is a combined high performance GPS receiver and a differential beacon receiver in an extremely compact and fully waterproof enclosure providing 1~5 meter DGPS positioning accuracy by utilizing the broadcasted (283.5~325KHz) differential GPS corrections from the USCG, CCG, or IALA Beacons at no charge. Both GPS and Beacon receivers/antennas are built inside the enclosure, making **DGPS-220-PC** a single device featuring easy installation, maintenance and integrated services.

2.2 Main Features & Applications

2.2.1 The main features of DGPS-220-PC

- High positioning accuracy: 1~5m
- User configurable output sentences
- User programmable output time interval
- User selectable datum (WGS-84 plus 170 user selectable datum)
- Standard RTCM SC-104
- Standard RS-232 & optional RS-422 signal levels
- Wide operating voltage range 12~24V DC
- Compact construction/fully weatherproof
- Excellent noise immunity
- Easy installation & operation

2.2.2 Applications:

- Marine, terrestrial, or aeronautical applications
- Real time and post processing DGPS yield monitors
- Soil sampling location
- Crop and land mapping applications
- Public Safety precise vehicle location
- Construction
- Transportation

Chapter 3 Installation

3.1 Mounting the DGPS-220-PC

3.1.1 Choosing a Location:

To minimize potential reception problems, you are advised to mount the **DGPS-220-PC –**

1. on certain open space with a relatively unobstructed view of the horizon in all directions;
2. outside the path of radar, transmitting antennas and away from other sources of interference such as DC motors, transceivers, solenoids, and other electronic devices; and
3. at certain height to avoid the obstruction of other higher objects nearby.

3.1.2 Mount the DGPS-220-PC:

The **DGPS-220-PC** is designed for a pole mount of a standard 1"-14 marine thread.

1. Place the **DGPS-220-PC** on the 1"-14 threaded mast.
2. Tighten the **DGPS-220-PC** firmly on the pole mount by hand.

Note: Over tightening with a tool will cause damage to the threaded socket at the base of the **DGPS-220-PC**, and such damage goes beyond SANAV warranty.

3. To maximize signal reception, mount the **DGPS-220-PC** parallel to the horizon.

3.1.3 Connector Configuration

DGPS-220-PC comes with a cable with one 7-pin connector at one side that attaches the receiver itself and an open end the other side that can be configured as any kinds of connectors you want. In our example, we have made that open end two DB-9 connectors attaching one of the com ports of your computing device. One DB-9 connector is to receive signals from beacon stations (hereinafter refers to the **Beacon-Station connector**), and the other to receive RTCM-formatted signals from GPS-based satellites (hereinafter refers to the **GPS connector**).

A wiring label illustrating the function of each pin is attached on both the bottom of **DGPS-220-PC** and the cable, as shown below, to help you with configuring the two DB-9 connectors.

PIN#	COLOR	FUNCTION	DESCRIPTION
1	White	Receive-1&2	To receive commands from PC for setting up GPS and/or Beacon receiver's parameters.
2	Green	Transmit-1	To output accurate GPS data in NMEA0183 format.
3	Yellow	Ground	Signal ground common to receive & transmit.
4	Braid	Earth	To be connected to vehicle chasis for EMI suppression if necessary.
5	Blue	Transmit-2	To output status data showing the status of Beacon receiver.
6	Black	Power-	(Negative)
7	Red	Power+	(Positive)Power input DC12V~24V.

Wiring Label

3.2 Routing the Power / Data Cable

The 15-meter Power/Data Cable provided with the **DGPS-220-PC** is terminated on one end with a circular 7-pin connector and on the other end with exposed wires.

3.2.1 Choosing a Cable Route:

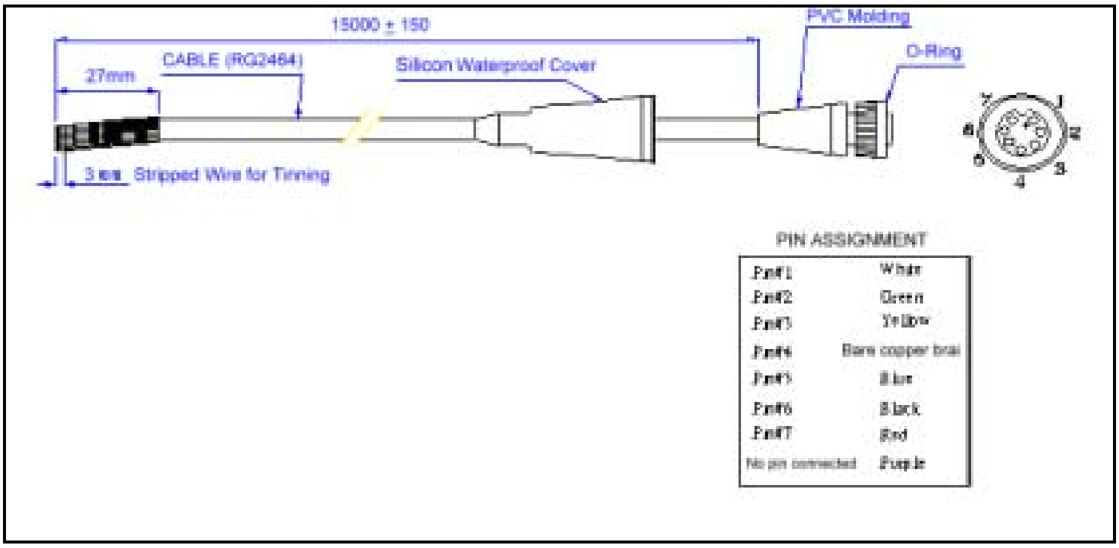
Right after the mounting of the **DGPS-220-PC**, you should go on routing the power/data cable from the **DGPS-220-PC** to your computing device. While routing the cable, choose the most direct path to the display device and consider the following suggestions:

1. Keep the cable away from corrosive chemicals, sharp or abrasive surfaces, and from areas of excessive heat.
2. Avoid excessive tension, sharp bends or kinks in the cable.
3. Locate the cable away from rotating machinery or reciprocating equipment.
4. Avoid routing the cable through door or window jams.

3.2.2 Securing the Cable:

After the cable routing has been completed, you should now fasten the 7-pin connector to the **DGPS-220-PC** and secure the cable with tie-wraps along the routing.

1. Align the cable connector with the mating connector on the **DGPS-220-PC**. Please note that power has to be turned off if you've previously connected the cable to a power source. Otherwise, ill-matched connection between the pins and the **DGPS-220-PC** connector will damage the receiver.
2. Fasten the interconnection with the locking nut.
3. Seal up the cable connector by pulling the watertight sleeve up to the **DGPS-220-PC**.
4. Use tie-wraps to secure the cable along the routing.



Wiring Layout

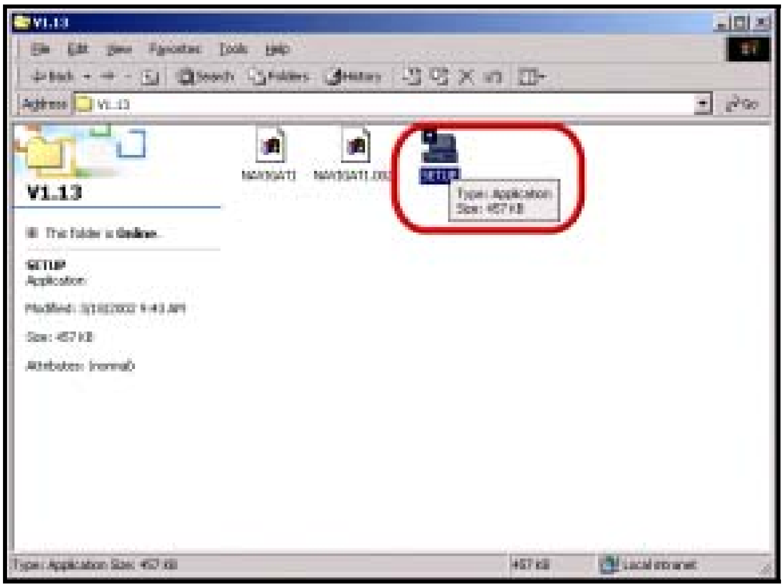
3.3 Software Installation

Since all of the **DGPS-220-PC** operations are carried out in your computing device, the product is especially shipped with one CD, in which an application program called "**DGPS Viewer PC220**" **(version V1.13)** is stored. The "**DGPS Viewer PC220**" is formulated to work with the device.

3.3.1 Installing DGPS Viewer PC220

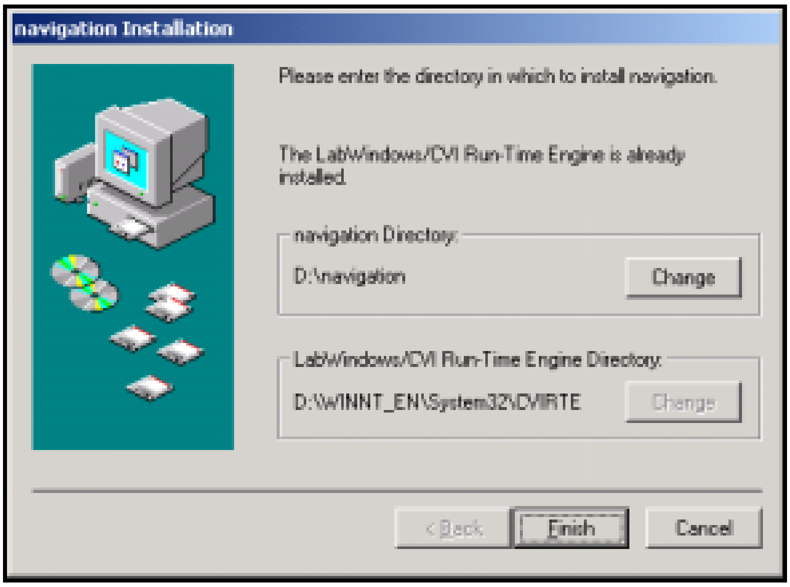
Procedures:

1. Insert the appropriate CD into your computing device. Double-click the setup icon to install the program in your system drive. In our example, we assume the system drive is the **D** drive, as shown below:



Note: The folder name of the software (in our example it is **V1.13**) is subject to change without prior notice.

2. Then an installation window will appear as below:



3. The default folder for the program is in your system drive. If you want to change it, press the **Change** button; otherwise, press the **Finish** button to complete the installation.

Chapter 4 Operation Instruction

DGPS-220-PC can be operated under the manual or the automatic mode, which are detailed as follows:

4.1 Operation Under Manual Mode

This mode is particularly designed for those who are certain about the frequency and the baud rate for a reference beacon station. In general, operating efficiency under this mode is significantly higher than the **Auto Mode**, and thus you are strongly recommended to choose this mode whenever it is possible.

4.1.1 Contacting Beacon Stations

Procedures:

1. Click Start → Programs → navigation. Then launch the program by double-clicking the icon 

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2. The main screen of the program will then appear as below:

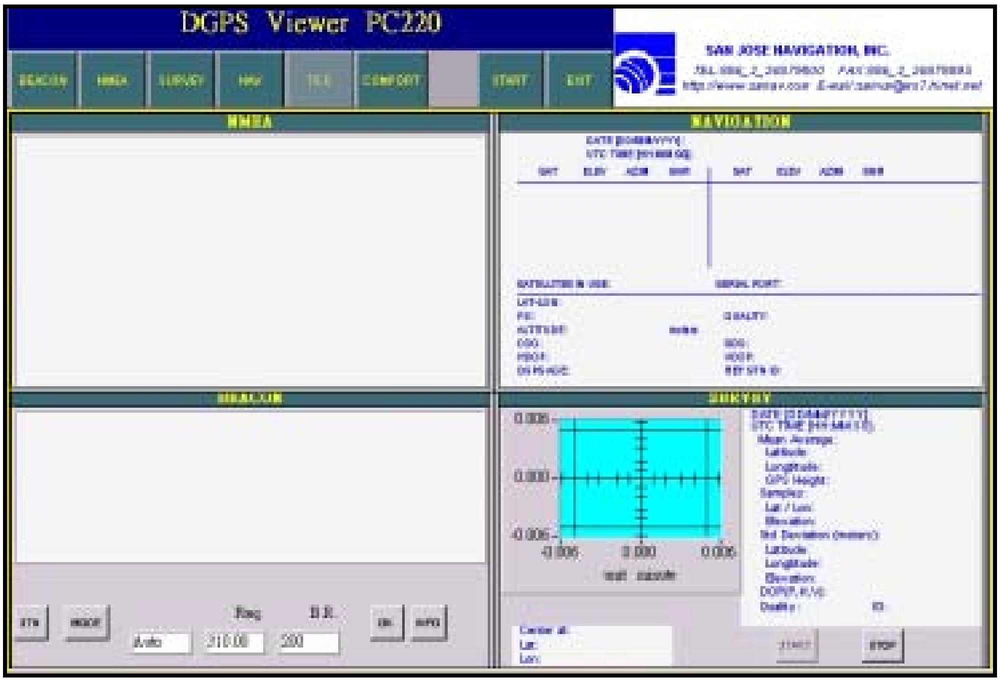
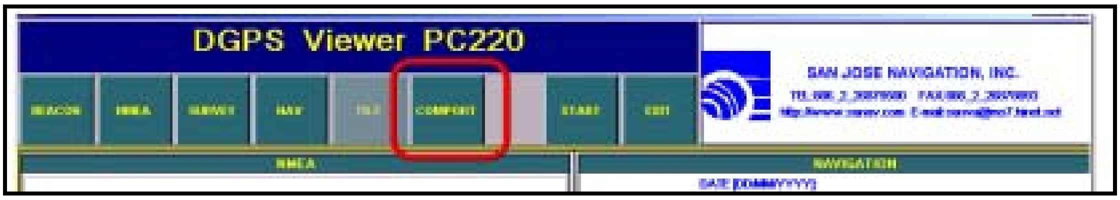


Fig 1

Referring to the Fig 1, there are four separate windows, namely, **NMEA**,

BEACON, **NAVIGATION** and **SURVEY**.

3. Press the **Comport** button to set up the Com Port of your computing device:



4. A dropdown List will then appear as follows:

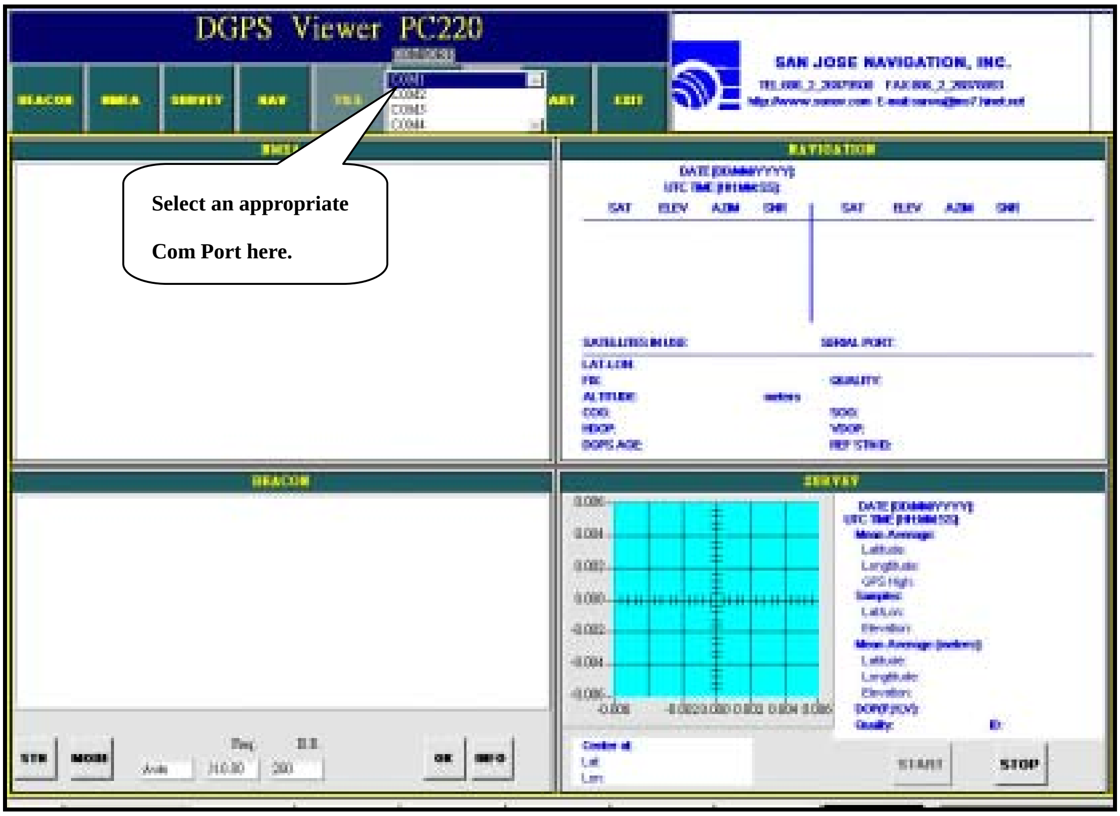
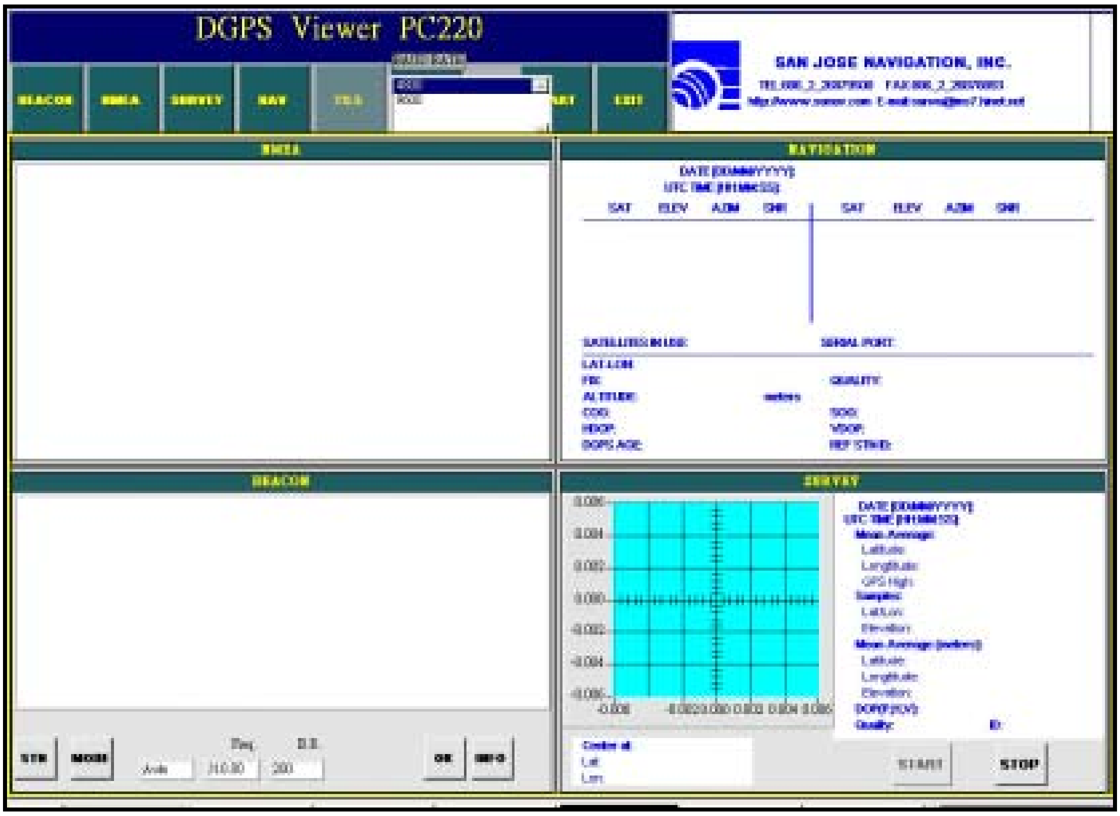


Fig 2

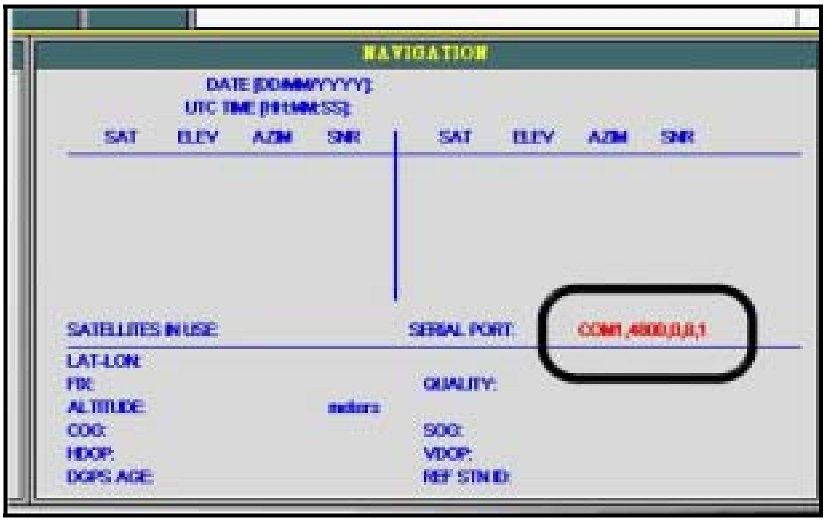
Referring to the Fig 2, there are four comports for you to select. In our example, we connect the **DGPS-220-PC** with our computing device through the **Com Port 1**, so we select **COM1** here by double-clicking it.

Note: If you use other comport, such as the **Com Port 2**, for connection, you must select **COM2** accordingly.

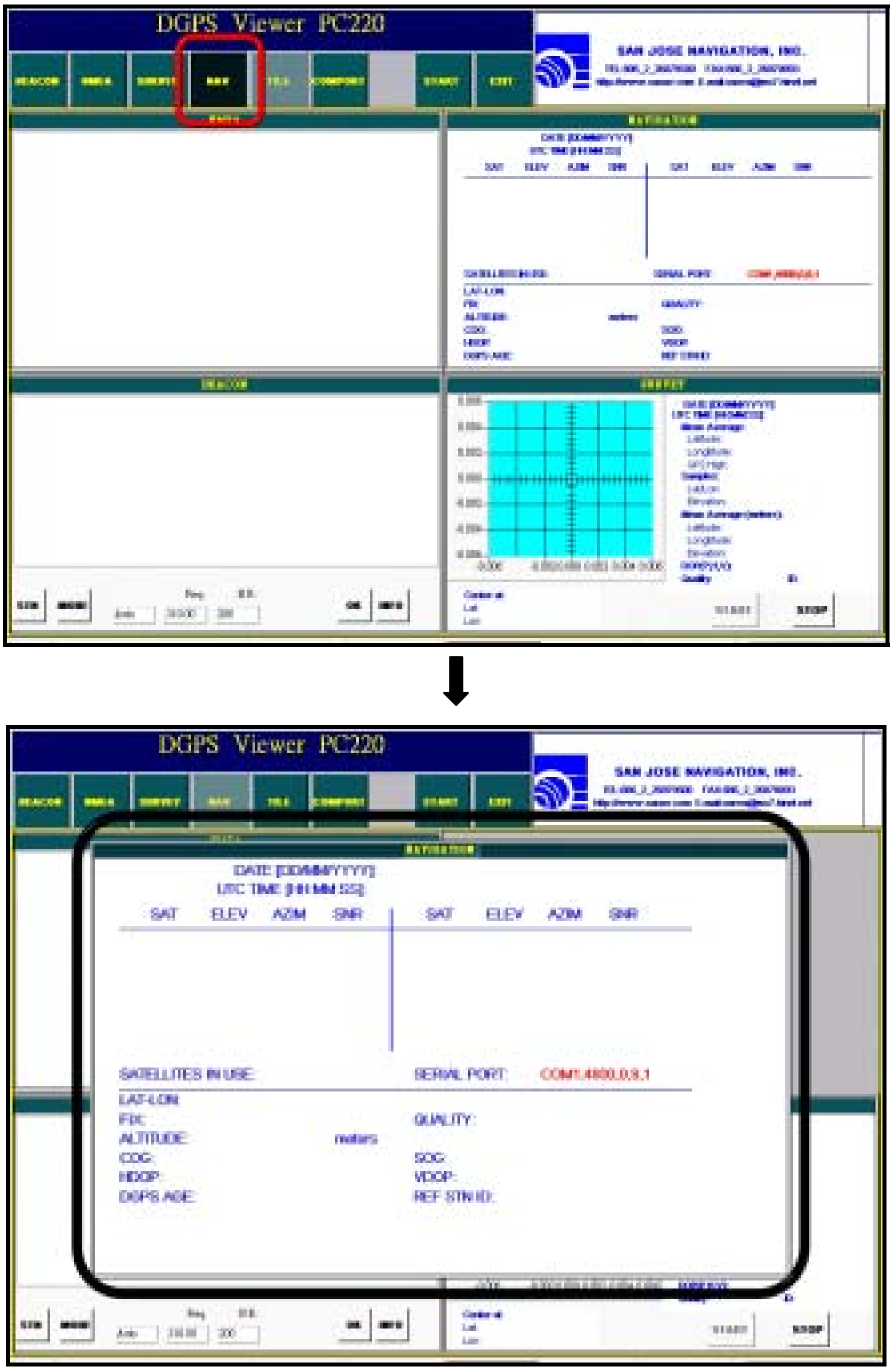
5. The program will then ask you to select an appropriate baud rate. In line with general GPS configuration, we strongly recommend you to select 4800 here by double-clicking it.



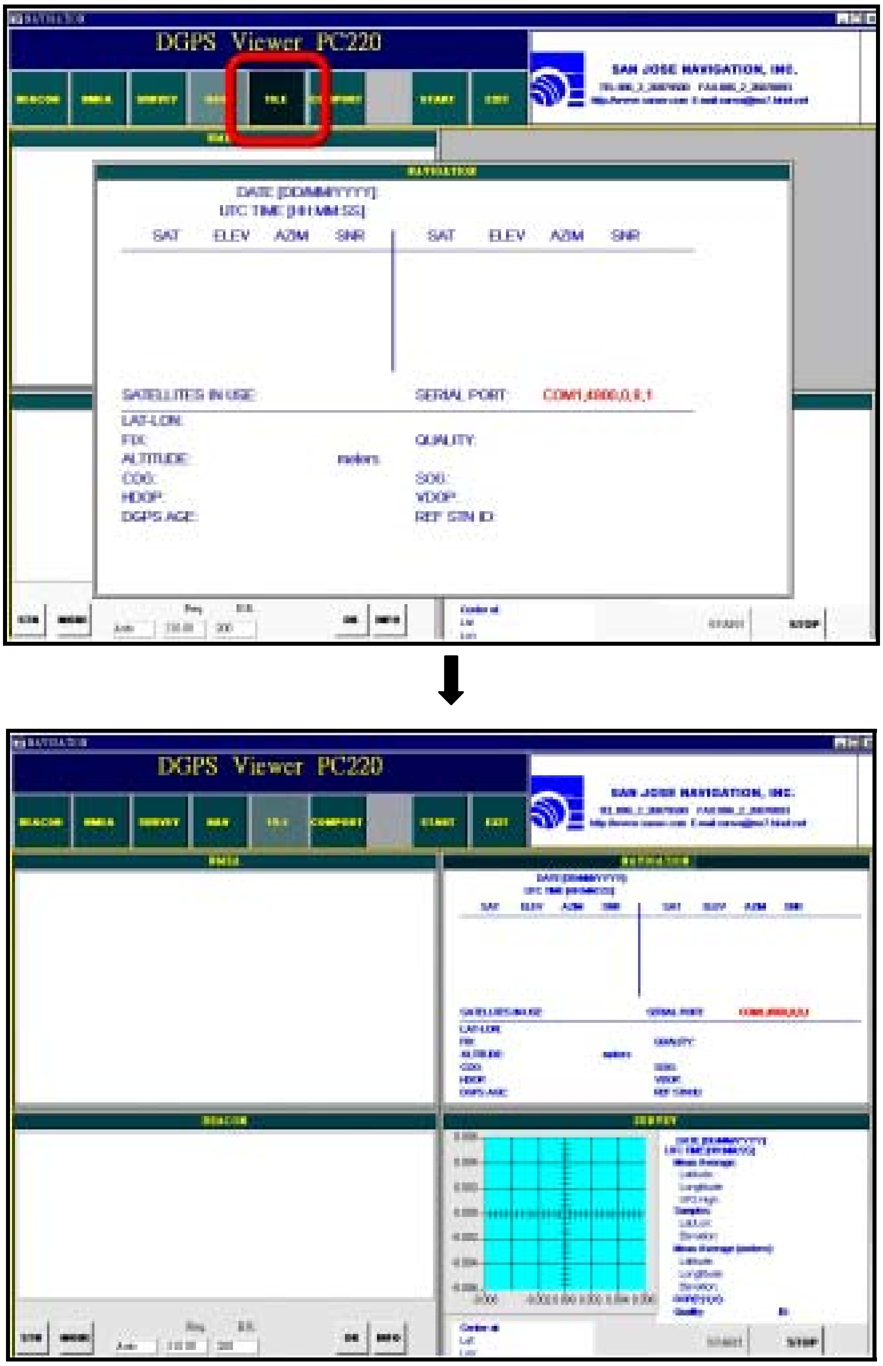
6. The configuration you have done will then display at the **SERIAL PORT** of the **NAVIGATION** window, as shown below:



✧ Tips: To enlarge one of the four windows, just press the corresponding button at the menu bar in the top of the main screen. For instance, to enlarge the **NAVIGATION** window, press the **NAV** button, as shown below:

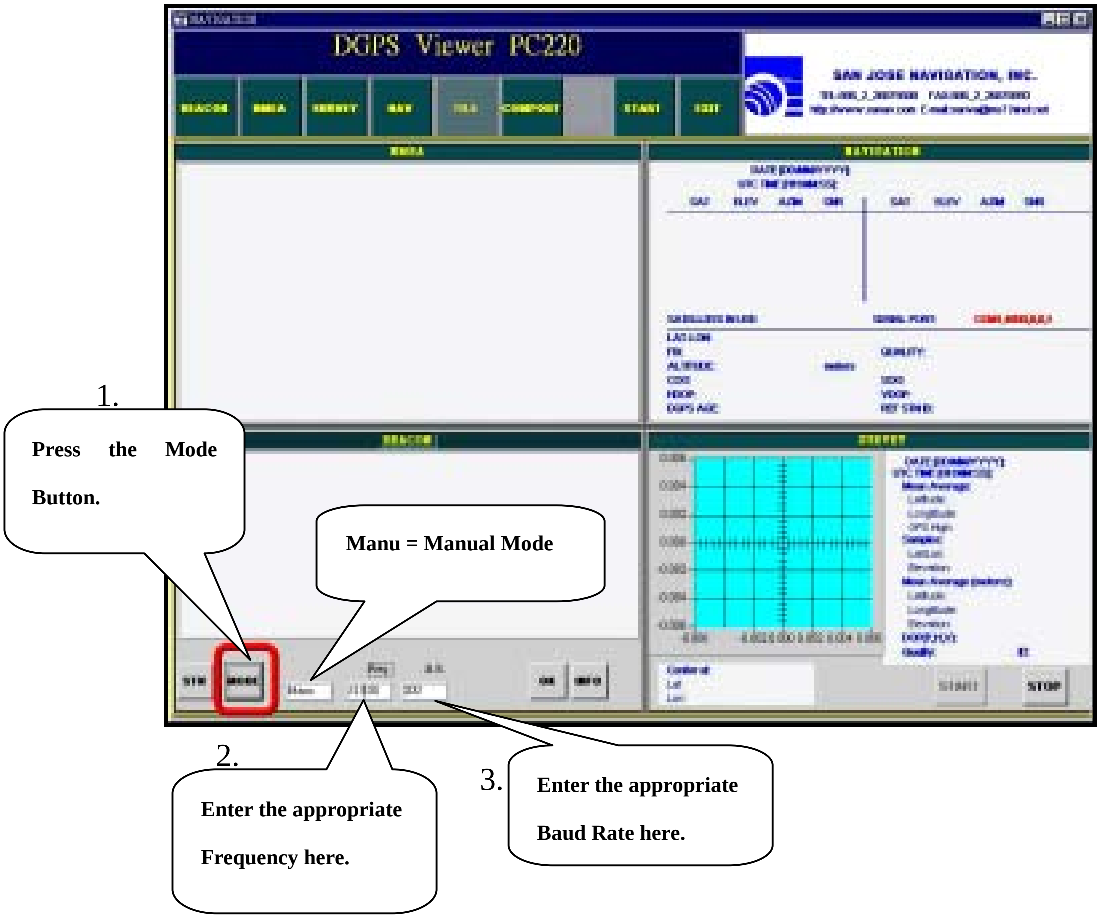


To minimize the window, press the **Tile** button at the menu bar in the top of the main screen:


DGPS Viewer PC220
SAN JOSE NAVIGATION, INC.
UTC TIME [HH:MM:SS]
SAT ELEV AZIM SNR SAT ELEV AZIM SNR
SATELLITES IN USE
SERIAL PORT
LAT-LON
FIX
QUALITY
ALTITUDE
meters
COG
SOG
HDOP
VDOP
DGPS AGE
REF STN ID
STOP
DGPS Viewer PC220
SAN JOSE NAVIGATION, INC.
STOP

7. Press the **Start** button to activate the Com Port:

8. Press the **Mode** button at the bottom of the main screen to select the **Manual** mode (which appears as **Manu** in the field). Then enter the appropriate frequency and the baud rate in the **Freq.** and **B.R.** fields respectively:



9. Press the **OK** button to complete the beacon-station configuration:

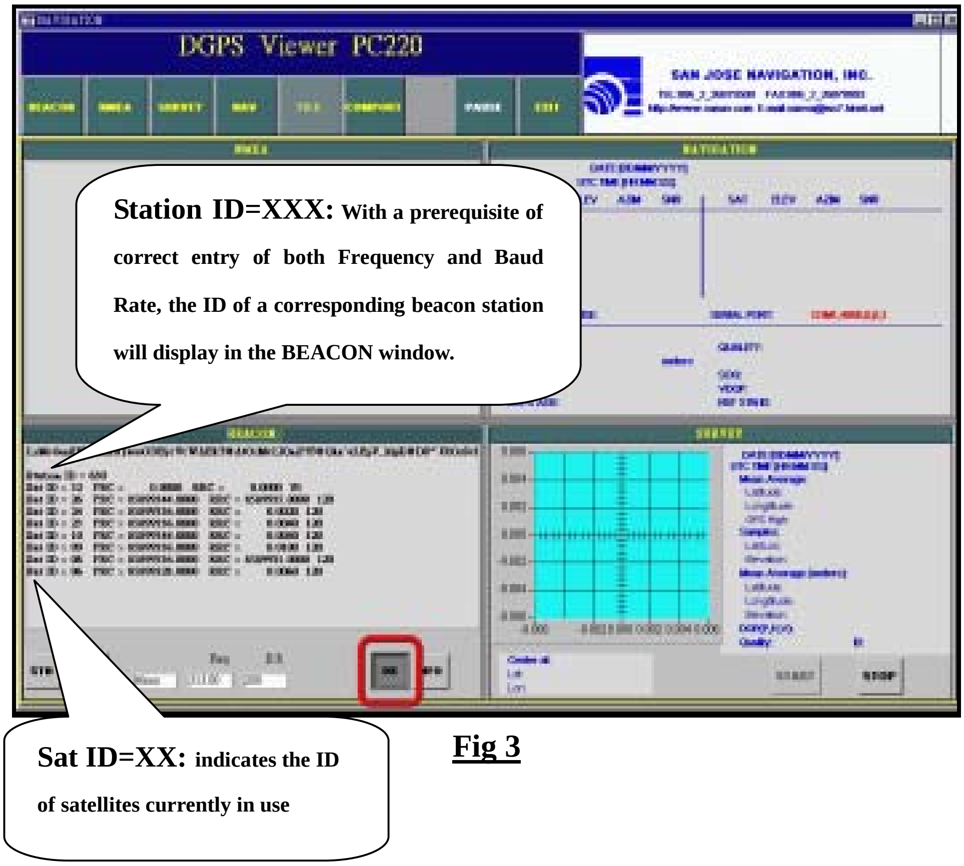
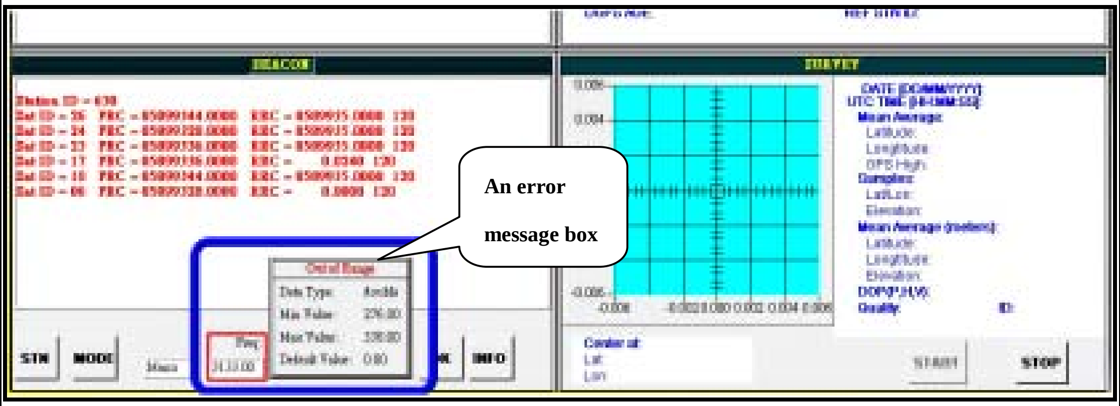


Fig 3

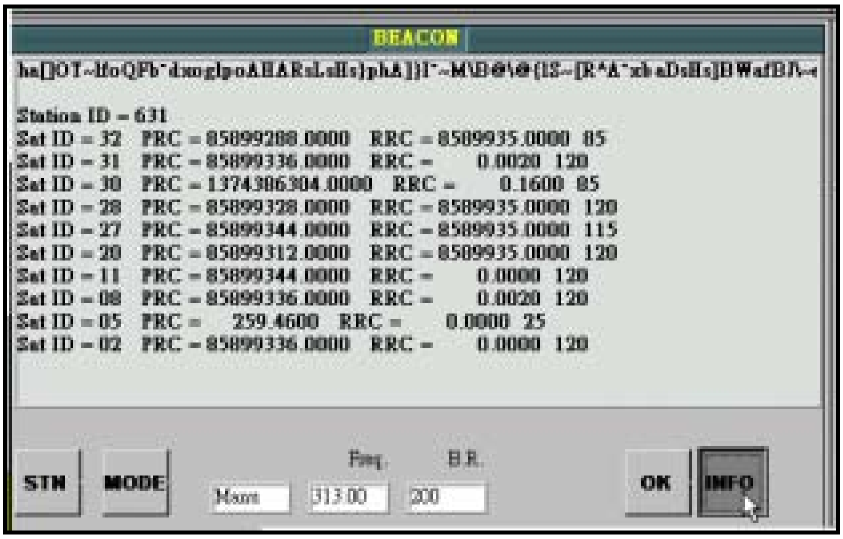
Referring to the Fig 3, RTCM signals from a reference beacon station displays in the **BEACON** window after the **OK** button is pressed, with a prerequisite of correct entry.

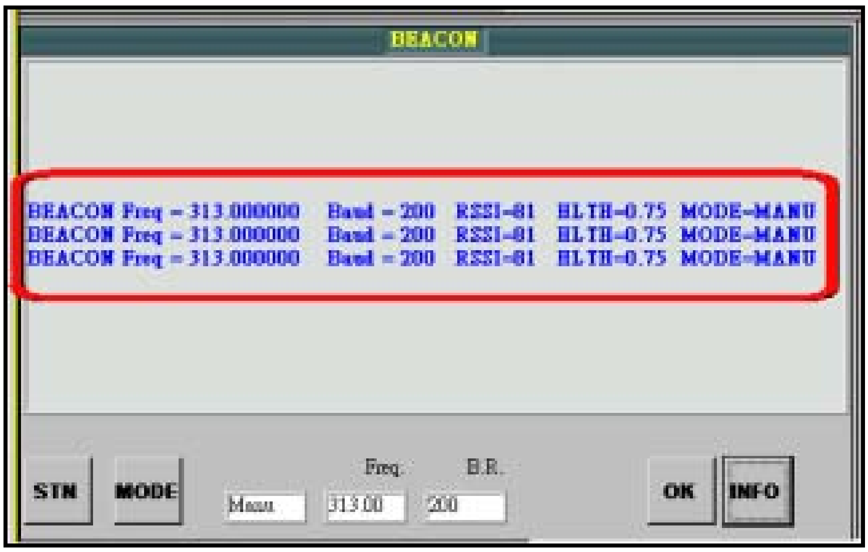
Note: If your entry is out of range, an error message box will appear immediately:



As long as your entry of Frequency and Baud Rate can reach the beacon station currently available within your range, the information on **Station ID**, **Sat ID**, **PRC** and **RRC** will flash every five minutes. These data will be gone, however, if your original entry is no longer able to contact that beacon station for two minutes.

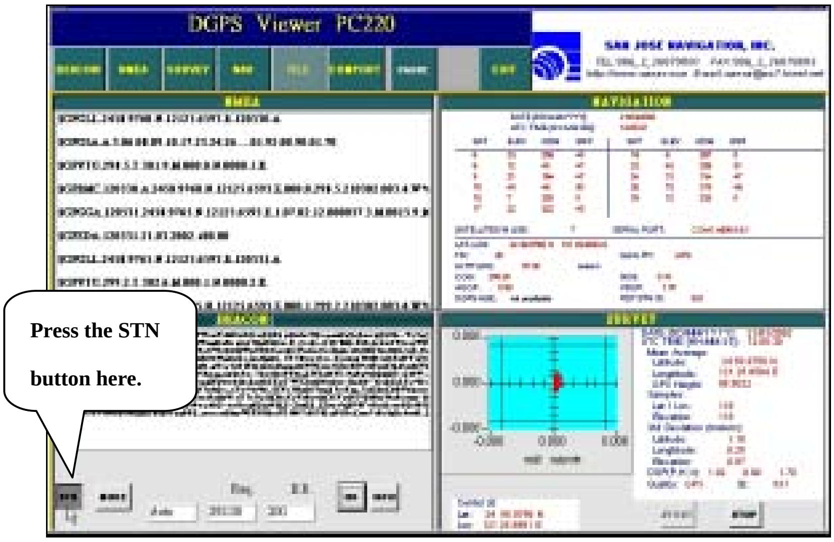
To learn about the current status of the beacon-station configuration, press the **INFO** button:

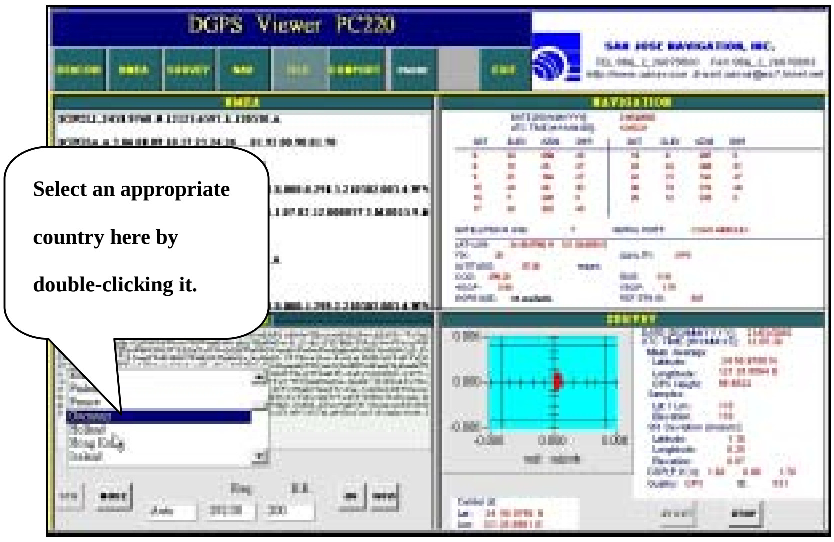


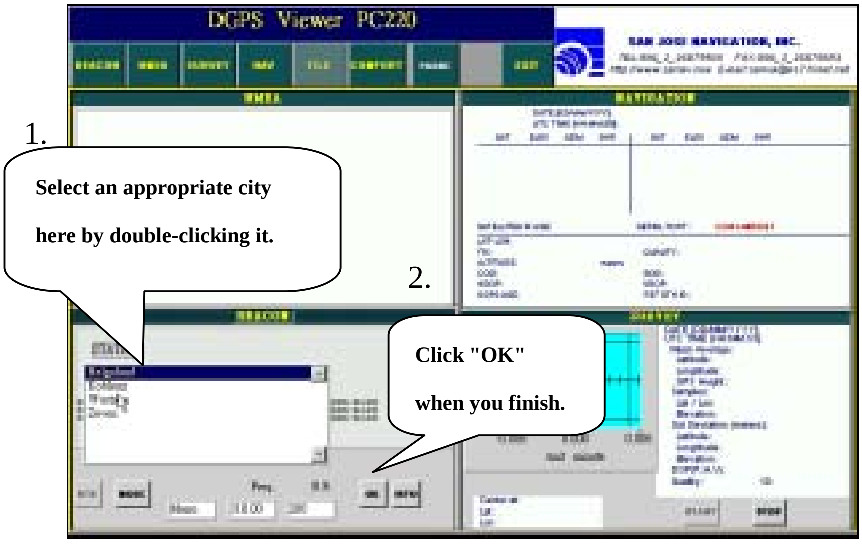


4.1.2 Applying Built-in Beacon Station List

DGPS Viewer PC220 provides you with a list of beacon stations currently available all over the world. To use this feature, press the **STN** button of the **BEACON** window, and click **OK** when you finish:

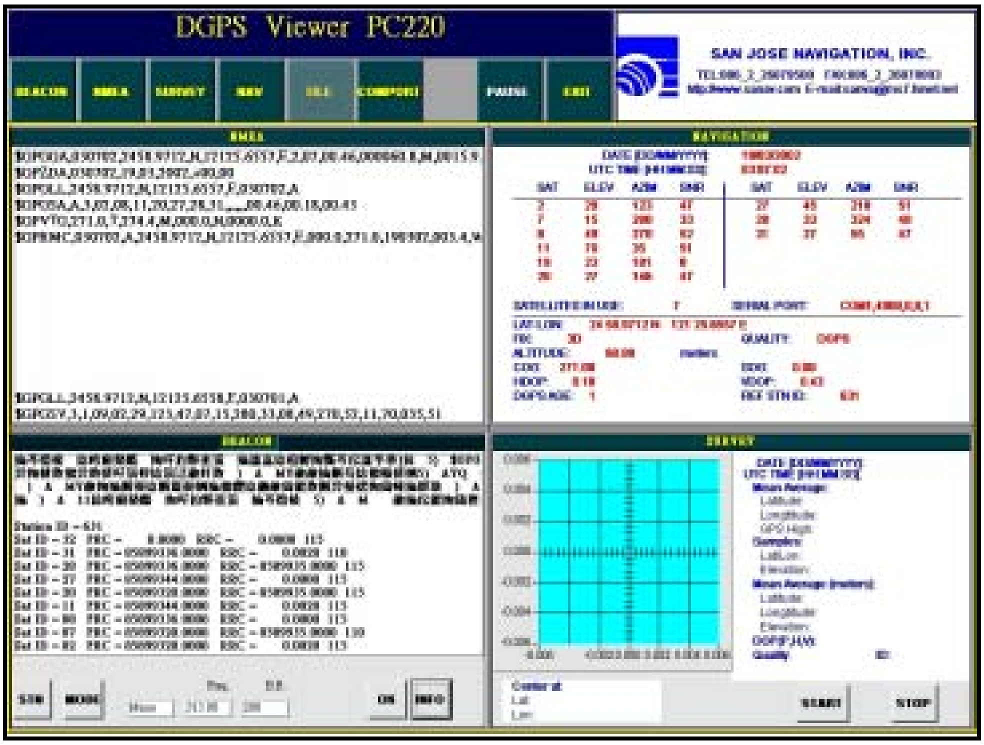






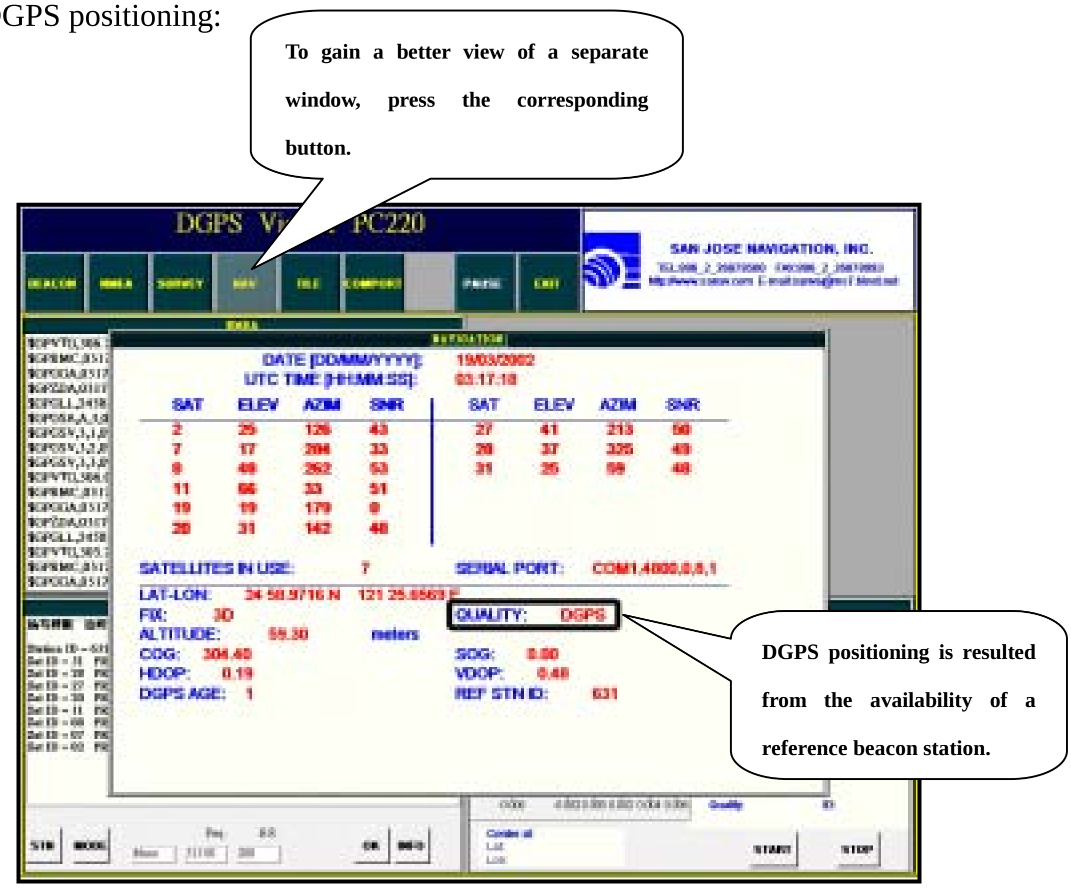
4.1.3 Making Use of DGPS / GPS Signals

After successfully contacting a reference beacon station, you are supposed to be able to receive DGPS signals through our **DGPS-220-PC**. To begin receiving signals, switch the **Beacon-Station connector** to the **GPS connector**. Then related data will display in the other three windows, namely, **NMEA**, **NAVIGATION** and **SURVEY**:



GPS data in the **NAVIGATION**, **NMEA** and **SURVEY** windows are briefly described in following pages:

1. If you have successfully contacted a reference beacon station, the **Quality** field of the **NAVIGATION** window will show DGPS, indicating you are currently under DGPS positioning:

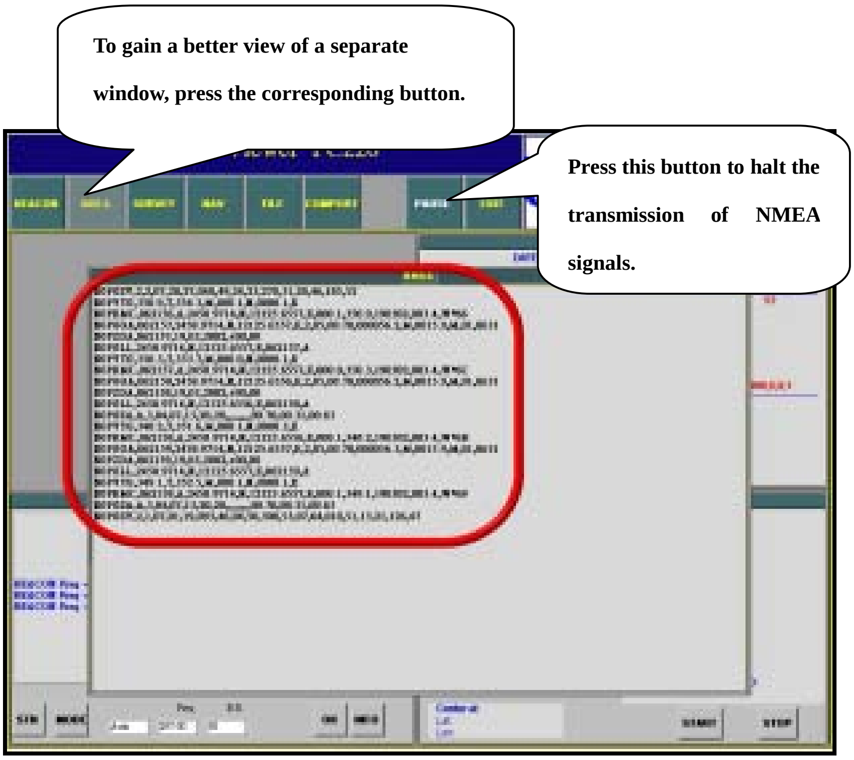


2. Other data in the **NAVIGATION** window are described below:

Data	Descriptions
Date (DD/MM/YYYY)	The date of positioning
UTC TIME (HH:MM:SS)	(**C**oordinated **U**niversal **T**ime, **T**emps **U**niversal **C**ordon) The international time standard (formerly Greenwich Mean Time, or GMT). Zero hours UTC is midnight in Greenwich England, which is located at 0 degrees longitude. Everything east of Greenwich (up to 180 degrees) is later in time; everything west is earlier.
SAT	Satellite ID
ELEV	Elevation
AZM	Azimuth

SNR	The signal to noise ratio: The ratio of the amplitude (power, volume) of a data signal to the amount of noise (interference) in the line. Usually measured in decibels, it measures the clarity or quality of a transmission channel, audio signal or electronic device. The intent is always to make the ratio greater so that the unwanted noise can be more easily identified and thus eliminated.
SATELLITES IN USE	The number of satellites currently in use
SERIAL PORT	The Com Port currently in use
LAT-LON	Latitude and Longitude
FIX	A position determined by observation and computation, which can be **2D** or **3D** (**D** stands for **D**imension here). **2D** means that the current positioning is being conducted in the two dimensions without measuring the altitude, thereby resulting in GPS positioning. 3D means that the current positioning is being conducted in the three dimensions, thereby resulting in DGPS positioning – a more accurate position fix than GPS.
Altitude	The height of a thing above a reference level, especially above sea level or above the earth's surface.
COG	Course Over Ground
SOG	Speed Over Ground
HDOP	Horizontal Dilution of Precision
VDOP	Vertical Dilution of Precision
DGPS AGE	The interval between the DGPS data currently in use and the impending one. The shorter the Age, the better DGPS performance.
REF STN ID	Reference Station ID: The ID of the beacon station that transmits RTCM signals for DGPS operation.

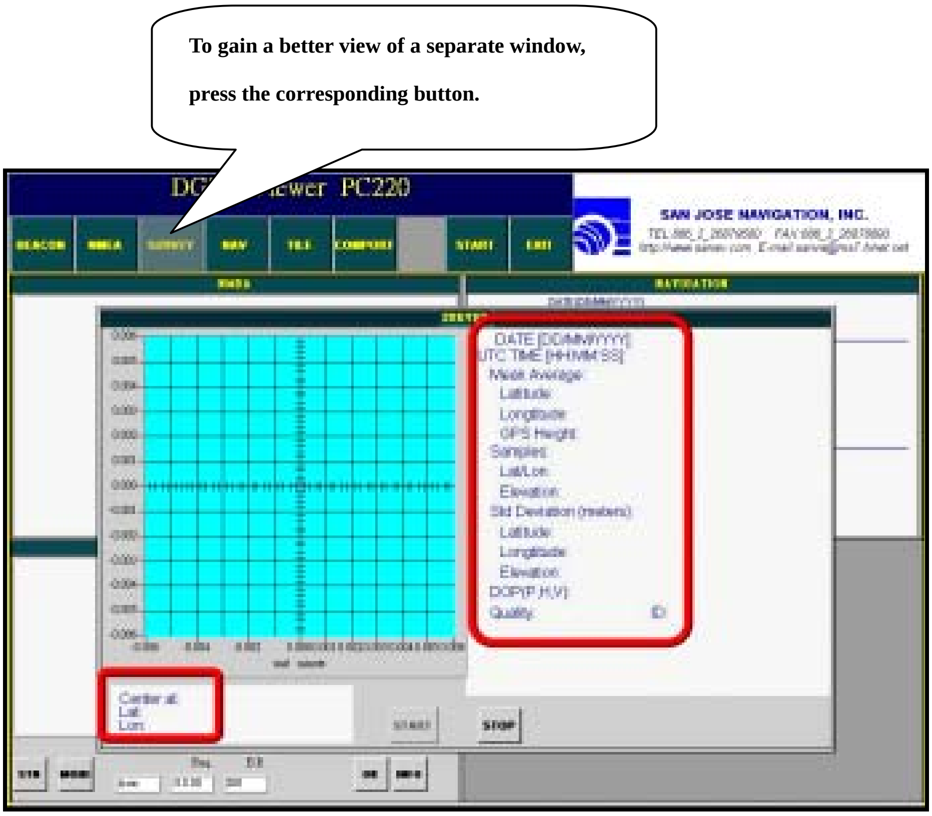
3. Data shown in the **NMEA** window are GPS sentences transmitted via the NMEA 0183 protocol:



For more information on GPS sentences, please see the Section 6.2 of Chapter 6.

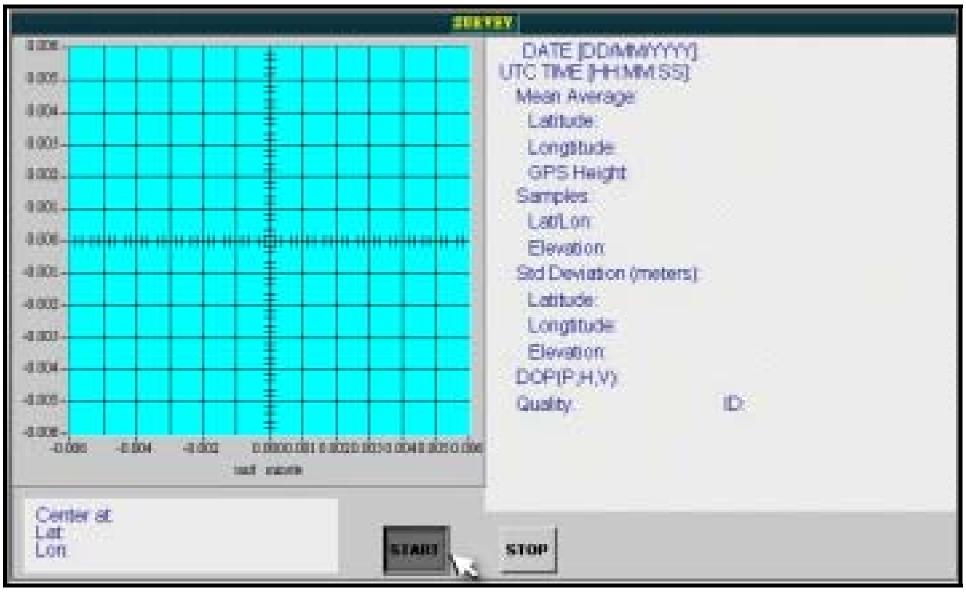
4. To halt the receipt of NMEA data, click **PAUSE**.

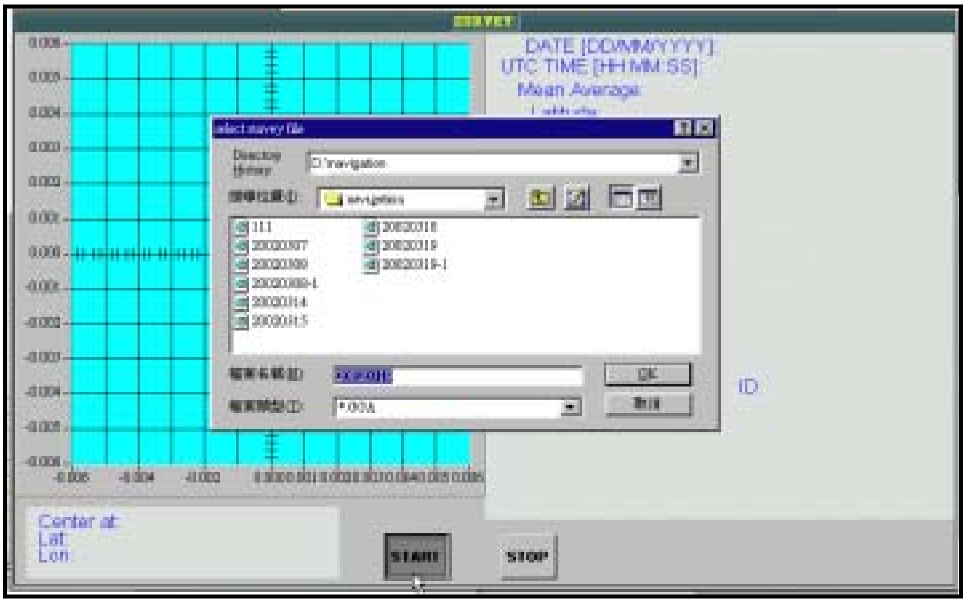
5. The **SURVEY** window contains data as follows:



Note: 1 min = 1.8 km → 0.001 min = 1.8 m

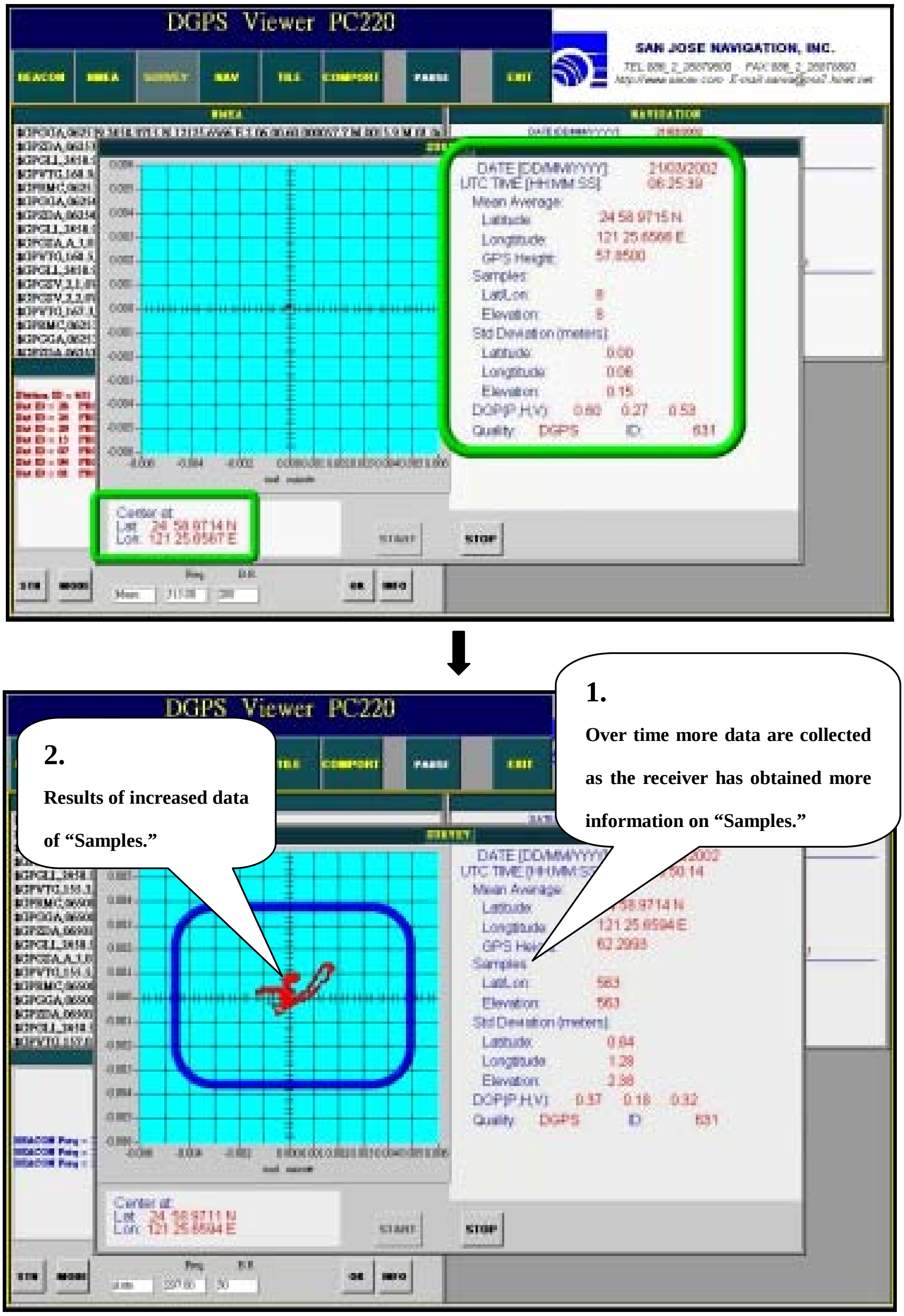
6. With availability of DGPS positioning, you can launch various SURVEY functions by clicking **START** in the window. Then a message box will appear asking you where you want to save a log file for the survey, as shown below:





Click **OK** when you finish.

7. Related data will display in the **SURVEY** window shortly:



8. To close the program, press the **Exit** button:

4.2 Operation Under Auto Mode

This mode is designed for those users who have no idea about the appropriate Frequency and Baud Rate of the reference beacon station available for their location.

A default set of Frequency and Baud Rate, which are configured in line with export destinations, is stored in the **RAM** of ex-factory **DGPS-220-PCs**. Over time after applications, eight sets of used Frequency and Baud Rate are stored in the **RAM**. (The default set of Frequency and Baud Rate serves as the first of the eight sets in the **RAM** under **Auto Mode** operation. Over time after applications, the set of Frequency and Baud Rate used in the last time serves as the first set in the **RAM**.

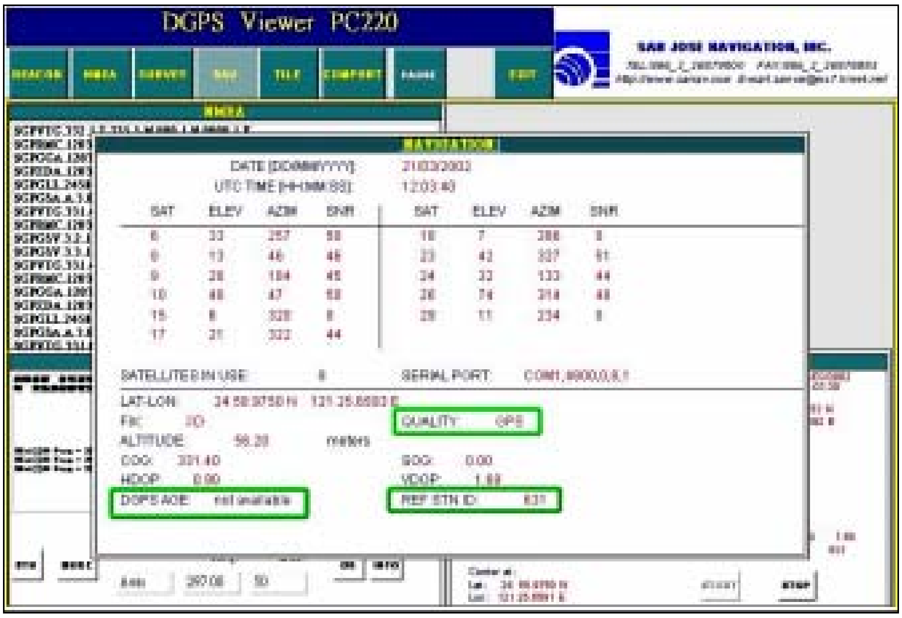
The receiver adopts the first set of Frequency and Baud Rate for four minutes and three minutes, respectively, and then switches to the second and so on every one minute, until having found a matching set of Frequency and Baud Rate of a reference beacon station for your location. Therefore, the entire process of this mode lasts for eleven minutes (four minutes for the first trial and one minute for each of the remaining seven trial)

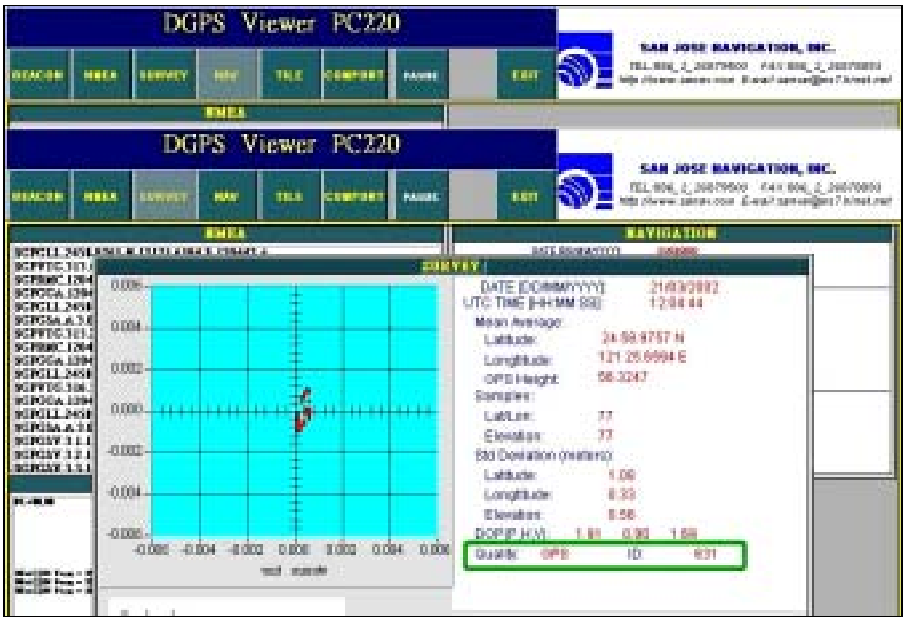
4.3 Auto Search Operation

In case there is no matching Frequency and Baud Rate in the eight sets stored in the **RAM**, the receiver would launch an automatic search for any beacon stations available for your location. As such, this approach generally spends even more time finding an appropriate reference beacon station than the **Manual Mode**. In addition, this approach could even end up in void, so you are strongly recommended to adopt the **Manual Mode** first whenever it is possible, and use the **Auto Mode** as an alternative for the **Manual Mode**.

4.4 Operation Without DGPS Features

DGPS-220-PC allows you to receiver GPS signals even if you fail to obtain DGPS features largely due to unavailability of an appropriate reference beacon station for your location. In this case, **DGPS Viewer PC220** displays a **REF STN ID** shown the last time (in our example, it is **631**), its **Quality** refers to **GPS** and the **DGPS AGE** is **not available**:





Chapter 5 Accessories

5.1 Standard Accessories

1.

RS 232 Cable

(15m, attached with a **Wiring Label** surrounded by a red rectangle shown in the picture above)

2.

PIN#	COLOR	FUNCTION	DESCRIPTION
1	White	Receive-1&2	To receive commands from PC for setting up GPS and/or Beacon receiver's parameters
2	Green	Transmit-1	To output accurate GPS data in NMEA0183 format.
3	Yellow	Ground	Signal ground common to receive & transmit.
4	Braid	Earth	To be connected to vehicle chasis for EMI suppression if necessary.
5	Blue	Transmit-2	To output status data showing the status of Beacon receiver.
6	Black	Power-	(Negative)
7	Red	Power+	(Positive)Power input DC12V~24V

Wiring Label

(Attached to the **RS 232 Cable** and to the bottom of **DGPS-220-PC**, surrounded by a red rectangle bar as shown in the left picture)

3. Utility Programs: **DGPS Viewer PC220** (Version 2.0)

4. User Manual (Version A)

5.2 Optional Accessories

1. Magnetic Mount

2. Permanent Mount

Chapter 6 Technical Information

6.1 Specifications:

6.1.1 GPS RECEIVER GENERAL

SIGNAL PROCESSING

Antenna:	High-reliability ceramic patch
Antenna LNA gain:	26+/-2dBi, NF: 2.0dB max
Receiver Frequency:	1575.42MHz, C/A code, L1 band
Receiver Architecture:	12-channel ail-in-view algorithm tracks & uses up to 12 satellites
Update Rate:	1 second continuous
Dynamics:	Up to 49m/s.s (tracking sustained)
Datum:	WGS-84 plus 170 user selectable datum

ACCURACY

GPS Positioning Accuracy:	15m (2DRMS, L1, C/A code, HDOP<=4 without SA)
GPS Positioning Speed:	0.1 Kt RMS
DGPS Positioning Accuracy:	1~5m (2DRMS, L1, C/A code, HDOP<=4)
DGPS Positioning Speed:	0.1 Kt RMS

TIME TO FIRST FIX

Cold Start:	90 seconds
Warm Start:	20 seconds
Reacquisition:	2 seconds

6.1.2 BEACON RECEIVER GENERAL

SIGNAL PROCESSING

Frequency Range:	283.5~325.0 kHz
Channel Spacing:	500 Hz
Frequency Resolution:	0.01 Hz
Minimum Signal Strength:	< 5 uV/m @100bps
Dynamic Range:	> 90 dB
Adjacent Channel Rejection:	60 dB @1 kHz
Acquisition Time:	< 2 sec., manual command
	< 2 sec., automatic warm start
	< 1 min., automatic cold start
Selection of Station:	Automatic or manual
Signal Detection:	Direct digital synthesis (DDS)

DATA PROCESSING

Demodulation:	MSK (Minimum Shift Keying)
Error Detection:	Parity error check
MSK Bit Rates:	50, 100, 200 (automatic)

6.1.3 COMBINED RECEIVER GENERAL

DATA PORTS	
Monitor/Control Port:	RS-232 at 4800 baud
Control Format:	NMEA-0183
Housing:	7 pin circular, hermetically sealed
Pins:	Gold plated for anti-corrosion
POWER REQUIREMENTS	
Input Voltage:	12~24V DC with power-reverse protection
Power Consumption:	Less than 3W @12 V DC (max.)
ENVIRONMENTAL	
Operating Temperature:	-30° to +75°C
Storage Temperature:	-40° to +85°C
Relative Humidity:	95% non-condensing
PHYSICAL	
Dimension:	3.25 inches (height) x 4.4 inches (diameter)
Weight:	1.5 lbs
Enclosure:	High impact, corrosion-proof, PC (polycarbonate) resin
Construction:	Hermetically sealed, fully weatherproof
Mounting:	Pole mount to 1"-14 threaded pipe
OEM OPTIONS	
Sentence Available:	GGA, GLL, GSA, GSV, VTG, RMC, ZDA
Output Interval:	0~60 sec. selectable
Operating Mode:	2D or 2D/3D automatic
Satellite Masks:	SNR, Elevation, PDOP
Type of Interface:	RS-232 (standard), RS-422 (optional)
Datum:	WGS-84 plus 170 user selectable datum
Extend Input Voltage:	Up to 60 VDC

6.2 NMEA-0183 Protocol

6.2.1 About NMEA-0183 Protocol

- **Approved Sentences**

  Approved sentences are those of which formats are defined and fixed within the NMEA-0183 standard. Any portion within an approved sentence format is NOT user-definable. An approved sentence generally takes the following form:

$<address field>,<data field>…..【*<checksum field>】<CR><LF> Where:

Field	Description
$	Start-of-Sentence marker
<address field>	5-byte fixed length. First 2 bytes represent a talker ID, and the rest 3 bytes do a sentence formatter. All sentences transmitted by DGPS-220 bear talker ID "GP" meaning a GPS receiver. For the sentences received from an external equipment, the DGPS-220 accepts any talker ID. Talker ID "XX" found on the succeeding pages is a wildcard meaning "any valid talker ID."
,<data field>…	Variable or fixed-length fields preceded by delimiter "," (comma). Commas are required even when valid field data are not available i.e. null fields. EX. ",,,,," In a numeric field with fixed field length, fill unused leading digits with zeroes. (Do not suppers leading zeroes.)
*<checksum field>	Generally not required, with the exception of "RMC" sentence. 8 bits data between "$" and "*" (excluding "$" and "*") are XORed, and the resultant value is converted to 2 bytes of hexadecimal letters. Note that two hexadecimal letters must be preceded by "*", and delimiter "," is not required before *<checksum>. Only RMC sentences are transmitted with checksum. All other output sentences do not include *<checksum>. For input sentences, *<checksum> is ignored.
<CR><LF>	End-of-Sentence marker

Maximum length from "$" to <CR><LF> is limited to 82 bytes including "$" and <CR><LF>.

- Examples of Approved Sentences:
  $GPGLL, 3444.000,N, 13521.00,E, E<CR><LF>
  $XXGLL, 3444.000,N, 13521.00,E, E<CR><LF>
  "XX" may be any valid talker ID, such as "LC" (Loran C).

➢ **Proprietary Sentences**

The NMEA-0183 standard allows nav-aid makers to send proprietary sentences if the minimum rules defined by the NMEA are obeyed. Proprietary sentences must take the following form, but it is free to makers what kind of fields are included and in what order they are transmitted out.

$P<maker ID>, <data field>…..<CR><LF> where:

Field	Description
$	Start-of-Sentence marker
P	Proprietary sentence identifier
<maker ID>	3-byte fixed length DGPS-220 maker ID is "FEC' meaning Furuno Electric Company.
, <data field>…	Variable or fixed-length fields preceded by delimiter "," (comma). (Layout is maker-definable.)
<CR><LF>	End-of-Sentence marker

6.2.2 Baud Rate & Character Format

- System: Asynchronous/ Full Duplex
- Speed: 4800 BPS
- Start Bit: 1 bit
- Data Length: 8 bits (MSB=0)
- Stop Bit: 1 bit
- Parity Bit: None

Start Bit	B0	B1	B2	B3	B4	B5	B6	B7	**Stop Bit**

- Flow Control: None
- Signal Lines used: TD & RD only
- Data Output Interval: 0 to 2 seconds
- Character Codes used:

  NMEA-0183 Sentences: ASCII (HEX 0D, 0A, 24, 2A, 2C, 2E and alphanumeric)

  Differential GPS Data: Binary ("6-of-8" format, B7=0, B6=1, Only B5 to B0 are used.)

6.3 NMEA-0183 Output Sentences

6.3.1 $GPGGA (out)

Position, Altitude, UTC, etc.

Example

$GPGGA	,123456	,3444.0000,N	,13521.0000,E
Field#	1	2	4

,1	,04	,02.00	,000123.0	,M	,0036.0
6	7	8	9	10	11

,M	,13	,001	CR LF
12	13	14	

Description	Range	【Bytes】
1. UTC		
"12": hh	00-23	【2】
"34": mm	00-59	【2】
"56": ss	00-59	【2】
2. Latitude		
"34": degree	0-90	【2】
"44": minute (integer)	0-59	【2】
"0000": minute (fraction)	0000-9999	【4】
"N": North/South	N or S	【1】
4. Longitude		
"135": degree	000-180	【3】
"21": minute (integer)	00-59	【2】
"0000": minute (fraction)	0000-9999	【4】
"E": East/West	E or W	【1】
6. Status	0-2 ("0": Positioning not started yet "1": Stand-alone GPS positioning "2": Differential GPS positioning)	【1】
7. No. of satellites used	00-08	【2】
8. DOP (2D: HDOP, 3D: PDOP)	n/a (Note: "00.00" is output while positioning is interrupted.)	【5】
9. Altitude	-00999.9 to 017999.9	【8】
10. Unit for altitude	M	【1】
11. Geoide Altitude	-999.9 to 9999.9	【6】
12. Unit for geoide altitude	M	【1】
13. DGPS Data Time	00-99	【variable】

	This value indicates the time elapsed since the last RTCM-SC104 TYPE1 or 9 data updating. Unless DGPS mode is selected, a null field is output.	
14. DGPS Station ID	0000-1023 Unless DGPS mode is selected, a null field is output.	【4】

Interpreting Example

UTC 12:34:56/ 34 deg 44.0000 min N/ 135 deg 21.0000 min E/ Status: Stand-alone GPS

No. of satellites: 4 satellites/ DOP: 2.00/ Altitude: 123.0 meters high

Geoide Altitude: 36.0 meters high/ DGPS Data Time: 13/ DGPS Station ID: 1

6.3.2 $GPZDA (out)

Date / Time

Example

$GPZDA	,123456	,01	,02	,1995	,+09	,00	CR LF

Field# 1 2 3 4 5 6

Description	Range	【Bytes】
1. UTC: Time		
"12": hh	00-23	【2】
"34": mm	00-59	【2】
"56": ss	00-59	【2】
2. UTC: Day of Month		
"01": DD	01-31	【2】
3. UTC: Month		
"02": MM	01-12	【2】
4. UTC: Year		
"1995": YYYY	1994-2040	【4】
1. Local Zone Time (Hour)		
"+09": hh	-13…+00…+13	【3】
	(-/+: East/West of date line)	
6. Local Zone Time (Minute)		
"00": mm	00-59	【2】

NOTE: Local zone time setting is used for calculating local time when outputting $PFEC, GPast:

(Local Time) = (UTC) - (Local Zone Time)

Interpreting Example

February 1, 1995

12:34:56

Local Zone Time: +09:00

6.3.3 $GPGLL (out)

Position, UTC, etc.

Example

$GPGLL	,3444.1234,N	,03521.0000,E	,123456	,A	CR LF
Field#	1	3	5	6	

Description	Range	【Bytes】
1. Latitude		
"34": degree	00-90	【2】
"44": minute (integer)	00-59	【2】
"1234": minute (fraction)	0000-9999	【4】
"N": North/South	N or S	【1】
3. Longitude		
"035": degree	000-180	【3】
"21": minute (integer)	00-59	【2】
"0000": minute (fraction)	0000-9999	【4】
"E": East/West	E or W	【1】
5. UTC		
"12": hh	00-23	【2】
"34": mm	00-59	【2】
"56": ss	00-59	【2】
6. Status	A or V	【1】
	"A": Stand-alone or DGPS positioning	
	"V": Positioning interrupted	

Interpreting Example

34 degree 44.1234 min N

35 degree 21.0000 min E

UTC: 12:34:56

Status: Positioning

6.3.4 $GPGSA (out)

Positioning Status

Example

$GPGSA	,A	,3	,01	,02	,03	……	,02.00	,03.00	,04.00	CR LF
Field#	1	2	3	4	5	6…	15	16	17	

Description	Range	【Bytes】
1. Operation Mode	M or A "M": 2D-only Mode "A": 2D/3D Auto-switching Mode	【1】
2. Positioning Status	1-3 ("1": Positioning interrupted "2": 2D positioning "3": 3D positioning)	【1】
3~14. Satellite Numbers Used for Positioning	01-32 (Note: A null field is output unless a satellite is available.)	【2】
15. PDOP	n/a (Note: "00.00" is output unless 3D positioning is performed.)	【5】
16. HDOP	n/a (Note: "00.00" is output while positioning is interrupted.)	【5】
17. VDOP	n/a (Note: "00.00" is output unless 3D positioning is performed.)	【5】

Interpreting Example

2D/3D Auto-switching Mode
3D Positioning
Satellites used: 01, 02, 03…
PDOP: 2.00
HDOP: 3.00
VDOP: 4.00

6.3.5 $GPGSV (out)

Satellite Details

Example

$GPGSV	,2	,1	,06	,01	,05	,234	,56
Field#	1	2	3	4	5	6	7

	,04	,11	,223	,44
Field#	8	9	10	11

	,01	,75	,088	,32
Field#	12	13	14	15

	,01	,42	,234	,48	CR LF
Field#	16	17	18	19	

Description	**Range**	**【Bytes】**
1. Total No. of Messages	1~3	【1】
2. No. of Message	1~3	【1】
3. No. of satellites in line-of -site (with elevation angle higher than 5 degrees only)	00~12	【2】
4. 1st Sat. SV#	01~32	【2】
5. 1st Sat. Elevation Angle	05~90	【2】
6. 1st Sat. Bearing Angle	000~359	【3】
7. 1st Sat. SNR (Signal/Noise Ratio) (C/No)	00~99	【2】
8~11. 2nd Sat. Details		
12~15. 3rd Sat. Details		
16~19. 4th Sat. Details		

6.3.6 $GPVTG (out)

Course & Speed

Example

$GPVTG	,012.3,T	,001.1,M	,001.2,N	,0002.2,K	CR LF
Field#	1	3	5	7	

Description	Range	【Bytes】
1. True Course		
"012.3": degree	000.0-359.9	【variable】
"T": True	T (Note: A null field is output unless true course information is available.)	【1】
3. Magnetic Course		
"001.1": degree	000.0-359.9	【variable】
"M": Magnetic	M (Note: A null field is output unless magnetic course information is available.)	【1】
5. Speed (kts)		
"001.2": speed (kts)	000.0-999.9	【variable】
"N": kNot	N (Note: A null field is output unless speed information is available.)	【1】
7. Speed (km/h)		
"0002.2": speed (km/h)	0000.0-9999.9	【variable】
"K": Km/h	K (Note: A null field is output unless speed information is available.)	【1】

6.3.7 $GPRMC (out)

UTC, Position, Course, Speed, etc.

Example

$GPRMC	,123456	,A	,3444.1234,N	,13521.4567,E
Field#	1	2	3	5

Field#	,005.6	,123.5	,020195	,001.0,W
	7	8	9	10

*FF	CR LF
Checksum	

Description	Range	【Bytes】
1. UTC: Time		
"12": hh	00-23	【2】
"34": mm	00-59	【2】
"56": ss	00-59	【2】
2. Status	A or V	【1】
	"A": Stand-alone or DGPS positioning	
	"V": Positioning interrupted	
3. Latitude		
"34": degree	0-90	【2】
"44": minute (integer)	0-59	【2】
"1234": minute (fraction)	0000-9999	【4】
"N": North/South	N or S	【1】
5. Longitude		
"135": degree	000-180	【3】
"21": minute (integer)	00-59	【2】
"4567": minute (fraction)	0000-9999	【4】
"E": East/West	E or W	【1】
7. Speed (kts)		
"005.6": speed (kts)	000.0-999.9	【variable】
	(Note: A null field is output unless speed information is available.)	
8. True Course		
"123.5": degree	000.0-359.9	【variable】
	(Note: A null field is output unless true course information is available.)	
9. UTC: Date		

"02": DD	01-31	【2】
"01": MM	01-12	【2】
"95": YY	94-40 (1994-2040)	【2】

10. Magnetic Deviation (degree)

"001.0": degree	000.0-180.0	【5】
"W": West	W or E	【1】
	"W": West (MAG=TRUE-DEV)	
	"E": East (MAG=TRUE+DEV)	

* **Checksum:** 8 bits data between "$" and "*" (excluding "$" & "*") are XORed, and the result is converted to 2 bytes of hexadecimal letters. Only RMC sentences are transmitted with checksum. All other output sentences do not include checksum fields.

Interpreting Example

UTC 12:34:56/ 34 deg 44.1234 min N/135 deg 21.4567 min E/Status: Positioning

Speed:5.6 kts/True Course:123.5 degrees/UTC date: Jan. 2, 1995/Magnetic Deviation:1.0 degree, West

6.4 Geodetic Datum

There are many geodetic systems in the world. Enter a right geodetic system datum in accordance with your chart or map in use. If the geodetic system in which you are situated differs from the geodetic system employed in your chart or map, GPS fixes may be deviated from the actual position on the chart or map.

➢ International Geodetic Datum

001 WGS-84	
002 WGS-72	
003 TOKYO	Mean Value (Japan, Korea & Okinawa)
004 NORTH AMERICAN 1927	Mean Value (CONUS)
005 EUROPEAN 1950	Mean Value
006 AUSTRALIAN GEODETIC 1984	Australia and Tasmania Island
007 ADIADAN	Mean Value
008	Ethiopia
009	Mali
010	Senegal
011	Sudan
012 AGF	Somalia
013 AIN EL ABD 1970	Bahrain Island
014 ANNA 1 ASTRO 1955	Cocos Island
015 ARC 1950	Mean Value
016	Botswana
017	Lesotho
018	Malawi
019	Swaziland
020	Zaire
021	Zambia
022	Zimbabwe
023 ARC	Mean Value (Kenya & Tanzania)
024	Kenya
025	Tanzania
026 ASCENSION ISLAND 1958	Ascension Island
027 ASTRO BECON "E"	Iwo Jima Island
028 ASTRO B4 SOR. ATOLL	Tern Island
029 ASTRO POS 714	St. Helena Island
030 ASTRONOMIC STATION 1952	Marcus Island

031 AUSTRALIAN GEODETIC 1966	Australia and Tasmania Island
032 BELLEVUE (IGN)	Efate and Erromango Islands
033 BERMUDA 1957	Bermuda Islands
034 BOGOTA OBSERVATORY	Columbia
035 CAMPO INCHAUPE	Argentina
036 CANTON ISLAND 1966	Phoenix Islands
037 CAPE	South Africa
038 CAPE CANAVERAL	Mean Value (Florida & Bahama Islands)
039 CARTHAGE	Tunisia
040 CHATHAM 1971	Chatham Island (New Zealand)
041 CHUA ASTRO	Paraguay
042 CORREGO ALEGRE	Brazil
043 DJAKARTA (BARAVIA)	Sumatra Island (Indonesia)
044 DOS 1968	Gizo Island (New Georgia Islands)
045 EASTER ISLAND 1967	Easter Island
046 EUROPEAN 1950 (Cont'd)	Western Europe
047	Cyprus
048	Egypt
049	England, Scotland, Channel & Shetland Islands
050	England, Scotland, Channel & Shetland Islands
051	Greece
052	Iran
053	Italy-Sardinia
054	Italy-Sicily
055	Norway and Finland
056	Portugal and Spain
057 EUROPEAN 1979	Mean Value
058 GANDAJIKA BASE	Republic of Maldives
059 GEODETIC DATUM 1949	New Zealand
060 GUAM 1963	Guam Island
061 GUX 1 ASTRO	Guadalcanal Island
062 HJORSEY 1955	Iceland
063 HONG KONG 1963	Hong Kong
064 INDIAN	Thailand and Vietnam
065	Bangladesh, India and Nepal
066 IRELAND	Ireland
067 ISTS 073 ASTRO 1969	Diego Garcia

068 JHONSTON ISLAND 1961	Jhonston Island
069 KANDAWALA	Sri Lanka
070 KERGUELEN ISLAND	Kerguelen Island
071 KERTAU 1948	West Malaysia and Singapore
072 LA REUNION	Mascarene Island
073 L.C. 5 ASTRO	Cayman Brac Island
074 LIBERIA 1964	Liberia
075 LUZON	Philippines (Excluding Mindanao Island)
076	Mindanao Island
077 MAHE 1971	Mahe Island
078 MARCO ASTRO	Salvage Islands
079 MASSAWA	Eritrea (Ethiopia)
080 MERCHICH	Morocco
081 MIDWAY ASTRO 1961	Midway Island
082 MINNA	Nigeria
083 NAHRWAN	Masirah Island (Oman)
084	United Arab Emirates
085	Saudi Arabia
086 NAMIBIA	Namibia
087 MAPARIMA, BWI	Trinidad and Tobago
088 NORTH AMERICAN 1927	Western United States
089	Eastern United States
090	Alaska
091	Bahamas (Excluding San Salvador Island)
092	Bahamas-San Salvador Island
093 NORTH AMERICAN 1927	Canada (Including Newfoundland Island)
094	Alberta and British Columbia
095	East Canada
096	Manitoba and Ontario
097	Northwest Territories and Saskatchewan
098	Yukon
099 NORTH AMERICAN 1927	Canal Zone
100	Caribbean
101	Central America
102	Cuba
103	Greenland
104	Mexico

105 NORTH AMERICAN 1983	Alaska
106	Canada
107	CONUS
108	Mexico, Central America
109 OBSERVATORIO 1966	Corvo and Flores Islands (Azores)
110 OLD EGYPTIAN 1930	Egypt
111 OLD HAWAIIAN	Mean Value
112	Hawaii
113	Kauai
114	Maui
115	Oahu
116 OMAN	Oman
117 Ordnance Survey of Great Britain 1936	Mean Value
118	England
119	England, Isles of Man and Wales
120	Scotland and Shetland Islands
121	Wales
122 PICO DE LAS NIVIES	Canary Islands
123 PITACAIRN ASTRO 1967	Pitacaim Island
124 Provisional South Chilean 1963	South Chile (near 53°S)
125 Provisional South American 1956	Mean Value
126	Bolivia
127	Chile-Northern Chile (near 19°S)
128	Chile-Southern Chile (near 43°S)
129	Colombia
130	Ecuador
131	Guyana
132	Peru
133	Venezuela
134 PUERTO RICO	Puerto Rico and Virgin Islands
135 QATAR NATIONAL	Qatar
136 QORNOQ	South Greenland
137 ROME 1940	Sardinia Islands
138 SANTA BRAZ	Sao Maguel, Santa Maria Islands (Azoes)
139 SANTO (DOS)	Espirito Santo Island
140 SAPPER HILL 1943	East Falkland Island
141 SOUTH AMERICAN 1969	Mean Value

142	Argentina
143	Bolivia
144	Brazil
145	Chile
146	Columbia
147	Ecuador
148	Guyana
149	Paraguay
150	Peru
151	Trinidad and Tobago
152	Venezuela
153 SOUTH ASIA	Singapore
154 SOUTHEAST BASE	Porto Santo and Madeira Islands
155 SOUTHWEST BASE	Faial, Graciosa, Pico, Sao Jorge and Terceira Island
156 TIMBALAI 1948	Brunei and East Malaysia (Sarawak & Sadah)
157 TOKYO	Japan
158	Korea
159	Okinawa
160 TRISTAN ASTRO 1968	Tristan da Cunha
161 VITI LEVU 1916	Viti Levu Island (Fiji Islands)
162 WAKE-ENISETOK 1960	Marshall Islands
163 ZANDERIJ	Suriname
164 BUKIT RIMPAH	Bangka and Belitung Islands (Indonesia)
165 CAMP AREA ASTRO	Camp Memurdo Area, Antarctica
166 G. SEGARA	Kalimantan Islands (Indonesia)
167 HEART NORTH	Afghanistan
168 HU-TZU-SHAN	Taiwan
169 Tananarive Observatory 1925	Madagascar
170 YUCARE	Urguay
171 RT90	Sweden

Chapter 7 Beacon Station List

For the most updated information on the Beacon Station List, please visit http://www.csi-wireless.com/support/pdfs/radiolistings.pdf. In addition, our utility program also provides you with information on beacon stations.

Chapter 8 Glossary

- Almanac (GPS Data)

  Almanac is constellation data for all GPS satellites. Each GPS satellite transmits almanac. The unit receives GPS satellites referring to almanac. (Unlike ephemeris, almanac indicates rough constellation only, and is not directly used for position/time fixing.) Unless almanac is available, the unit must try to acquire satellites sequentially until it successfully acquires one.

- Almanac Data (Output Data)

  Almanac is a very stable data like your calendar. So, once the unit receives almanac, it is preserved for a considerable long term. Almanac date output indicates when the unit received the existing almanac.

- RTCM SC-104 Differential GPS

  Error correcting data based on the standard released by the Radio Technical Commission for Maritime Services, Washington D.C. This unit supports the following three data:

  - Type 1 Message: Differential GPS Correction Data (Basic Data)
  - Type 3 Message: Locations of Base Stations
  - Type 9 Message: High-rate Differential GPS Correction Data

  When these correction data are entered, DGPS mode is invoked automatically, resulting in high-precision position fixing. When DGPS mode is invoked, the position fixing status changes to DGPS automatically.

  * DGPS-220-PC ignores messages other than TYPE 1, 3, and 9.

- 3D Position Fixing

  In 3D position fixing, altitude is obtained in addition to L/L. For 3D fixing the following conditions should be met:

  - More than four satellites can be acquired/tracked.
  - PDOP, which is determined by relative allocations of satellites in the sphere, must be smaller than the preset threshold:
    PDOP < PDOP Threshold (Default=6, Setting may be altered.)

- Number of Satellites for DGPS

  Satellite correction number involved in DGPS input data.

- DGPS Station ID

  DGPS station ID number ranging from 0 to 1023 as defined by RTCM SC-104 specifications.

- 2D Positioning

  Assuming the altitude at 0 meter, the unit fixes L/L. If a reliable altitude had been obtained by 3D positioning, that altitude is assumed instead of 0 meter.

2D positioning is performed when the following two conditions are met:

At least one satellite is available for acquisition and tracking.

HDOP, which is determined by satellite allocations in the sphere, is smaller than 10.

HDOP < 10

The unit does its best to perform 3D positioning, but switches to 2D positioning only when either condition can't be met.

- PDOP Threshold

  When PDOP degrades exceeding this parameter, the unit switches from 3D to 2D positioning automatically. Bear in mind that the altitude is updated by 3D positioning only.

- PDOP, HDOP, VDOP

  In GPS positioning, position fixing accuracy depends on satellite allocating positions in the sphere. Parameters PDOP, HDOP, and VDOP indicate this type of degrading indexes for GPS position fixing; the smaller the values are, the higher the position fixing accuracy gets. HDOP means horizontal dilution of position fixing and affects 2D positioning; VDOP does vertical dilution; PDOP contains these two components as expressed below, and can be used for 3D positioning.

  PDOP = SQRT (HDOP x HDOP + VDOP x VDOP)

- UTC Time

  This is Coordinated Universal Time. Depending on earth's rotating speed, leap second of one second or so may be inserted per year. The UTC output by the unit is based on both almanac data and satellite tracking. Therefore, the UTC output directly after power-on may not be accurate. Japanese local time is obtainable by adding 9 hours to UTC. The UTC which you enter is used for the first time search of a satellite directly after power-on. If UTC you enter is deviated much from the actual UTC, first fix will delay accordingly. UTC entry with 10 minutes' accuracy is desirable. When DGPS-220 internal UTC is incorrect due to discharge of the backup battery, etc., enter UTC as correctly as possible. DGPS-220 internal UTC is automatically adjusted to a correct value once a satellite is tracked.

8.1 Common Terms:

1. PC: Personal Computer
2. Comm Communications
3. LED: Light Emitting Diode
4. GPS: Global Positioning System
5. MOB: Man Over Board

6. INT: Interval
7. GGA: Global Positioning System Fixed Data
8. GLL: Geographic Positioning –latitude/longitude
9. GSA: GNSS DOP and active satellites
10. GSV: GNSS Satellites in View
11. RMC: Recommended Minimum Specific GNSS Data
12. VTG: Course Over Ground and Ground Speed
13. DC: Direct Current
14. TTL: Transistor-Transistor Logic
15. TTFF: Time To First Fix

Chapter 9 IMPORTANT NOTES

1. It is recommended that you familiarize yourself with our operation by connecting the unit to the PC cable and mains power pack. This will enable you to practice the operation of the unit. Read the manual carefully and its operation will become clear and simple.

2. We use an internal battery to retain the memory of stored data. After a certain period, this battery will need to be replaced. This is **not** covered under warranty.

3. Please **do not disassemble our DGPS receiver**. This will destroy the unit's security seal and the logger may no longer function. If you disassemble the unit it will have to be returned to us for reassembly. This will also **void** the warranty.

4. It is always safer that you seek assistance with our technical engineers if you are inexperienced with electronic work.

Chapter 10 WARRANTY

LIMITED WARRANTY

SANJOSE NAVIGATION, INC. expressly warrants that for a period of one (1) year from the date of purchase. Our accessories will be free of defects in material (parts) and workmanship (labor). Within the warranty period, a unit will be tested, repaired, or replaced at our option at no charge.

If your unit is out warranty, we will quote repair charges necessary to bring your unit up to factory standards.

THIS WARRANTY APPLIES ONLY TO ORIGINAL PURCHASE

Any unit under warranty should be shipped prepaid to our factory. Warranty replacements will take approximately ninety (90) days.

WARRANTY EXCLUSION

THE FOREGOING EXPRESS WARRANTY IS MADE IN LIEU OF ALL OTHER PRODUCT WARRANTIES, EXPRESSED AND IMPLIED, INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE WHICH ARE SPECIFICALLY DISCLAIMED. The express warranty will not apply to defects or damage due to accidents, neglect, misuse, alternations, operator error, or failure to properly maintain, clean or repair products.

LIMIT OF LIABILITY

In no event will San Jose Navigation, Inc. or any seller will be responsible or liable for any injury, loss or damage, direct or consequential, arising out of the use or the inability to use the product. Before using, users shall determine in the suitability of the product for their intended use, and users assume all risk and liability whatsoever in connection therewith.

PURCHASER'S DUTIES

The purchaser must return the unit postpaid, with proof of the date of original purchase with the return address to:

SANJOSE NAVIGATION, INC.

9F, No. 105, Shi-Cheng Road, Pan-Chiao City

Taipei Hsein, Taiwan, R.O.C.

TEL: 886-2-2687-9500, FAX: 886-2-2687-8893