GPS 16/17 SERIES TECHNICAL SPECIFICATIONS

GARMIN®

RECORD OF REVISIONS

Revision	Revision Date	Description	ECO #
A	1/29/02	Initial Release	--
B	11/7/02	Add GPS 16A	19451
C	10/26/05	GPS 17N has been replaced by the GPS 17HVS. The GPS 16A has been discontinued.	33833

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1   INTRODUCTION

1.1   Caution

The GPS system is operated by the government of the United States, which is solely responsible for its accuracy and maintenance. Although the GPS 16/17 is a precision electronic NAVigation AID (NAVAID), any NAVAID can be misused or misinterpreted, and therefore become unsafe. Use these products at your own risk. To reduce the risk, carefully review and understand all aspects of these Technical Specifications before using the GPS 16/17. When in actual use, carefully compare indications from the GPS to all available navigation sources including the information from other NAVAIDs, visual sightings, charts, etc. For safety, always resolve any discrepancies before continuing navigation.

1.2   FCC Compliance

The GPS 16/17 complies with Part 15 of the FCC interference limits for Class B digital devices FOR HOME OR OFFICE USE. These limits are designed to provide reasonable protection against harmful interference in a residential installation, and are more stringent than "outdoor" requirements.

Operation of this device is subject to the following 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.

This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

• Reorient or relocate the receiving antenna.

• Increase the separation between the equipment and receiver.

• Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

• Consult the dealer or an experienced radio/TV technician for help.

The GPS 16/17 does not contain any user-serviceable parts. Unauthorized repairs or modifications could result in permanent damage to the equipment, and void your warranty and your authority to operate this device under Part 15 regulations.

1.3 Limited Warranty

This Garmin product is warranted to be free from defects in materials or workmanship for one year from the date of purchase. Within this period, Garmin will at its sole option repair or replace any components that fail in normal use. Such repairs or replacement will be made at no charge to the customer for parts or labor, provided that the customer shall be responsible for any transportation cost. This warranty does not cover failures due to abuse, misuse, accident, or unauthorized alteration or repairs.

THE WARRANTIES AND REMEDIES CONTAINED HEREIN ARE EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES EXPRESS OR IMPLIED OR STATUTORY, INCLUDING ANY LIABILITY ARISING UNDER ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, STATUTORY OR OTHERWISE. THIS WARRANTY GIVES YOU SPECIFIC LEGAL RIGHTS, WHICH MAY VARY FROM STATE TO STATE.

IN NO EVENT SHALL GARMIN BE LIABLE FOR ANY INCIDENTAL, SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES, WHETHER RESULTING FROM THE USE, MISUSE, OR INABILITY TO USE THIS PRODUCT OR FROM DEFECTS IN THE PRODUCT. Some states do not allow the exclusion of incidental or consequential damages, so the above limitations may not apply to you.

Garmin retains the exclusive right to repair or replace the unit or software or offer a full refund of the purchase price at its sole discretion. SUCH REMEDY SHALL BE YOUR SOLE AND EXCLUSIVE REMEDY FOR ANY BREACH OF WARRANTY.

To obtain warranty service, contact your local Garmin authorized dealer or call Garmin Product Support at one of the numbers listed below for shipping instructions and an RMA tracking number. The unit should be securely packed with the tracking number clearly written on the <u>outside</u> of the package. The unit should then be sent, freight charges prepaid, to any Garmin warranty service station. A copy of the original sales receipt is required as the proof of purchase for warranty repairs.

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Online Auction Purchases: Products sold through online auctions are not eligible for rebates or other special offers from Garmin. Online auction confirmations are not accepted for warranty verification. To obtain warranty service, an original or copy of the sales receipt from the original retailer is required. Garmin will not replace missing components from any package purchased through an online auction.

International Purchases: A separate warranty is provided by international distributors for units purchased outside the United States. This warranty is provided by the local in-country distributor and this distributor provides local service for your unit. Distributor warranties are only valid in the area of intended distribution. Units purchased in the United States or Canada must be returned to the Garmin service center in the United Kingdom, the United States, Canada, or Taiwan for service.

1.4   Overview

The GPS 16/17 series products are complete GPS sensors including embedded receiver and antenna, designed for a broad spectrum of OEM (Original Equipment Manufacture) system applications. Based on the proven technology found in other Garmin 12-channel GPS receivers, the GPS 16/17 tracks up to 12 satellites at a time while providing fast time-to-first-fix, one-second navigation updates, and low power consumption. This generation of GPS sensors adds the capability of FAA Wide Area Augmentation System (WAAS) differential GPS. The GPS 16/17's far-reaching capability meets the sensitivity requirements of land navigation as well as the dynamics requirements of high-performance aircraft.

The GPS 16/17 design uses the latest technology and high-level circuit integration to achieve superior performance while minimizing space and power requirements. All critical components of the system including the RF/IF receiver hardware and the digital baseband are designed and manufactured by Garmin to ensure the quality and capability of the GPS. The hardware capability combined with software intelligence makes the GPS 16/17 easy to integrate and use.

The GPS 16/17 series products are designed to withstand rugged operating conditions and are waterproof to IEC 60529 IPX7, immersion in 1 meter of water for 30 minutes. These complete GPS receivers require minimal additional components to be supplied by an OEM or system integrator. A minimum system must provide the GPS with a source of power and a clear view of the GPS satellites. The system may communicate with the GPS via two full-duplex communication channels. Internal FLASH memory allows the GPS to retain critical data such as satellite orbital parameters, last-known position, date and time. End user interfaces such as keyboards and displays are the responsibility of the application designer.

Note: Due to parts availability, the GPS 17N has been replaced by the GPS 17HVS. References to the GPS 17N are for current GPS 17N product information.

Note: The GPS 16A has been discontinued. References to the GPS 16A are for current GPS 16A product information. A comparable replacement sensor is the GPS 18-5Hz.

1.5   Features

- 12-channel GPS receiver tracks and uses up to 12 satellites for fast, accurate positioning and low power consumption.
- Differential DGPS capability using real-time WAAS or RTCM corrections yielding 3 to 5 meter position accuracy (see Section 1.7 Technical Specifications).
- Compact, rugged design ideal for applications with minimal space.
- May be remotely mounted in an out-of-the-way location.
- Receiver position information can be displayed directly on a chartplotter or PC.
- User initialization is not required. Once the unit is installed and has established a location fix, the unit automatically produces navigation data.
- User-configurable navigation mode (2-dimensional or 3-dimensional fix).
- (Not Available on GPS 16A or GPS 17N) Highly accurate one-pulse-per-second (PPS) output for precise timing measurements. Pulse width is configurable in 20 millisecond increments from 20 ms to 980 ms with 1 μs accuracy.
- Configurable for binary format carrier phase data output on COM 1 port.
- Flexible input voltage levels of 3.3 VDC to 6.0 VDC with over-voltage protection in the GPS 16LVS; 6.0 VDC to 40 VDC in the GPS 16HVS and GPS 17HVS; and 8.0 VDC to 40 VDC in the GPS 16A and 17N.
- FLASH-based program and non-volatile memory. New software revisions available through Web site download. Non-volatile memory does not require battery backup.
- Waterproof design allows continuous exposure to the prevailing weather conditions at most locations.

1.6   GPS 16/17 Series

There are several different products in the GPS 16/17 product series. Refer below for a description of each product and the differences between the products.

1.6.1   GPS 16LVS & 16HVS

Both the GPS 16LVS and GPS 16 HVS are black with a white logo.

GPS 16LVS & 16HVS

1.6.2   GPS 16A

Due to parts availability, the GPS 16A has been discontinued. References to the GPS 16A are for current GPS 16A product information. The GPS 16A is white with a black logo.

GPS 16A

1.6.3   GPS 17HVS & 17N

Due to parts availability, the GPS 17N has been replaced by the GPS 17HVS. References to the GPS 17N are for current GPS 17N product information. Both units are white with a black logo.

GPS 17HVS & 17N

1.7 Technical Specifications

Specifications are subject to change without notice.

1.7.1 Physical Characteristics

1.7.1.1 Size
- GPS 16: 3.39" (86 mm) diameter, 1.65" (42 mm) high
- GPS 17: 3.39" (86 mm) diameter, 4.25" (108 mm) high

1.7.1.2 Weight
- GPS 16LVS & 16HVS: 6.4 oz. (181 g) without cable; 11.7 oz. (332 g) with 5 meter cable
- GPS 16A: 9.6 oz. (272 g) without cable; 17.6 oz. (500 g) with 5 meter cable
- GPS 17HVS: 6.7 oz. (190 g) without cable; 16.4 oz. (465 g) with 30 foot cable
- GPS 17N: 6.4 oz. (181 g) without cable; 16.0 oz. (454 g) with 30 foot cable

1.7.1.3 Cable
- GPS 16LVS & 16HVS: Black PVC-jacketed, 5 meter, foil-shielded, 8-conductor 28 AWG with RJ-45 termination
- GPS 16A: White Teflon-jacketed, 5 meter, foil-shielded, 5-conductor 22 AWG with bare wire termination
- GPS 17HVS: White PVC-jacketed, 30 foot, foil-shielded, 8-conductor 28 AWG with RJ-45 termination
- GPS 17N: White PVC-jacketed, 30 foot, foil-shielded 8-conductor 28 AWG with bare wire termination

1.7.1.4 Color
- GPS 16LVS & 16HVS: Black with white logos
- GPS 17HVS, 17N, & 16A: White with black logos

1.7.1.5 Case Material
Polycarbonate thermoplastic that is waterproof to IEC 60529 IPX7 level (immersion in 1 meter of water for 30 minutes)

1.7.2 Electrical Characteristics

1.7.2.1 Input Voltage
- GPS 16LVS: 3.3 VDC to 6.0 VDC regulated, < 100 mV ripple
- GPS 16HVS & 17HVS 6.0 VDC to 40 VDC unregulated
- GPS 16A & 17N 8.0 VDC to 40 VDC unregulated

1.7.2.2 Input Current
- GPS 16HVS, GPS 17HVS 100 mA @ 6 VDC;
  65 mA @ 12 VDC;
  28 mA @ 40 VDC
- GPS 16A, & GPS 17N 100 mA @ 8 VDC
  65 mA @ 12 VDC;
  28 mA @ 40 VDC
- GPS 16LVS: 80 mA typical

1.7.2.3 GPS Receiver Sensitivity
-165 dBW minimum

1.7.3 Environmental Characteristics
- Operating Temperature: -30°C to +80°C
- Storage Temperature: -40°C to +90°C

1.7.4   GPS Performance

1.7.4.1 Receiver
WAAS Enabled™; 12 parallel channel GPS receiver continuously tracks and uses up to 12 satellites (up to 11 with PPS active) to compute and update your position.

1.7.4.2 Acquisition Times
- Reacquisition: Less than 2 seconds
- Warm: Approx. 15 seconds (all data known)
- Cold: Approx. 45 seconds (initial position, time, and almanac known; ephemeris unknown)
- AutoLocate®:   5 minutes (almanac known; initial position and time unknown)
- SkySearch: 5 minutes (no data known)

1.7.4.3 Sentence Rate
- GPS 16LVS, 16HVS,

  17HVS, & 17N: 1 second default; NMEA 0183 output interval configurable from 1 to 900 seconds in 1-second increments
- GPS 16A: 1 second independent update rate, propagated every 200 milliseconds

1.7.4.4 Accuracy
- GPS Standard Positioning Service (SPS)
  Position: < 15 meters, 95% typical (100 meters with Selective Availability on)
  Velocity: 0.1 knot RMS steady state

- DGPS (USCG/RTCM)
  Position: 3–5 meters, 95% typical
  Velocity: 0.1 knot RMS steady state

- DGPS (WAAS)
  Position: < 3 meters, 95% typical
  Velocity: 0.1 knot RMS steady state

- PPS Time (Not available on GPS 16A or 17N):   ±1 microsecond at rising edge of PPS pulse (subject to Selective Availability)

- Dynamics: 999 knots velocity (only limited at altitude greater than 60,000 feet), 6g dynamics

1.7.5 Interfaces

- True RS-232 output (TTL output for GPS 16A and 17N), asynchronous serial input compatible with RS-232 or TTL voltage levels, RS-232 polarity.

- User selectable baud rate: 300, 600, 1200, 2400, 4800, 9600, or 19200. 38400 available for GPS 16A.

1.7.5.1 Port 1

- Configurable between NMEA 0183 Versions 2.00 and 3.00

- ASCII output sentences GPALM, GPGGA, GPGLL, GPGSA, GPGSV, GPRMC, GPVTG (NMEA-approved sentences); PGRMB, PGRME, PGRMF, PGRMM, PGRMT, and PGRMV (Garmin proprietary sentences)

- NMEA 0183 Outputs (see Section 4.2 Transmitted NMEA 0183 Sentences for full protocol specifications)
  Position, velocity and time
  Receiver and satellite status
  Differential Reference Station ID and RTCM Data age
  Geometry and error estimates

- NMEA 0183 Inputs (see Section 4.1 Received NMEA 0183 Sentences for full protocol specifications)
  Initial position, date and time (not required)
  Earth datum and differential mode configuration command, PPS Enable, GPS satellite almanac

- Configurable for binary data output including GPS carrier phase data

1.7.5.2 Port 2

Real-time Differential Correction input (RTCM SC-104 message types 1, 2, 3, 7, and 9)

1.7.5.3 PPS (Not available on GPS 16A or GPS 17N)

1 Hz pulse, programmable width, 1 μs accuracy

1.7.5.4 Power Control (Not available on GPS 16A)

- Off: Open circuit
- On: Ground, or pull to low logic level < 0.3 volts

2 GPS 16/17 WIRING AND PINOUTS

2.1 GPS 16/17 Pinout

The GPS 16LVS, GPS 16HVS, and GPS 17HVS sensors utilize an 8-pin RJ-45 plug. The GPS 16A and GPS 17N feature a stripped and pre-tinned, 5-wire cable assembly for connection flexibility. The following is a functional description of each wire in the cable assembly.

RJ-45 Pin #	Wire Color	Signal Name	Description
1	Red	POWER	**GPS 16LVS:** Regulated +3.3 to +6 VDC. Typical operating current is 80 mA. An internal 6.8 V transient zener diode and a positive temperature coefficient thermistor protect from transients and over-voltages. With voltages greater than 6.8 VDC the zener will draw several amps of current through the thermistor, causing it to heat rapidly and eventually power the unit off, unless an external fuse blows first. When proper supply voltages are returned, the thermistor will cool and allow the GPS 16LVS to operate. The CMOS/TTL output buffers are powered by Vin; therefore, a 3.3 VDC supply will create 3.3 V logic output levels. **GPS 16HVS, GPS 16A, GPS 17HVS, & GPS 17N:** Vin can be an unregulated 6.0 VDC (8.0 VDC for GPS 16A and GPS 17N) to 40 VDC, optimized for 12 VDC. Typical operating power is 800 mW. This voltage drives a switching regulator with a nominal 5.0 VDC output, which powers the internal linear regulators, and the CMOS output buffers.
2	Black	GROUND	Power and Signal Ground
3	Yellow	REMOTE POWER ON/OFF	(N/A for GPS 16A) External Power Control Input. Active (ON) if less than 0.3 VDC. Inactive (OFF) if open-circuit. 51 kΩ internal pull-up resistor to the voltage on the POWER input. Activation of this input powers the internal regulators off and drops the supply current below 20mA in the GPS 16LVS, and below 1 mA in the GPS 16HVS, GPS 17HVS, and GPS 17N. This input is intended to be driven by an open-collector output.
4	Blue	PORT 1 DATA IN	First Serial Asynchronous Input. RS-232 compatible with maximum input voltage range -25 < V < 25. This input may also be directly connected to standard 3 to 5 VDC CMOS logic. The low signal voltage requirement is < 0.9 V, and the high signal voltage requirement is > 2.1 V. Maximum load impedance is 4.7 kΩ. This input may be used to receive serial initialization/ configuration data as specified in Section 4.1 Received NMEA 0183 Sentences.
5	White	PORT 1 DATA OUT	First Serial Asynchronous Output. This RS-232 compatible (TTL level on GPS 16A and GPS 17N) output normally provides serial data which is formatted per *NMEA 0183, Version 3.0*. This output is also capable of outputting phase data information, see Appendix C for details. The NMEA 0183 baud rate is switchable in the range of 300 to 19200 baud (38400 for GPS 16A). The default baud rate is 19200 for GPS 16A and 4800 for all other products.
6	Gray	PPS	(N/A for GPS 16A and GPS 17N) One-Pulse-Per-Second Output. Typical voltage rise and fall times are 300 ns. Impedance is 250 Ω. Open circuit output voltage is low=0 V and high=Vin in the GPS 16LVS, and low=0 V and high=5.0 V in the GPS 16HVS and GPS 17HVS. The default format is a 100 ms wide active-high pulse at a 1 Hz rate; the pulse width is configurable in 20 ms increments. Rising edge is synchronized to the start of each GPS second. This output will provide a nominal 700 mVp-p signal into a 50 Ω load. The pulse time measured at the 50% voltage point will be about 50 ns earlier with a 50 Ω load than with no load.
7	Green	PORT 2 DATA IN	Second Serial Asynchronous Input, electrically identical to PORT 1 DATA IN. This input may be used to receive serial differential GPS data formatted per *RTCM SC-104 Recommended Standards For Differential Navstar GPS Service, Version 2.2* (see Section 4.5 Received RTCM Data for details).
8	Violet	PORT 2 DATA OUT	(N/A for GPS 16A) Second Serial Asynchronous Output, electrically identical to PORT 1 DATA OUT. Reserved for future use.

Table 1: GPS 16/17 Wire Pinout

2.2   GPS 16/17 Wiring Diagrams
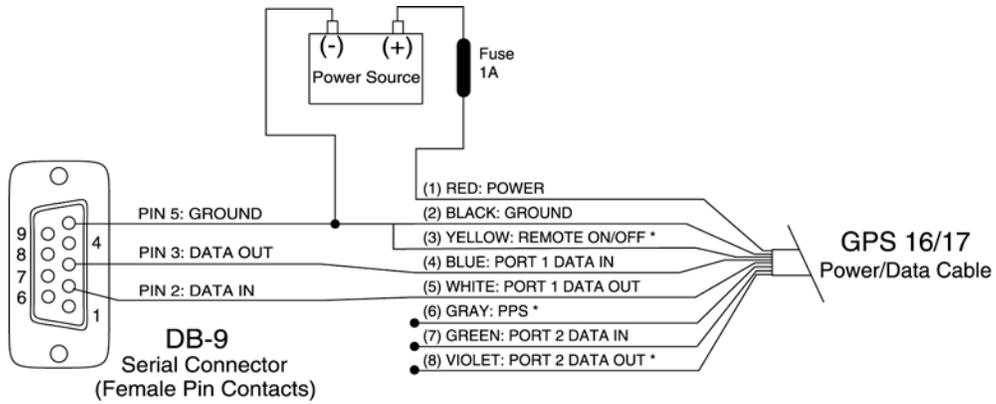
Figure 1: Computer Serial Port Interconnection
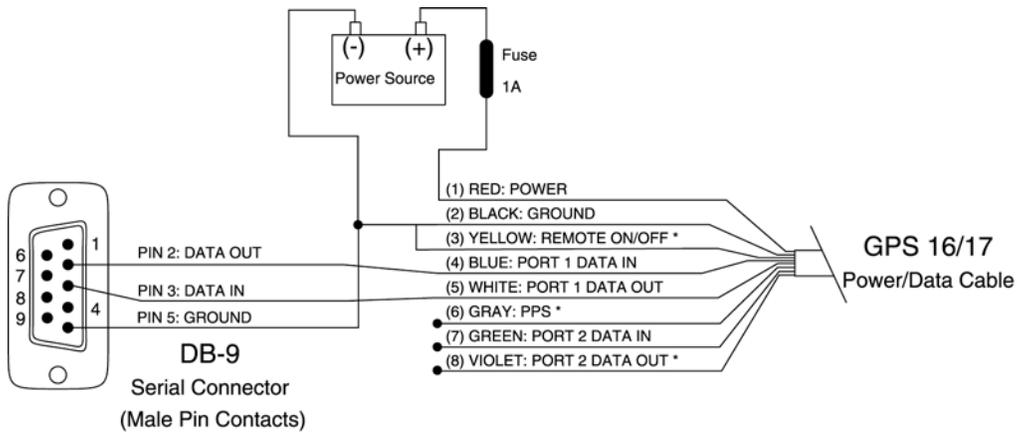
Figure 2. PDA Serial Port Interconnection
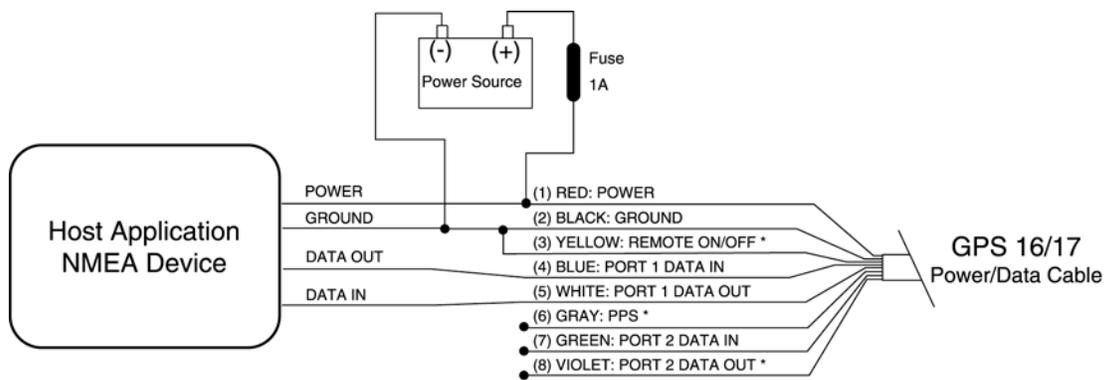
Figure 3. Basic NMEA Device Interconnection

* Not Applicable on the GPS 16A

3   MECHANICAL CHARACTERISTICS & MOUNTING

3.1   GPS 16
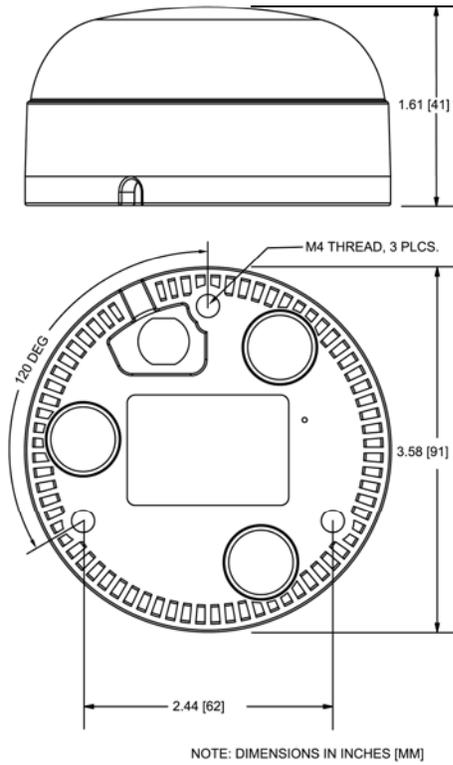
Figure 4. GPS 16 Dimensions
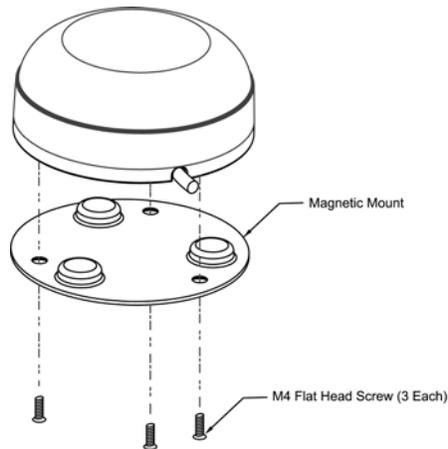
Figure 5. GPS 16 Magnetic Mount Attachment

3.2   GPS 17
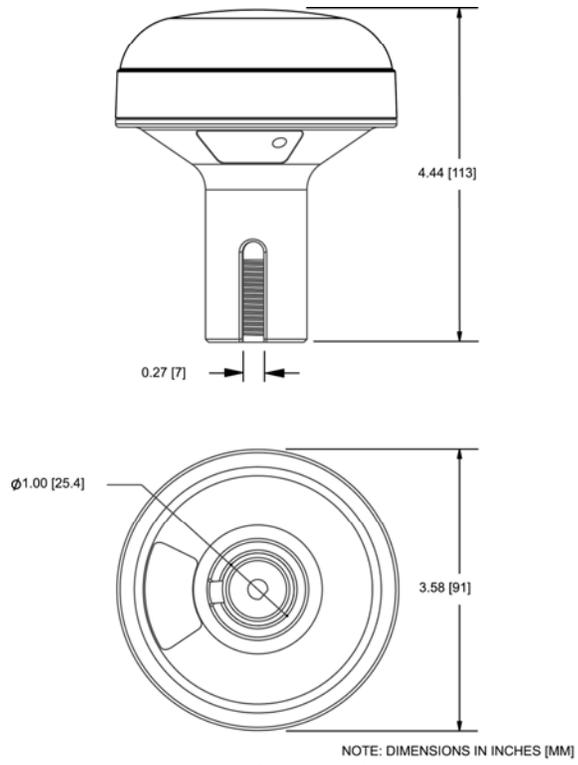
Figure 6. GPS 17 Dimensions

4 SOFTWARE INTERFACE

The GPS 16/17 series products interface protocol design on COM 1 is based on the National Marine Electronics Association's NMEA 0183 ASCII interface specification. The COM 2 port can receive differential GPS (DGPS) correction data using the Radio Technical Commission for Maritime Services' RTCM SC-104 standard. These standards are fully defined in *NMEA 0183, Version 3.0* (copies may be obtained from NMEA, www.nmea.org) and *RTCM Recommended Standards For Differential Navstar GPS Service, Version 2.2, RTCM Special Committee No. 104* (copies may be obtained from RTCM, www.rtcm.org).

The GPS 16/17 series products interface protocol, in addition to transmitting navigation information as defined by NMEA 0183, transmits additional information using the convention of Garmin proprietary sentences.

Binary phase data information can alternatively be output on the COM 1 port; see Appendix B: Binary Phase Output Format for details.

The following sections describe the NMEA 0183 data format of each sentence transmitted and received by the GPS 16/17 series products. The baud rate selection, one-pulse-per-second output interfaces and RTCM differential GPS input are also described.

4.1 Received NMEA 0183 Sentences

The following paragraphs define the sentences that can be received on the GPS sensors' COM 1 port. Null fields in the configuration sentence indicate no change in the particular configuration parameter. All sentences received by the GPS sensor must be terminated with <CR><LF>, the ASCII characters for carriage return (0D hexadecimal) and line feed (0A hexadecimal). The checksum *hh is used for parity checking data and is not required, but is recommended for use in environments containing high electromagnetic noise. It is generally not required in normal PC environments. When used, the parity bytes (hh) are the ASCII representation of the exclusive-or (XOR) sum of all the characters between the "$" and "*" characters, non-inclusive. The hex representation must be a capital letter, such as 3D instead of 3d. Sentences may be truncated by <CR><LF> after any data field and valid fields up to that point will be acted on by the sensor.

4.1.1 Almanac Information (ALM)

The $GPALM sentence can be used to initialize the GPS sensor's stored almanac information in the unlikely event of non-volatile memory loss or after storing longer than six months without tracking GPS satellites.

$GPALM,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,<10>,<11>,<12>,<13>,<14>,<15>*hh<CR><LF>

<1>	Total number of ALM sentences to be transmitted by the GPS sensor during almanac download. This field can be null or any number when sending almanac to the GPS sensor.
<2>	Number of current ALM sentence. This field can be null or any number when sending almanac to the GPS sensor.
<3>	Satellite PRN number, 01 to 32
<4>	GPS week number
<5>	SV health, bits 17-24 of each almanac page
<6>	Eccentricity
<7>	Almanac reference time
<8>	Inclination angle
<9>	Rate of right ascension
<10>	Root of semi major axis
<11>	Omega, argument of perigee
<12>	Longitude of ascension node
<13>	Mean anomaly
<14>	af0 clock parameter
<15>	af1 clock parameter

4.1.2   Sensor Initialization Information (PGRMI)

The $PGRMI sentence provides information used to initialize the GPS sensor's set position and time used for satellite acquisition. Receipt of this sentence by the GPS sensor causes the software to restart the satellite acquisition process. If there are no errors in the sentence, it will be echoed upon receipt. If an error is detected, the echoed PGRMI sentence will contain the current default values. Current PGRMI defaults (with the exception of the Receiver Command, which is a command rather than a mode) can also be obtained by sending $PGRMIE to the GPS sensor.

$PGRMI,<1>,<2>,<3>,<4>,<5>,<6>,<7>*hh<CR><LF>

<1>	Latitude, ddmm.mmm format (leading zeros must be transmitted)
<2>	Latitude hemisphere, N or S
<3>	Longitude, dddmm.mmm format (leading zeros must be transmitted)
<4>	Longitude hemisphere, E or W
<5>	Current UTC date, ddmmyy format
<6>	Current UTC time, hhmmss format
<7>	Receiver Command, A = Auto Locate, R = Unit Reset

4.1.3   Sensor Configuration Information (PGRMC)

The $PGRMC sentence provides information used to configure the GPS sensor's operation. Configuration parameters are stored in non-volatile memory and retained between power cycles. The GPS sensor will echo this sentence upon its receipt if no errors are detected. If an error is detected, the echoed PGRMC sentence will contain the current default values. Current default values can also be obtained by sending $PGRMCE to the GPS sensor.

$PGRMC,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,<10>,<11>,<12>,<13>,<14>*hh<CR><LF>

<1>	Fix mode, A = automatic, 2 = 2D exclusively (host system must supply altitude), 3 = 3D exclusively
<2>	Altitude above/below mean sea level, -1500.0 to 18000.0 meters
<3>	Earth datum index. If the user datum index (96) is specified, fields <4> through <8> must contain valid values. Otherwise, fields <4> through <8> must be null. Refer to Appendix A: Earth Datums for a list of earth datums and the corresponding earth datum index.
<4>	User earth datum semi-major axis, 6360000.000 to 6380000.000 meters (.001 meters resolution)
<5>	User earth datum inverse flattening factor, 285.0 to 310.0 (10^{-9} resolution)
<6>	User earth datum delta x earth centered coordinate, -5000.0 to 5000.0 meters (1 meter resolution)
<7>	User earth datum delta y earth centered coordinate, -5000.0 to 5000.0 meters (1 meter resolution)
<8>	User earth datum delta z earth centered coordinate, -5000.0 to 5000.0 meters (1 meter resolution)
<9>	Differential mode, A = automatic (output DGPS data when available, non-DGPS otherwise), D = differential exclusively (output only differential fixes)
<10>	NMEA 0183 Baud rate, 1 = 1200, 2 = 2400, 3 = 4800, 4 = 9600, 5 = 19200, 6 = 300, 7 = 600
<11>	Velocity filter, 0 = No filter, 1 = Automatic filter, 2 to 255 = Filter time constant (e.g., 10 = 10 second filter)
<12>	PPS mode, 1 = Off, 2 = 1 Hz
<13>	PPS pulse length, 0 though 48 = (n+1)*20 ms. Example: n = 4 corresponds to a 100 ms wide pulse
<14>	Dead reckoning valid time 1to 30 (sec)

All configuration changes take effect after receipt of a valid value except baud rate and PPS mode. Baud rate and PPS mode changes take effect on the next power cycle or an external reset event.

4.1.4 Additional Sensor Configuration Information (PGRMC1)

The $PGRMC1 sentence provides additional information used to configure the GPS sensor operation. Configuration parameters are stored in non-volatile memory and retained between power cycles. The GPS sensor will echo this sentence upon its receipt if no errors are detected. If an error is detected, the echoed PGRMC1 sentence will contain the current default values. Current default values can also be obtained by sending $PGRMC1E to the GPS sensor.

$PGRMC1,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>*hh<CR><LF>

<1>	NMEA 0183 output time 1-900 (sec)
<2>	Binary Phase Output Data, 1 = Off, 2 = On.
<3>	Automatic Position Averaging when Stopped, 1 = Off, 2 = On
<4>	No Effect (DGPS beacon frequency: 0.0, 283.5–325.0 kHz in 0.5 kHz steps)
<5>	No Effect (DGPS beacon bit rate:0, 25, 50, 100, or 200 bps)
<6>	No Effect (DGPS beacon scanning, 1 = Off, 2 = On)
<7>	NMEA 0183 version 2.30 mode indicator, 1 = Off, 2 = On
<8>	DGPS mode, W = WAAS Only, N = None (DGPS disabled)
<9>	Power Save Mode, P = Power Save mode, N = Normal
<10>	Adaptive Transmission Enabled, 1 = Off, 2 = On
<11>	Auto Power Off, 1 = Off, 2 = On
<12>	Power On with External Charger, 1 = Off, 2 = On
<13>	PPS Auto Off Mode, 1 = Off, 2 = On

Configuration changes take effect immediately, with the exception of Binary Phase Output Data, which takes effect on the next power cycle or a reset event. A reset can be commanded by sending the sentence "$PGRMI,,,,,,,R" (refer to Section 4.1.2 Sensor Initialization Information (PGRMI)). If the GPS sensor is in the Binary data mode, it is necessary to send the following eight-byte data stream to temporarily change the data format to NMEA 0183. Then follow by sending a PGRMC1 sentence that turns off the Binary Phase Output Data format:

10 0A 02 26 00 CE 10 03 (Hexadecimal)

4.1.5 Output Sentence Enable/Disable (PGRMO)

The $PGRMO sentence provides the ability to enable and disable specific output sentences. The following sentences are enabled at the factory: GPGGA, GPGSA, GPGSV, GPRMC, and PGRMT.

$PGRMO,<1>,<2>*hh<CR><LF>

<1>	Target sentence description (e.g., PGRMT, GPGSV, etc.)
<2>	Target sentence mode, where: 0 = disable specified sentence 1 = enable specified sentence 2 = disable all output sentences 3 = enable all output sentences (except GPALM) 4 = restore factory default output sentences

The following notes apply to the PGRMO input sentence:

1. If the target sentence mode is '2' (disable all), '3' (enable all), or '4' (restore defaults), the target sentence description is not checked for validity. In this case, an empty field is allowed (e.g., $PGRMO,,3), or the mode field may contain from 1 to 5 characters.

2. If the target sentence mode is '0' (disable) or '1' (enable), the target sentence description field must be an identifier for one of the sentences that can be output by the GPS sensor.

3. If either the target sentence mode field or the target sentence description field is not valid, the PGRMO sentence will have no effect.

4. $PGRMO,GPALM,1 will cause the GPS sensor to transmit all stored almanac information. All other NMEA 0183 sentence transmission will be suspended temporarily.

5. $PGRMO,,G will cause the COM port to change to Garmin Data Transfer format for the duration of the power cycle. The Garmin mode is required for GPS 16/17 series product software updates.

4.1.6 Tune DGPS Beacon Receiver (PSLIB)

The $PSLIB sentence provides the ability to tune a Garmin GBR 21, GBR 23 or equivalent beacon receiver.

$PSLIB,<1>,<2>*hh<CR><LF>

<1>	Beacon tune frequency, 0.0, 283.5–325.0 kHz in 0.5 kHz steps
<2>	Beacon bit rate, 0, 25, 50, 100, or 200 bps

If valid data is received, the GPS sensor will store it in the EEPROM and echo the PSLIB command to the beacon receiver. If the GPS sensor is using any stored beacon frequency other than 0.0, it will tune the beacon receiver once immediately after power up or external reset.

4.2   Transmitted NMEA 0183 Sentences

The subsequent paragraphs define the sentences that can be transmitted on COM 1 by the GPS sensor.

4.2.1   Sentence Transmission Rate

Sentences are transmitted with respect to the user selected baud rate.

The GPS sensor will transmit each sentence (except where noted in particular transmitted sentence descriptions) at a periodic rate based on the user selected baud rate and user selected output sentences. The GPS sensor will transmit the selected sentences contiguously. The length of the transmission can be determined by the following equation and Tables 2 and 3:

$$\text{length of transmission} = \frac{\text{total characters to be transmitted}}{\text{characters transmitted per second}}$$

Sentence	Output by Default?	Maximum Characters
GPRMC	✔	74
GPGGA	✔	82
GPGSA	✔	66
GPGSV	✔	70
PGRME	✔	35
GPGLL		44
GPVTG		42
PGRMV		32
PGRMF		82
PGRMB	✔ *	40
PGRMM	✔	32
PGRMT	Once per minute	50

* Except GPS 16A

Table 2: NMEA 0183 Output Sentence Order and Size

Baud	Characters per Second
300	30
600	60
1200	120
2400	240
4800	480
9600	960
19200	1920
38400 **	3840

Table 3: Characters per Second for Available Baud Rates

** GPS 16A Only

The maximum number of fields allowed in a single sentence is 82 characters including delimiters. Values in the table include the sentence start delimiter character "$" and the termination delimiter <CR><LF>. The factory set defaults will result in a once-per-second transmission at 4800 baud, which is the NMEA 0183 specification transmission rate.

4.2.1.1 GPS 16LVS, 16HVS, and GPS 17HVS (not 17N)

Regardless of the selected baud rate, the information transmitted by the GPS sensor is referenced to the one-pulse-per-second output pulse immediately preceding the GPRMC sentence, or whichever sentence is output first in the burst (see Table 2 above).

4.2.1.2 GPS 16A

Sentences are transmitted at a fixed 200-millisecond interval.

4.2.2 Transmitted Time

The GPS sensor outputs UTC (Coordinated Universal Time) date and time of day in the transmitted sentences. Before the initial position fix, the on-board clock provides the date and time of day. After the initial position fix, the date and time of day are calculated using GPS satellite information and are synchronized with the one-pulse-per-second output.

The GPS sensor uses information obtained from the GPS satellites to add or delete UTC leap seconds and correct the transmitted date and time of day. The transmitted date and time of day for leap second correction follow the guidelines in *National Institute of Standards and Technology Special Publication 432 (Revised 1990)*. This document is for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, U.S.A.

When a positive leap second is required, one second is inserted at the beginning of the first hour (0h 0m 0s) of the day that the positive leap is occurring. The minute containing the leap second is 61 seconds long. The GPS sensor would have transmitted the following information for the leap second added December 31, 1998:

$GPRMC,235959,A,3851.3651,N,09447.9382,W,000.0,221.9,071103,003.3,E*69

$GPRMC,000000,A,3851.3651,N,09447.9382,W,000.0,221.9,081103,003.3,E*67

$GPRMC,000000,A,3851.3651,N,09447.9382,W,000.0,221.9,081103,003.3,E*67

$GPRMC,000001,A,3851.3651,N,09447.9382,W,000.0,221.9,081103,003.3,E*66

If a negative leap second should be required, one second will be deleted at the end of some UTC month. The minute containing the leap second will be only 59 seconds long. In this case, the GPS sensor will not transmit the time of day 0h 0m 0s (the "zero" second) for the day from which the leap second is removed.

$GPRMC,235959,A,3851.3650,N,09447.9373,W,000.0,000.0,111103,003.3,E*69

$GPRMC,000001,A,3851.3650,N,09447.9373,W,000.0,000.0,121103,003.3,E*6A

$GPRMC,000002,A,3851.3650,N,09447.9373,W,000.0,000.0,121103,003.3,E*69

4.2.3 Global Positioning System Almanac Data (ALM)

Almanac sentences are not normally transmitted. Almanac transmission can be initiated by sending the GPS sensor a $PGRMO,GPALM,1 command. Upon receipt of this command, the GPS sensor will transmit available almanac information on GPALM sentences. During the transmission of almanac sentences, other NMEA 0183 data output will be suspended temporarily.

$GPALM,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,<10>,<11>,<12>,<13>,<14>,<15>*hh<CR><LF>

<field information> can be found in Section 4.1.1 Almanac Information (ALM).

4.2.4 Global Positioning System Fix Data (GGA)

$GPGGA,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,M,<10>,M,<11>,<12>*hh<CR><LF>

<1>	UTC time of position fix, hhmmss format
<2>	Latitude, ddmm.mmmm format (leading zeros will be transmitted) (The GPS 16A reports the decimal fraction of minutes with 5 digits of precision)
<3>	Latitude hemisphere, N or S
<4>	Longitude, dddmm.mmmm format (leading zeros will be transmitted) (The GPS 16A reports the decimal fraction of minutes with 5 digits of precision)
<5>	Longitude hemisphere, E or W
<6>	GPS quality indication, 0 = fix not available, 1 = Non-differential GPS fix available, 2 = Differential GPS (DGPS) fix available, 6 = Estimated (only output if NMEA 0183 version 2.30 active)
<7>	Number of satellites in use, 00 to 12 (leading zeros will be transmitted)
<8>	Horizontal dilution of precision, 0.5 to 99.9
<9>	Antenna height above/below mean sea level, -9999.9 to 99999.9 meters
<10>	Geoidal height, -999.9 to 9999.9 meters
<11>	Differential GPS (RTCM SC-104) data age, number of seconds since last valid RTCM transmission (null if not an RTCM DGPS fix)
<12>	Differential Reference Station ID, 0000 to 1023 (leading zeros will be transmitted, null if not an RTCM DGPS fix)

4.2.5 GPS DOP and Active Satellites (GSA)

$GPGSA,<1>,<2>,<3>,<3>,<3>,<3>,<3>,<3>,<3>,<3>,<3>,<3>,<3>,<3>,<4>,<5>,<6>*hh<CR><LF>

<1>	Mode, M = manual, A = automatic
<2>	Fix type, 1 = not available, 2 = 2D, 3 = 3D
<3>	PRN number, 01 to 32, of satellite used in solution, up to 12 transmitted (leading zeros will be transmitted)
<4>	Position dilution of precision, 0.5 to 99.9
<5>	Horizontal dilution of precision, 0.5 to 99.9
<6>	Vertical dilution of precision, 0.5 to 99.9

4.2.6 GPS Satellites in View (GSV)

$GPGSV,<1>,<2>,<3>,<4>,<5>,<6>,<7>,...<4>,<5>,<6>,<7>*hh<CR><LF>

<1>	Total number of GSV sentences to be transmitted
<2>	Number of current GSV sentence
<3>	Total number of satellites in view, 00 to 12 (leading zeros will be transmitted)
<4>	Satellite PRN number, 01 to 32 (leading zeros will be transmitted)
<5>	Satellite elevation, 00 to 90 degrees (leading zeros will be transmitted)
<6>	Satellite azimuth, 000 to 359 degrees, true (leading zeros will be transmitted)
<7>	Signal to noise ratio (C/No) 00 to 99 dB, null when not tracking (leading zeros will be transmitted)

Note: Items <4>,<5>,<6>, and <7> repeat for each satellite in view to a maximum of four (4) satellites per sentence. Additional satellites in view information must be sent in subsequent bursts of NMEA 0183 data. These fields will be null if unused.

4.2.7 Recommended Minimum Specific GPS/TRANSIT Data (RMC)

$GPRMC,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,<10>,<11>,<12>*hh<CR><LF>

<1>	UTC time of position fix, hhmmss format
<2>	Status, A = Valid position, V = NAV receiver warning
<3>	Latitude, ddmm.mmmm format (leading zeros will be transmitted) (The GPS 16A reports the decimal fraction of minutes with 5 digits of precision)
<4>	Latitude hemisphere, N or S
<5>	Longitude, dddmm.mmmm format (leading zeros will be transmitted) (The GPS 16A reports the decimal fraction of minutes with 5 digits of precision)
<6>	Longitude hemisphere, E or W
<7>	Speed over ground, 000.0 to 999.9 knots (leading zeros will be transmitted)
<8>	Course over ground, 000.0 to 359.9 degrees, true (leading zeros will be transmitted)
<9>	UTC date of position fix, ddmmyy format
<10>	Magnetic variation, 000.0 to 180.0 degrees (leading zeros will be transmitted)
<11>	Magnetic variation direction, E or W (westerly variation adds to true course)
<12>	Mode indicator (only output if NMEA 0183 version 2.30 active), A = Autonomous, D = Differential, E = Estimated, N = Data not valid

4.2.8 Track Made Good and Ground Speed (VTG)

$GPVTG,<1>,T,<2>,M,<3>,N,<4>,K,<5>*hh<CR><LF>

<1>	True course over ground, 000 to 359 degrees (leading zeros will be transmitted)
<2>	Magnetic course over ground, 000 to 359 degrees (leading zeros will be transmitted)
<3>	Speed over ground, 000.0 to 999.9 knots (leading zeros will be transmitted)
<4>	Speed over ground, 0000.0 to 1851.8 kilometers per hour (leading zeros will be transmitted)
<5>	Mode indicator (only output if NMEA 0183 version 2.30 active), A = Autonomous, D = Differential, E = Estimated, N = Data not valid

4.2.9 Geographic Position (GLL)

$GPGLL,<1>,<2>,<3>,<4>,<5>,<6>,<7>*hh<CR><LF>

<1>	Latitude, ddmm.mmmm format (leading zeros will be transmitted) (The GPS 16A reports the decimal fraction of minutes with 5 digits of precision)
<2>	Latitude hemisphere, N or S
<3>	Longitude, dddmm.mmmm format (leading zeros will be transmitted) (The GPS 16A reports the decimal fraction of minutes with 5 digits of precision)
<4>	Longitude hemisphere, E or W
<5>	UTC time of position fix, hhmmss format
<6>	Status, A = Valid position, V = NAV receiver warning
<7>	Mode indicator (only output if NMEA 0183 version 2.30 active), A = Autonomous, D = Differential, E = Estimated, N = Data not valid

4.2.10 Estimated Error Information (PGRME)

$PGRME,<1>,M,<2>,M,<3>,M*hh<CR><LF>

<1>	Estimated horizontal position error (HPE), 0.0 to 999.9 meters
<2>	Estimated vertical position error (VPE), 0.0 to 999.9 meters
<3>	Estimated position error (EPE), 0.0 to 999.9 meters

4.2.11 GPS Fix Data Sentence (PGRMF)

$PGRMF,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,<10>,<11>,<12>,<13>,<14>,<15>*hh<CR><LF>

<1>	GPS week number (0 to 1023)
<2>	GPS seconds (0 to 604799)
<3>	UTC date of position fix, ddmmyy format
<4>	UTC time of position fix, hhmmss format
<5>	GPS leap second count
<6>	Latitude, ddmm.mmmm format (leading zeros will be transmitted) (The GPS 16A reports the decimal fraction of minutes with 5 digits of precision)
<7>	Latitude hemisphere, N or S
<8>	Longitude, dddmm.mmmm format (leading zeros will be transmitted) (The GPS 16A reports the decimal fraction of minutes with 5 digits of precision)
<9>	Longitude hemisphere, E or W
<10>	Mode, M = manual, A = automatic
<11>	Fix type, 0 = no fix, 1 = 2D fix, 2 = 3D fix
<12>	Speed over ground, 0 to 1851 kilometers/hour
<13>	Course over ground, 0 to 359 degrees, true
<14>	Position dilution of precision, 0 to 9 (rounded to nearest integer value)
<15>	Time dilution of precision, 0 to 9 (rounded to nearest integer value)

4.2.12 Map Datum (PGRMM)

The Garmin Proprietary sentence $PGRMM gives the name of the map datum currently in use by the GPS sensor. This information is used by the Garmin MapSource real-time plotting application.

$PGRMM,<1>*hh<CR><LF>

<1>	Name of map datum currently in use (variable length field, e.g., "WGS 84")

4.2.13 Sensor Status Information (PGRMT)

The Garmin Proprietary sentence $PGRMT gives information concerning the status of the GPS sensor.
This sentence is transmitted once per minute regardless of the selected baud rate.

$PGRMT,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>*hh<CR><LF>

<1>	Product, model and software version (variable length field, e.g., "GPS 16/17HVS VER 2.05")
<2>	ROM checksum test, P = pass, F = fail
<3>	Receiver failure discrete, P = pass, F = fail
<4>	Stored data lost, R = retained, L = lost
<5>	Real time clock lost, R = retained, L = lost
<6>	Oscillator drift discrete, P = pass, F = excessive drift detected
<7>	Data collection discrete, C = collecting, null if not collecting
<8>	GPS sensor temperature in degrees C
<9>	GPS sensor configuration data, R = retained, L = lost

4.2.14 3D Velocity Information (PGRMV)

$PGRMV,<1>,<2>,<3>*hh<CR><LF>

<1>	True east velocity, -514.4 to 514.4 meters/second
<2>	True north velocity, -514.4 to 514.4 meters/second
<3>	Up velocity, -999.9 to 999.9 meters/second

4.2.15 DGPS Beacon Information (PGRMB)

Note: PGRMB is not supported at this time.

$PGRMB,<1>,<2>,<3>,<4>,<5>,K,<6>,<7>*hh<CR><LF>

<1>	Beacon tune frequency, 0.0, 283.5–325.0 kHz in 0.5 kHz steps
<2>	Beacon bit rate, 0, 25, 50, 100, or 200 bps
<3>	Beacon SNR, 0 to 31
<4>	Beacon data quality, 0 to 100
<5>	Distance to beacon reference station in kilometers
<6>	Beacon receiver communication status (0 = Check Wiring, 1 = No Signal, 2 = Tuning, 3 = Receiving, 4= Scanning)
<7>	DGPS fix source (R = RTCM, W = WAAS, N = Non-DGPS Fix)
<8>	DGPS mode, A = Automatic, W = WAAS Only, R = RTCM Only, N = None (DGPS disabled)

4.3   Baud Rate Selection

Baud rate selection can be performed by sending the appropriate configuration sentence to the GPS sensor as described in the $PGRMC Section 4.1.3 Sensor Configuration Information (PGRMC), field <10>.

4.4   One-Pulse-Per-Second (PPS) Output

(This signal not available on the GPS 16A or GPS 17N.)

The highly accurate one-pulse-per-second (PPS) output is provided for applications requiring precise timing measurements. The signal is generated after the initial position fix has been calculated, and the signal continues until power down. The rising edge of the signal is synchronized to the start of each GPS second.

Regardless of the selected baud rate, the information transmitted by the GPS sensor is referenced to the pulse immediately preceding the NMEA 0183 RMC sentence.

The accuracy of the one-pulse-per-second output is maintained only while the GPS sensor can compute a valid position fix. To obtain the most accurate results, the one-pulse-per-second output should be calibrated against a local time reference to compensate for cable and internal receiver delays and the local time bias.

The default pulse width is 100 ms, however; it may be programmed in 20 ms increments between 20 ms and 980 ms as described in $PGRMC Section 4.1.3 Sensor Configuration Information (PGRMC), field <13>.

4.5   Received RTCM Data

Position accuracy of less than 5 meters can be achieved with the GPS 16/17 series products by using Differential GPS (DGPS) real-time pseudo-range correction data in RTCM SC-104 format, with message types 1, 2, 3, 7, and 9. These corrections can be received by the GPS 16/17 series products on COM 2. The RTCM data must be received at the same baud rate as the COM 1 port. For details on the SC-104 format, refer to RTCM Paper 134-89/SC 104-68 by the Radio Technical Commission for Maritime Services.

APPENDIX A: EARTH DATUMS

The following is a list of the Garmin GPS 16/17 Earth datum indices and the corresponding earth datum name (including the area of application):

0   ADINDAN - Ethiopia, Mali, Senegal, Sudan

1   AFGOOYE - Somalia

2   AIN EL ABD 1970 - Bahrain Island, Saudi Arabia

3   ANNA 1 ASTRO 1965 - Cocos Island

4   ARC 1950 - Botswana, Lesotho, Malawi, Swaziland, Zaire, Zambia, Zimbabwe

5   ARC 1960 - Kenya, Tanzania

6   ASCENSION ISLAND 1958 - Ascension Island

7   ASTRO BEACON "E" - Iwo Jima Island

8   AUSTRALIAN GEODETIC 1966 - Australia, Tasmania Island

9   AUSTRALIAN GEODETIC 1984 - Australia, Tasmania Island

10   ASTRO DOS 71/4 - St. Helena Island

11   ASTRONOMIC STATION 1952 - Marcus Island

12   ASTRO B4 SOROL ATOLL - Tern Island

13   BELLEVUE (IGN) - Efate and Erromango Islands

14   BERMUDA 1957 - Bermuda Islands

15   BOGOTA OBSERVATORY - Colombia

16   CAMPO INCHAUSPE - Argentina

17   CANTON ASTRO 1966 - Phoenix Islands

18   CAPE CANAVERAL - Florida, Bahama Islands

19   CAPE - South Africa

20   CARTHAGE - Tunisia

21   CHATHAM 1971 - Chatham Island (New Zealand)

22   CHUA ASTRO - Paraguay

23   CORREGO ALEGRE - Brazil

24   DJAKARTA (BATAVIA) - Sumatra Island (Indonesia)

25   DOS 1968 - Gizo Island (New Georgia Islands)

26   EASTER ISLAND 1967 - Easter Island

27   EUROPEAN 1950 - Austria, Belgium, Denmark, Finland, France, Germany, Gibraltar, Greece, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland

28   EUROPEAN 1979 - Austria, Finland, Netherlands, Norway, Spain, Sweden, Switzerland

29   FINLAND HAYFORD 1910 - Finland

30   GANDAJIKA BASE - Republic of Maldives

31   GEODETIC DATUM 1949 - New Zealand

32   ORDNANCE SURVEY OF GREAT BRITAIN 1936 - England, Isle of Man, Scotland, Shetland Islands, Wales

33   GUAM 1963 - Guam Island

34   GUX 1 ASTRO - Guadalcanal Island

35   HJORSEY 1955 - Iceland

36   HONG KONG 1963 - Hong Kong

37   INDIAN - Bangladesh, India, Nepal

38   INDIAN - Thailand, Vietnam

39   IRELAND 1965 - Ireland

40   ISTS O73 ASTRO 1969 - Diego Garcia

41   JOHNSTON ISLAND 1961 - Johnston Island

42   KANDAWALA - Sri Lanka

43   KERGUELEN ISLAND - Kerguelen Island

44   KERTAU 1948 - West Malaysia, Singapore

45   L.C. 5 ASTRO - Cayman Brac Island

46   LIBERIA 1964 - Liberia

47   LUZON - Mindanao Island

48   LUZON - Phillippines (excluding Mindanao Island)

49   MAHE 1971 - Mahe Island

50   MARCO ASTRO - Salvage Islands

51   MASSAWA - Eritrea (Ethiopia)

52   MERCHICH - Morocco

53   MIDWAY ASTRO 1961 - Midway Island

54   MINNA - Nigeria

55   NORTH AMERICAN 1927 - Alaska

56   NORTH AMERICAN 1927 - Bahamas (excluding San Salvador Island)

57   NORTH AMERICAN 1927 - Central America (Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua)

58   NORTH AMERICAN 1927 - Canal Zone

59   NORTH AMERICAN 1927 - Canada (including Newfoundland Island)

60   NORTH AMERICAN 1927 - Caribbean (Barbados, Caicos Islands, Cuba, Dominican Republic, Grand Cayman, Jamaica, Leeward Islands, Turks Islands)

61   NORTH AMERICAN 1927 - Mean Value (CONUS)

62   NORTH AMERICAN 1927 - Cuba

63   NORTH AMERICAN 1927 - Greenland (Hayes Peninsula)

64   NORTH AMERICAN 1927 - Mexico

65   NORTH AMERICAN 1927 - San Salvador Island

66   NORTH AMERICAN 1983 - Alaska, Canada, Central America, CONUS, Mexico

67   NAPARIMA, BWI - Trinidad and Tobago

68   NAHRWAN - Masirah Island (Oman)

69   NAHRWAN - Saudi Arabia

70   NAHRWAN - United Arab Emirates

71   OBSERVATORIO 1966 - Corvo and Flores Islands (Azores)

72   OLD EGYPTIAN - Egypt

73   OLD HAWAIIAN - Mean Value

74   OMAN - Oman

75	PICO DE LAS NIEVES - Canary Islands
76	PITCAIRN ASTRO 1967 - Pitcairn Island
77	PUERTO RICO - Puerto Rico, Virgin Islands
78	QATAR NATIONAL - Qatar
79	QORNOQ - South Greenland
80	REUNION - Mascarene Island
81	ROME 1940 - Sardinia Island
82	RT 90 - Sweden
83	PROVISIONAL SOUTH AMERICAN 1956 - Bolivia, Chile, Colombia, Ecuador, Guyana, Peru, Venezuela
84	SOUTH AMERICAN 1969 - Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Venezuela, Trinidad and Tobago
85	SOUTH ASIA - Singapore
86	PROVISIONAL SOUTH CHILEAN 1963 - South Chile
87	SANTO (DOS) - Espirito Santo Island
88	SAO BRAZ - Sao Miguel, Santa Maria Islands (Azores)
89	SAPPER HILL 1943 - East Falkland Island
90	SCHWARZECK - Namibia
91	SOUTHEAST BASE - Porto Santo and Madeira Islands
92	SOUTHWEST BASE - Faial, Graciosa, Pico, Sao Jorge, and Terceira Islands (Azores)
93	TIMBALAI 1948 - Brunei and East Malaysia (Sarawak and Sabah)
94	TOKYO - Japan, Korea, Okinawa
95	TRISTAN ASTRO 1968 - Tristan da Cunha
96	User defined earth datum
97	VITI LEVU 1916 - Viti Levu Island (Fiji Islands)
98	WAKE-ENIWETOK 1960 - Marshall Islands
99	WORLD GEODETIC SYSTEM 1972
100	WORLD GEODETIC SYSTEM 1984
101	ZANDERIJ - Surinam
102	CH-1903 - Switzerland
103	Hu - Tzu - Shan
104	Indonesia 74
105	Austria
106	Potsdam
107	Taiwan - modified Hu-Tzu-Shan
108	GDA - Geocentric Datum of Australia
109	Dutch

APPENDIX B: BINARY PHASE OUTPUT FORMAT

Note: The following applies to GPS 17N software version 2.06 and higher, and all software versions of GPS 16LVS, GPS 16HVS, GPS 16A, and GPS 17HVS.

Two records are transmitted once per second by the GPS 16/17 series products. One record contains primarily post-process information, such as position and velocity information. The second record contains receiver measurement information. The records are sent at a default baud rate of 9600 baud, 8 data bits, and no parity.

Records begin with a delimiter byte (10 hex). The second byte identifies the record type (33 hex for a position record, 34 hex for a receiver measurement). The third byte indicates the size of the data. The fourth byte is the first byte of data. The data is then followed by a checksum byte, a delimiter byte (10 hex), and an end-of-transmission character (03 hex).

Note: If RTCM-104 differential data is sent to the GPS sensor the board will reset the Phase Output Data baud rate to the same baud rate used for RTCM-104 data. If the differential inputs are used on the GPS sensor then the RTCM-104 data must be sent to the GPS sensor at 9600 baud (preferred) or 4800 baud. RTCM-104, baud rates less than 4800 baud are not supported by the GPS sensors since it would limit bus bandwidth past the point where a once per second phase output data rate could be maintained.

Note that the satellite data information is also enabled when the position record is enabled.

Records sent over RS232 begin with a delimiter byte (10 hex). The second byte identifies the record type (33 hex for a position record, 34 hex for a receiver measurement and 72 hex for a satellite data record). The third byte indicates the size of the data. The fourth byte is the first byte of data. The data is then followed by a checksum byte, a delimiter byte (10 hex), and an end-of-transmission character (03 hex). Additionally, any DLEs (0x10) that appear between the delimeters are escaped with a second DLE. There is sample code at the end of this section that will strip off the DLEs and ETXs.

RS232 Packet:

- 0x10	(DLE is first byte)
- 0x##	(Record ID – single byte)
- 0x##	(Number of data bytes – single byte)
- data bytes	(See descriptions below)
- 0x##	(2's complement of the arithmetic sum of the bytes between the delimiters)
- 0x10	(DLE)
- 0x03	(ETX is last byte)

The data bytes of each packet contain the record specified by the record ID. A description of each record follows.

Satellite Data Record

The satellite data has a record ID of 0x72 with 84 (0x54) data bytes. The data bytes contain the data for the 12 channels as described below. For each satellite, the following data is available:

```
typedef    struct
           {
           uint8     svid;      //space vehicle identification (1–32 and 33–64 for WAAS)
           uint16    snr;       //signal-to-noise ratio
           uint8     elev;      //satellite elevation in degrees
           uint16    azmth;     //satellite azimuth in degrees
           uint8     status;    //status bit-field
           } cpo_sat_data;
```

The status bit field represents a set of booleans described below:

Bit	Meaning when bit is one (1)
0	The unit has ephemeris data for the specified satellite.
1	The unit has a differential correction for the specified satellite.
2	The unit is using this satellite in the solution.

This pattern is repeated for all 12 channels for a total of 12 X 7 bytes = 84 (0x54) bytes :

```
typedef    struct

           {

           cpo_sat_data

           cpo_sat_data

           cpo_sat_data

           cpo_sat_data

           cpo_sat_data

           cpo_sat_data

           cpo_sat_data

           cpo_sat_data

           cpo_sat_data

           cpo_sat_data

           cpo_sat_data

           cpo_sat_data

           } cpo_all_sat_data
```

The RS-232 Packet for the Satellite Record looks like:

- 0x10   (DLE is first byte)

- 0x72   (Record ID – single byte)

- 0x54   (Number of data bytes – single byte)

- cpo_all_sat_data

- 0x##   (2's complement of the arithmetic sum of the bytes between the delimiters)

- 0x10   (DLE)

- 0x03   (ETX is last byte)

Position Record
- 0x10   (DLE is first byte)
- 0x33   (Position record identifier)
- 0x40   (Size of data)
- cpo_pvt_data   (See description below)
- one-byte checksum   (The addition of bytes between the delimiters should equal 0)
- 0x10   (DLE)
- 0x03   (ETX is last byte)

```
typedef struct
    {
    float     alt;
    float     epe;
    float     eph;
    float     epv;
    int       fix;
    double    gps_tow;
    double    lat;
```

```
        double      lon;
        float       lon_vel;
        float       lat_vel;
        float       alt_vel;
        float       msl_hght;
        int         leap_sec;
        long        grmn_days;
        } cpo_pvt_data;
```

alt   Ellipsoid altitude (meters)
epe   Est pos error (meters)
eph   Pos err, horizontal (meters)
epv   Pos err, vertical (meters)
fix   0 = no fix; 1 = no fix; 2 = 2D; 3 = 3D; 4 = 2D differential; 5 = 3D differential;
            6 and greater = not defined
gps_tow   GPS time of week (sec)
lat   Latitude (radians)
lon   Longitude (radians)
lon_vel   Longitude velocity (meters/second)
lat_vel   Latitude velocity (meters/second)
alt_vel   Altitude velocity (meters/ second)
msl_hght   Mean sea level height (meters)
leap_sec   UTC leap seconds
grmn_days   Garmin days (days since December 31, 1989)

Receiver Measurement Record

- 0x10   (DLE is first byte)
- 0x34   (Receiver record identifier)
- 0xE2   (Size of data)
- cpo_rcv_data   (See below)
- one byte checksum   (The sum of bytes between the delimiters should equal 0)
- 0x10   (DLE)
- 0x03   (ETX)

```
typedef struct
        {
        unsigned long   cycles;
        double          pr;
        unsigned int    phase;
        char            slp_dtct;
        unsigned char   snr_dbhz;
        char            svid;
        char            valid;
} cpo_rcv_sv_data;

typedef struct
        {
        double          rcvr_tow;
        int             rcvr_wn;
        cpo_rcv_sv_data sv[ 12 ];
} cpo_rcv_data;
```

rcvr_tow   Receiver time of week (seconds)
rcvr_wn   Receiver week number
cycles   Number of accumulated cycles
pr   Pseudorange (meters)
phase   To convert to (0 -359.999) multiply by 360.0 and divide by 2048.0
slp_dtct   0 = no cycle slip detected; non-zero = cycle slip detected
snr_dbhz   Signal strength
svid   Satellite number (0 to 31) Note: add 1 to offset to current svid numbers
valid   0 = information not valid; non-zero = information valid

Sample C Code

DLE and ETX bytes:

Sample C code to receive the two records should filter DLE and ETX bytes as described below:

```
typedef enum
    {
    DAT,
    DLE,
    ETX
    } rx_state_type;

/* Declare and initialize static variables */
static char         in_que[ 256 ];
static int          in_que_ptr = 0;
static rx_state_type rx_state = DAT;

.
.
.

void add_to_que( char data )
{
#define DLE_BYTE 0x10
#define ETX_BYTE 0x03

if ( rx_state == DAT )
    {
    if ( data == DLE_BYTE )
        {
        rx_state = DLE;
        }
    else
        {
        in_que[ in_que_ptr++ ] = data;
        }
    }
else if ( rx_state == DLE )
    {
    if ( data == ETX_BYTE )
        {
        rx_state = ETX;
        }
    else
        {
        rx_state = DAT;
        in_que[ in_que_ptr++ ] = data;
        }
    }
else if ( rx_state == ETX )
    {
    if ( data == DLE_BYTE )
        {
        rx_state = DLE;
        }
    }

if ( in_que_ptr > 255 )
    {
    in_que_ptr = 0;
    }
}
```

APPENDIX C: EPHEMERIS DATA DOWNLOAD (PROGRAMMING EXAMPLE)

Synopsis

This section describes, using an example, how to download ephemeris information from a Garmin 15, 16, 17 or 18 family GPS unit with the exception of the GPS 15-W and the GPS 15-F.

Garmin Binary Format Review

To download the ephemeris data, you must first command the unit to output information in Garmin Binary Format (Garmin mode) instead of the default NMEA output format. To put the unit in Garmin mode, connect to the unit using a terminal program and send the following NMEA sentence:
$PGRMO,,G*hh<CR><LF>

The checksum *hh is used for parity checking data and generally is not required in normal PC environments, but is recommended for use in environments containing high electromagnetic noise. When used, the parity bytes (hh) are the ASCII representation of the exclusive-or (XOR) sum of all the characters between the "$" and "*" characters, non-inclusive. Sentences may be truncated by <CR><LF> after any data field and valid fields up to that point will be acted on by the GPS sensor. See Section 4 Software Interface. The unit will stay in Garmin mode until the next power cycle.

Now that unit is in Garmin binary format, transmitted and received packets are structured as follows:

```
Byte Description           Name       Notes
Packet Delimiter           DLE        0x10
Packet ID (type)           ID         Packet type
Data Size                  SIZE       Number of bytes in data portion(not
                                      including escaped DLEs. See below)
Data bytes                 DATA       Not to exceed 256 bytes
.                          .          .
.                          .          .
.                          .          .
Checksum                   CHKSUM     2's complement of the arithmetic
                                      sum of all the bytes from the
                                      Packet ID byte to the last DATA
                                      byte(inclusive) not counting
                                      escaped DLEs. See below
Packet Delimiter           DLE        0x10
End of Packet              ETX        0x03
```

The DLE (0x10) is a delimiter byte used in conjunction with the ETX byte to determine beginning and ending of a packet. However, a 0x10 could appear in the data itself; if this occurs, the byte is escaped with another DLE byte (sometimes referred to as DLE stuffing). In other words, if a DLE occurs in the data, another DLE is transmitted immediately after to indicate that it is a data byte and it is not being used as a delimiter. Note that the size byte of the packet does not count the second DLE byte in an escaped DLE pair in the data field. Since a DLE that is a part of the data will have a second DLE to escape it, a single DLE followed by an ETX byte means that the end of a packet has been reached.

In order to interpret these packets properly, one must remove the escaped DLE bytes. This can be achieved using an algorithm similar to the Sample C Code fragment on the previous page.

Ephemeris Download Procedure

The following is the sequence of events that occurs when downloading ephemeris.

Send a packet containing the command that requests ephemeris data (`IOP_DOWN_LOAD_EPH`). The packet should look like this:

TX Packet: Ephemeris Data Request

Byte Description	Name	HEX Value
Delimiter	DLE	0x10
Command Data ID	IOP_CMND_DATA	0x0A
Number of bytes in data	SIZE	0x02
Request to D/L ephemeris	IOP_DOWN_LOAD_EPH	0x5D
Pad to 2 bytes	DATA	0x00
Checksum calculation	CHKSUM	0x97*
Delimiter	DLE	0x10
End	ETX	0x03

* From now on, checksum calculation will not be shown for every packet example

The unit will return an acknowledgement packet that will look like this:

RX Packet: Acknowledgement

Byte Description	Name	HEX Value
Delimiter	DLE	0x10
Acknowledgement ID	IOP_ACK_BYTE	0x06
Number of bytes in data	SIZE	0x02
Request to D/L ephemeris	IOP_CMND_DATA	0x0A
Pad	DATA	0x00
Checksum calculation	CHKSUM	----
Delimiter	DLE	0x10
End of packet	ETX	0x03

Then, the unit will immediately send a packet communicating how many data packets to expect for the ephemeris download (a maximum of twelve):

RX Packet: Number of Data Packets to Expect

Byte Description	Name	HEX Value
Delimiter	DLE	0x10
Record ID	IOP_RECORDS	0x1B
Number of bytes in data	SIZE	0x02
Number of records	NUM_SV	0x0C
Pad	DATA	0x00
Checksum calculation	CHKSUM	----
Delimiter	DLE	0x10
End of packet	ETX	0x03

This packet requires acknowledgement, as shown below (note that the data field contains the `IOP_RECORDS` ID to indicate the acknowledgement of the `IOP_RECORDS` packet):

TX Packet: Acknowledgement

Byte Description	Name	HEX Value
Delimiter	DLE	0x10
Record ID	IOP_ACK_BYTE	0x06
Number of bytes in data	SIZE	0x02
Pad	DATA	0x00
ID of packet being ACK'd	IOP_RECORDS	0x1B
Checksum calculation	CHKSUM	----
Delimiter	DLE	0x10
End of packet	ETX	0x03

Next, the unit will send the specified number of packets containing the ephemeris information. An example packet is shown below. Each packet should be acknowledged as before (be sure to modify the ACK packet to indicate what type of packet being acknowledged—for ephemeris data, the ID is 0x35).

RX Packet: Ephemeris Data

Byte Description	Name	HEX Value
Delimiter	DLE	0x10
Ephemeris data ID	IOP_SPC_EPH_DATA	0x35
Number of bytes in data	SIZE	0x78
Ephemeris data	DATA	----
.	.	.
.	.	.
.	.	.
Checksum calculation	CHKSUM	----
Delimiter	DLE	0x10
End of packet	ETX	0x03

The data portion of each packet can then be parsed into an instance of the following structure. Each of these structures represents data from a single satellite.

```
typedef struct      /* ephemeris data record for SPC                        */
{
sint16  wn;         /* week number (weeks)                                  */
float   toc;        /* reference time of clock parameters (s)               */
float   toe;        /* reference time of ephemeris parameters (s)           */
float   af0;        /* clock correction coefficient - group delay  (s)      */
float   af1;        /* clock correction coefficient         (s/s)           */
float   af2;        /* clock correction coefficient         (s/s/s)         */
float   ura;        /* user range accuracy                     (m)          */
double  e;          /* eccentricity                            (-)          */
double  sqrta;      /* square root of semi-major axis (a)  (m**1/2)         */
double  dn;         /* mean motion correction              (r/s)            */
double  m0;         /* mean anomaly at reference time       (r)             */
double  w;          /* argument of perigee                  (r)             */
double  omg0;       /* right ascension                      (r)             */
double  i0;         /* inclination angle at reference time  (r)             */
float   odot;       /* rate of right ascension             (r/s)            */
float   idot;       /* rate of inclination angle           (r/s)            */
float   cus;        /* argument of latitude correction, sine    (r)         */
float   cuc;        /* argument of latitude correction, cosine  (r)         */
float   cis;        /* inclination correction, sine         (r)             */
float   cic;        /* inclination correction, cosine       (r)             */
float   crs;        /* radius correction, sine                 (m)          */
float   crc;        /* radius correction, cosine               (m)          */
unsigned char  iod; /* issue of data                                        */
} SDM_spc_eph_type;
```

An example function to do the parsing is shown below. Note that the double data types are converted by the function `cnvt_ieee_double()`. This function merely swaps the upper and lower words of the double. This is necessary on GPS 15, 16, 17 series sensors due to a compatibility issue with the IEEE floating point standard): In this example, the array `m_TempArray` contains the data portion of the ephemeris packet (with DLE stuffing removed).

```
/***************************************************************************
*
*    PROCEDURE NAME:
*     copyData - ephemeris data unpacker
*
*    DESCRIPTION:
*     unpacks data from ephemeris packet DATA field after extraneous DLEs
*     have been removed.  Note that sint16 refers to a signed 16-bit
*     integer type.
*
***************************************************************************/
void GPM_ephList::copyData     /* ephemeris data unpacker                 */
     (
     GPM_ephData* pTemp         /* pointer to ephemeris data array         */
     )
{
pTemp->EphStruct.wn  = *(sint16*)&m_TempArray[IDX_EPH_WN];
pTemp->EphStruct.toc = *(float*)&m_TempArray[IDX_EPH_TOC];
pTemp->EphStruct.toe = *(float*)&m_TempArray[IDX_EPH_TOE];
pTemp->EphStruct.af0 = *(float*)&m_TempArray[IDX_EPH_AF0];
pTemp->EphStruct.af1 = *(float*)&m_TempArray[IDX_EPH_AF1];
pTemp->EphStruct.af2 = *(float*)&m_TempArray[IDX_EPH_AF2];
pTemp->EphStruct.ura = *(float*)&m_TempArray[IDX_EPH_URA];

cnvt_ieee_double((long *)&m_TempArray[IDX_EPH_E]);
pTemp->EphStruct.e = *(double*)&m_TempArray[IDX_EPH_E];

cnvt_ieee_double((long *)&m_TempArray[IDX_EPH_SQRTA]);
pTemp->EphStruct.sqrta = *(double*)&m_TempArray[IDX_EPH_SQRTA];

cnvt_ieee_double((long *)&m_TempArray[IDX_EPH_DN]);
pTemp->EphStruct.dn = *(double*)&m_TempArray[IDX_EPH_DN];

cnvt_ieee_double((long *)&m_TempArray[IDX_EPH_M0]);
pTemp->EphStruct.m0 = *(double*)&m_TempArray[IDX_EPH_M0];

cnvt_ieee_double((long *)&m_TempArray[IDX_EPH_W]);
pTemp->EphStruct.w = *(double*)&m_TempArray[IDX_EPH_W];

cnvt_ieee_double((long *)&m_TempArray[IDX_EPH_OMG0]);
pTemp->EphStruct.omg0 = *(double*)&m_TempArray[IDX_EPH_OMG0];

cnvt_ieee_double((long *)&m_TempArray[IDX_EPH_I0]);
pTemp->EphStruct.i0 = *(double*)&m_TempArray[IDX_EPH_I0];

pTemp->EphStruct.odot = *(float*)&m_TempArray[IDX_EPH_ODOT];
pTemp->EphStruct.idot = *(float*)&m_TempArray[IDX_EPH_IDOT];
pTemp->EphStruct.cus = *(float*)&m_TempArray[IDX_EPH_CUS];
pTemp->EphStruct.cuc = *(float*)&m_TempArray[IDX_EPH_CUC];
pTemp->EphStruct.cis = *(float*)&m_TempArray[IDX_EPH_CIS];
pTemp->EphStruct.cic = *(float*)&m_TempArray[IDX_EPH_CIC];
pTemp->EphStruct.crs = *(float*)&m_TempArray[IDX_EPH_CRS];
pTemp->EphStruct.crc = *(float*)&m_TempArray[IDX_EPH_CRC];
pTemp->EphStruct.iod = *(unsigned char*)&m_TempArray[IDX_EPH_IOD];

return;

}    /* copyData */
```

Each data member of the ephemeris data structure is indexed into the data array of the ephemeris packet and cast as the appropriate data type. The indices are as follows (note that they correlate to the data members of the structure respectively):

```
#define IDX_EPH_WN        0
#define IDX_EPH_TOC       4
#define IDX_EPH_TOE       8
#define IDX_EPH_AF0       12
#define IDX_EPH_AF1       16
#define IDX_EPH_AF2       20
#define IDX_EPH_URA       24
#define IDX_EPH_E         28
#define IDX_EPH_SQRTA     36
#define IDX_EPH_DN        44
#define IDX_EPH_M0        52
#define IDX_EPH_W         60
#define IDX_EPH_OMG0      68
#define IDX_EPH_I0        76
#define IDX_EPH_ODOT      84
#define IDX_EPH_IDOT      88
#define IDX_EPH_CUS       92
#define IDX_EPH_CUC       96
#define IDX_EPH_CIS       100
#define IDX_EPH_CIC       104
#define IDX_EPH_CRS       108
#define IDX_EPH_CRC       112
#define IDX_EPH_IOD       116
```

The last packet will be a "download complete" packet that will look like this:

TX Packet: Download Complete

Byte Description	Name	HEX Value
Delimiter	DLE	0x10
Download Complete ID	IOP_DL_CMPLT	0x0c
Number of bytes in data	SIZE	0x02
Ephemeris Download ID	IOP_DOWN_LOAD_EPH	0x5D
Pad	DATA	0x00
Checksum calculation	CHKSUM	----
Delimiter	DLE	0x10
End of packet	ETX	0x03

After properly acknowledging this packet (ACK the IOP_DL_CMPLT ID), the ephemeris download is complete.

APPENDIX D: SENSOR CONFIGURATION SOFTWARE

The Sensor Configuration software program (SNSRCFG) configures the GPS sensors based on user-selected parameters. Some application features include the ability to download GPS sensor configuration, maintain different configurations in files, and perform GPS sensor configurations quickly with the use of one function key.

This section provides a brief overview of the Sensor Configuration Software. Refer to this section when using the software to configure your Garmin sensor.
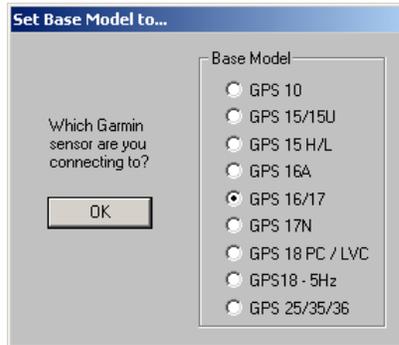
Downloading the Sensor Configuration Software
The Garmin Sensor Configuration Software (**SNSRCFG.exe)** is available from the Garmin Web site. To download the software, start at http://www.garmin.com/oem, select the GPS 16/17, and then select **Software Updates**. Download SNSRCFG.

Selecting a Model
After opening the program (snsrcfg.exe), the following screen appears. Select the radio button next to the type of Garmin sensor you are configuring. Then click **OK**.

Connecting to the Sensor
After selecting the type of sensor, the following window opens. This is the Main Interface Screen for the program. To configure your sensor, you must first connect to the sensor.

1. Select **Config** > **Switch to NMEA Mode (**or press the F10 key).

2. Select **Comm** > **Setup** to open the Comm Setup Window.

3. Select the Serial Port to which the sensor is connected. Select **Auto** to have the program automatically determine the Baud Rate, or select **Manual** to manually select the Baud Rate of the GPS 16/17. Click **OK** when done.

4. Click the **Connect** icon, or select **Comm** > **Connect**.

5. To view the current programming of the sensor, select **Config > Get Configuration from GPS** (or press the F8 key). The current programming of the sensor is displayed in the window shown to the right.
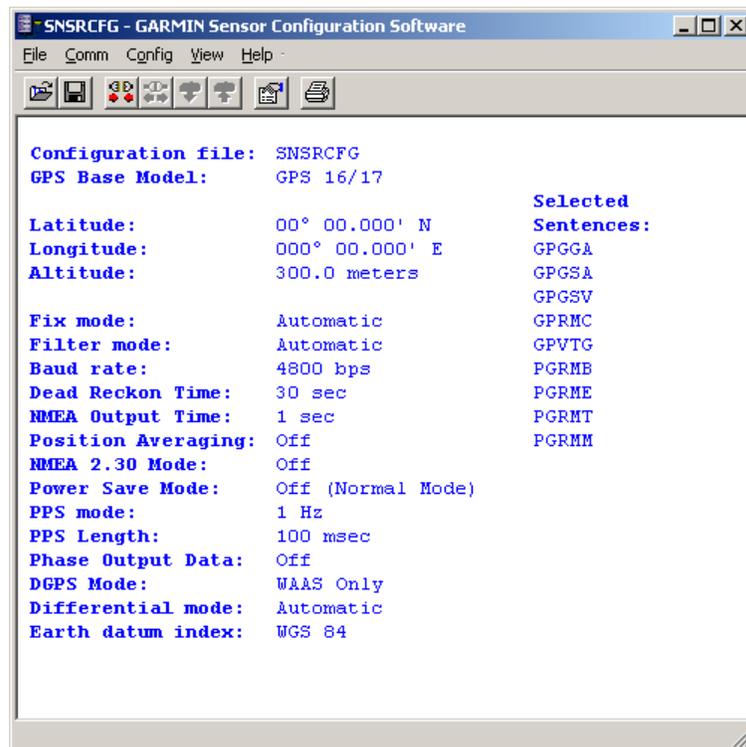
File Menu

The File Menu allows you to open, save, and print sensor configurations. The items in the File Menu work like most Windows-based programs.

Comm Menu

The Comm (Communication) Menu allows you to set the port number, baud rate, and then connect and disconnect from the sensor.
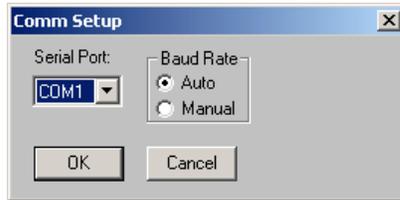
Setup: Opens the Comm Setup Window, shown to the left. Select the Serial Port to which the sensor is connected from the drop-down list. Then select **Auto** (the program determines the baud rate on its own) or **Manual** (you then enter the baud rate) for the Baud Rate entry.

Connect: Select **Connect** to connect to the sensor to change or view the configuration.

Disconnect: Select Disconnect to disconnect from the sensor.

Config Menu

The Config (Configuration) Menu allows you configure the sensor as it is connected.

Sensor Configuration (F6): Opens the Sensor Configuration Window, shown to the right. Many of the fields in this window should be left alone. Please refer to the beginning of this document for specific information about some of these fields. For the most part, this window is used to enter a new Latitude, Longitude, and Altitude for the sensor. This is especially helpful when you are programming the sensor for use in a particular geographic location.

Resetting the Unit (**Reset Unit**) performs a reset on the unit, much like cycling the power.

Resetting the non-volatile memory (**Reset NonVol**) will clear all of the data from the non-volatile memory.

NMEA Sentence Selections (F7): Displays the NMEA Sentence Selections Window. If the sentence is enabled, a check mark appears in the box to the left of the sentence name. Click the box to enable or disable to the sentence.
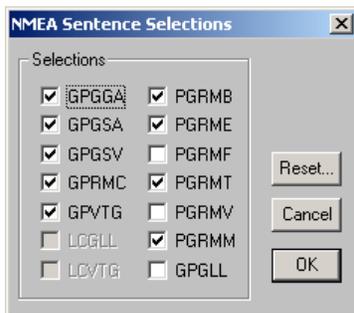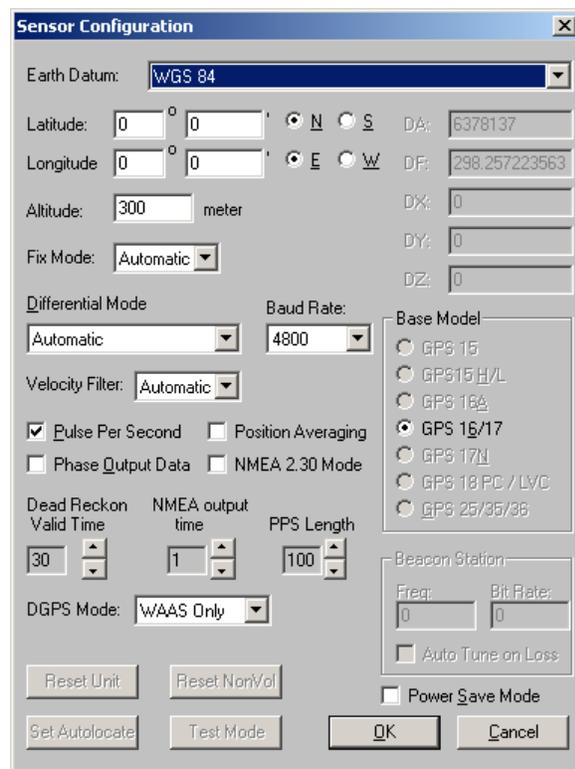
Get Configuration From GPS (F8): Retrieves the current programming from the sensor. The programming is then displayed in the Main Interface Window.

Send Configuration To GPS (F9): Sends the changes you have made to the programming to the sensor.

Switch to NMEA Mode (F10): Switches the unit to NMEA Mode. The sensor must be in NMEA Mode when connected to this software.

Switch to Garmin Mode (F11): Switches the unit to Garmin Mode.

Update Software (F12): After you have downloaded a new software version for the sensor, you can update the sensor with the new software. Select Update Software and then select the file using the Open dialog box. You must locate both the *.rgn file and the updater.exe file.

View Menu
The View Menu allows you to view the NMEA sentences transmitted by the sensor. You can also customize how the program looks by showing and hiding the Toolbar and Status Bar.

Help Menu
The Help Menu displays the software version and copyright information.

For the latest free software updates (excluding map data) throughout the life of your Garmin products, visit the Garmin Web site at www.garmin.com.