# ACE III GPS™

*System Designer Reference Manual*

**Part Number: 41265-00**

**Revision: A**

**Date: June 2000**

**Firmware: 8.08**

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# Preface

The Global Positioning System (GPS) is a satellite based navigation system operated and maintained by the U.S. Department of Defense. The GPS consists of a constellation of 24 satellites providing world-wide, 24 hour, three dimensional (3D) coverage. Although originally conceived for military needs, GPS has a broad array of civilian applications including surveying, marine, land, aviation, and vehicle navigation. GPS is the most accurate technology available for vehicle navigation.

As a satellite based system, GPS is immune to the limitations of land based systems such as Loran. Loran navigation is limited in coverage and is encumbered by adverse weather. In addition, the accuracy of Loran navigation varies with geographic location and, even under ideal conditions, cannot compare with GPS. By computing the distance to GPS satellites orbiting the earth, a GPS receiver can calculate an accurate position. This process is called satellite ranging. A 2D position calculation requires three satellite ranges. A 3D position calculation, which includes altitude, requires four satellite ranges. GPS receivers can also provide precise time, speed, and course measurements which are beneficial for vehicle navigation.

Differential GPS (DGPS) is a sophisticated form of GPS navigation which provides even greater positioning accuracy. Differential GPS relies on error corrections transmitted from a GPS receiver placed at a known location. This receiver, called a reference station, calculates the error in the satellite range data and outputs corrections for use by other GPS receivers. These GPS receivers are designated as mobile units and can be dispersed as far as 100 km from the base station. Differential GPS eliminates virtually all the measurement error in the satellite ranges and enables a highly accurate position calculation. The ACE III GPS is differential-ready for applications requiring DGPS accuracy.

## Scope and Audience

Even if you have used other Global Positioning System (GPS) receivers, we recommend that you spend some time reading this manual. The following section provides you with a guide to this manual, as well as to other documentation included with this product.

# ACE III GPS Manual Organization

All of the information required to integrate and operate the ACE III GPS is contained in this manual. This manual contains the following chapters and appendices:

Chapter 1:     Starter Kit

Chapter 2:     Hardware Integration

Chapter 3:     Software Interface

Chapter 4:     Operation and Performance

Appendix A:   Trimble Standard Interface Protocol

Appendix B:   TSIP Toolkit User's Guide

Appendix C:   Trimble ASCII Interface Protocol (TAIP)

Appendix D:   GPSSK User's Guide (TAIP)

Appendix E:   NMEA 0183

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The ACE III GPS is easy to integrate and simple to use. Before proceeding with Chapter 1, please review the information contained in this *Preface* for an overview of the Global Positioning System.

# Information Sources

The following sources provide useful information.

## World Wide Web (WWW) Site

For an interactive look at Trimble, visit our site on the World Wide Web

(http://www.trimble.com)

## File Transfer Protocol (FTP) Site

Use the Trimble FTP site to send files or to receive files such as software patches, utilities, and answers to frequently asked questions (FAQs). The address is

ftp://ftp.trimble.com

You can also access the FTP site from the Trimble World Wide Web site

http://www.trimble.com/support/support.htm

# Technical Assistance

If you have a problem and cannot find the information you need in the product documentation, you can call the Trimble Technical Assistance Center 24 hours per day, 7 days per week at 1-800-SOS-4TAC (1-800-767-4822). A support technician will take your call, help you determine the source of your problem, and provide you with any technical assistance you might need.

You can also e-mail the Technical Assistance Center with your question at

trimble_support@trimble.com

# Reader Comment Form

Thank you for purchasing this product. We would appreciate feedback about the documentation. Use the reader comment form at the back of this manual or, if this is not available, send comments and suggestions to the address in the front. All comments and suggestions become the property of Trimble Navigation Limited.

# Document Conventions

| | |
|---|---|
| *Italics* | Software menus, menu commands, dialog boxes and fields. |
| SMALL CAPITALS | DOS commands, directories, filenames, and filename extensions. |
| Courier | Represents what is printed on the computer screen. |
| **Courier Bold** | Information to be typed in a software screen or window. |
| Return or Ctrl + C | Identifies a hardware function key or key combination that must be pressed on a computer keyboard. |
| Helvetica | Bold represents a software command button. |

# Notes, Tips, Cautions, and Warnings

Notes, tips, cautions, and warnings are used to emphasize important information.

**Note –** Notes give additional significant information about the subject to increase your knowledge, or guide your actions. A note can precede or follow the text it references.

**Tip –** Indicates a shortcut or other time or labor-saving hint that can help you make better use of the product.

**Caution –** Cautions alert you to situations that could cause hardware damage or software error. A caution precedes the text it references.

**Warning –** Warnings alert you to situations that could cause personal injury or unrecoverable data loss. A warning precedes the text it references.

# 1    Starter Kit

The ACE III GPS, based on Colossus/Scorpion technology, delivers an unmatched level of performance for embedded GPS applications. Colossus/Scorpion technology is Trimble's 8-channel GPS architecture based on two ASICs, the Colossus RF ASIC and the Scorpion DSP.

The Colossus RF ASIC features:

- Double down-conversion process

- Higher sensitivity

- Lowest power consumption

The double down-conversion process improves immunity to in-band jammers. The system provides a higher sensitivity which allows ACE III GPS to track weak satellites and improves position availability in environments with obscured coverage.

The Scorpion DSP ASIC provides the following features in a single package:

- 8-channel DSP with 4 correlators per channel

- 32 bit microprocessor

- Real-time clock

- DUART

The 8-channel, 32-correlator design provides extremely fast cold starts while delivering 2 meter DGPS performance. The high level of integration provides a small footprint (3.25" x 1.83" x 0.45) and contributes to fast GPS signal acquisition. The combination of small size and low power consumption allows ACE III GPS to be embedded in small battery operated devices and in devices where heat dissipation must be minimized.

The Starter Kit makes it simple to evaluate the ACE III GPS module's exceptional performance. The kit includes the following:

- ACE III GPS receiver installed inside an interface unit

- Magnetic mount antenna

- AC power adapter

- Serial interface cable

- GPS Tool Kit Software used to communicate with the GPS module

The interface unit is a sturdy metal enclosure containing an interface motherboard. The motherboard accepts 9 - 32 VDC power and provides regulated +5V and +3.6V BBU power to the ACE III GPS receiver module. The motherboard also provides two RS-232 connectors for quick and direct connection to a PC COM port. The ACE III GPS board can be removed from the motherboard for integration into the user's application (see Chapter 2, Hardware Integration).

## 1.1    ACE III GPS Overview

The ACE III GPS is a complete 8-channel parallel tracking GPS receiver designed to operate with the L1 frequency, Standard Position Service, Coarse Acquisition code. Using two highly integrated Trimble custom integrated circuits, the receiver is designed in a modular format especially suited for embedded applications. The ACE III GPS features Trimble's latest signal processing code, a high-gain RF section for compatibility with standard 25 dB active gain GPS antennas, and a CMOS TTL level pulse-per-second (PPS) output for timing applications or as a general purpose synchronization signal.

The ACE III GPS acquires a position fix with minimal delay after power cycling. The information necessary to help track satellites is stored in RAM using backup power for the following:

- Almanac

- Ephemeris

- Real-time clock

- Last position

User settings, including port parameters and receiver processing options, are stored in a non-volatile electrically erasable ROM (EEROM) that does not require backup power.

The ACE III GPS has two independently configurable serial I/O communication ports. The dual data I/O port characteristics and other options are user programmable and stored in non-volatile memory.

**Warning –** When customizing port assignments or characteristics, confirm that your changes do not affect your ability to communicate with the receiver module (see Chapter 3, Software Interface).

### 1.1.1 Interface Protocols

The ACE III GPS communicates using three unique protocols — Trimble Standard Interface Protocol (TSIP), Trimble ASCII Interface Protocol (TAIP), and NMEA 0183. The ACE III GPS also supports RTCM SC-104 for DGPS. The factory default settings are:

- Port 1        TSIP bi-directional
- Port 2        NMEA 0183 out/RTCM SC-104 V2.1 in

Protocol selection and port assignments are user configurable.

#### Port 1

TSIP is a powerful binary packet protocol that allows the system designer maximum configuration control over the GPS receiver for optimum performance in any number of applications. TSIP supports over 40 commands and their associated response packets for use in configuring the ACE III GPS receiver module to meet user requirements.

#### Port 2

NMEA 0183 is an industry standard protocol common to marine applications. NMEA provides direct compatibility with other NMEA-capable devices such as chart plotters, radars, etc. The ACE III GPS receiver module supports most NMEA messages for GPS navigation. NMEA messages and output rates can be user selected as required.

#### DGPS

The ACE III GPS receiver module can be configured for RTCM SC-104 input which is the GPS industry standard for differential correction data. The receive side of port 2 is factory configured to accept RTCM data.

### 1.1.2 TAIP

The ACE III GPS Starter Kit can be configured by the user to communicate using the TAIP protocol. TAIP is designed for easy integration into systems requiring a powerful bi-directional ASCII language.

### 1.1.3    Starter Kit Components

The ACE III GPS is available in a developer's Starter Kit or as individual boards. The Starter Kit includes all the components necessary to quickly test and integrate the module.

The Starter Kit components and the accessory part numbers are listed in Table 1-1 and Table 1-2, and Table 1-3.

**Table 1-1      ACE III GPS Starter Kit**

| Starter Kit Part Reference | Part Number |
|---|---|
| ACE III GPS Starter Kit | 41186-00 |
| Magnetic Mount GPS Antenna with Cable | 28367-00 |
| AC Power Adapter | 29938 |
| Power Cable | 20260 |
| Interface Cable DB9M/DB9F (pin to pin) | 19309-00 |
| ACE III GPS Toolkit Disk | 37116-01 |
| System Designer Reference Manual | 41265-00 |

**Table 1-2      ACE III GPS Modules**

| Module Reference | Part Number |
|---|---|
| ACE III GPS | 41265-00 |

**Table 1-3      ACE III GPS Module Optional Antennas**

| Antenna Reference | Part Number |
|---|---|
| Hard Mount GPS Antenna | 28367-70 |
| Rooftop Antenna Kit with 75 foot cable | 23726-00 |

**Note –** Part numbers are subject to change. Confirm part numbers with your Trimble representative when placing your order.

## 1.2    GPS Receiver Module

In the Starter Kit, the ACE III GPS is installed on an interface motherboard which is housed in a metal enclosure (see Figure 1-1). This packaging simplifies testing and evaluation of the module by providing an RS-232 serial interface which is compatible with most PC communication ports, and by providing a DC power supply which converts a 9 to 32 VDC input to the regulated 5 volts required by the module. The DB9 connectors provide an easy connection to the PC's serial port using the interface cable provided in the kit. The metal enclosure protects the module and motherboard for testing outside of the laboratory environment.
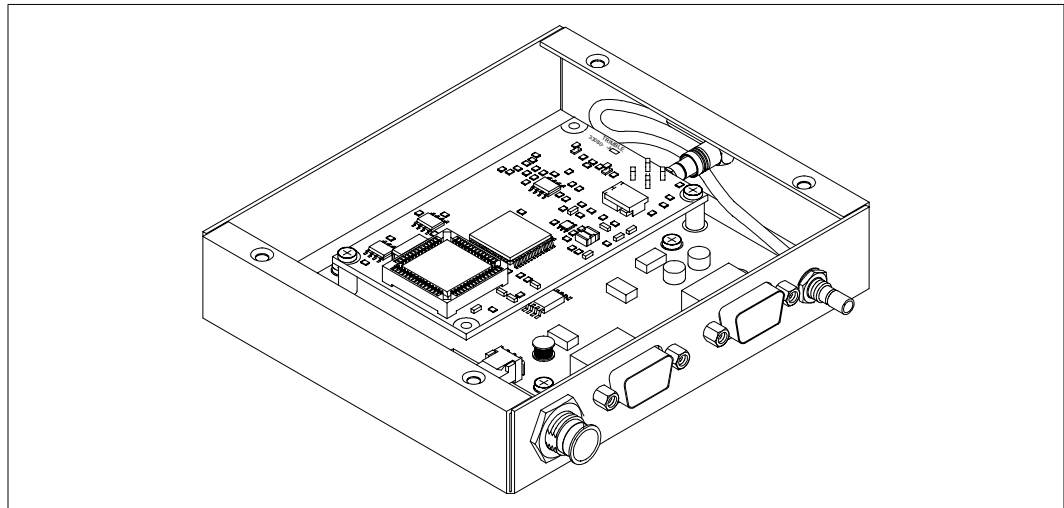


**Figure 1-1      The Module Installed Inside the Interface Unit**

The receiver module (see Figure 1-2) consists of a single 3.25" x 1.83" x 0.45" module. A standard SMB RF connector (J1) supports the GPS antenna connection. The center conductor supplies +5 VDC for the Low Noise Amplifier of the active antenna. An 8-pin, 0.1 inch header (J4) supports the serial interface (CMOS TTL level), the pulse-per-second (PPS) signal (CMOS TTL level), and the input power (+5 VDC). This module connects to the motherboard via the 8-pin header and is secured by two standoffs. An RF-interface cable connects the antenna port to an SMB connector on the enclosure panel.
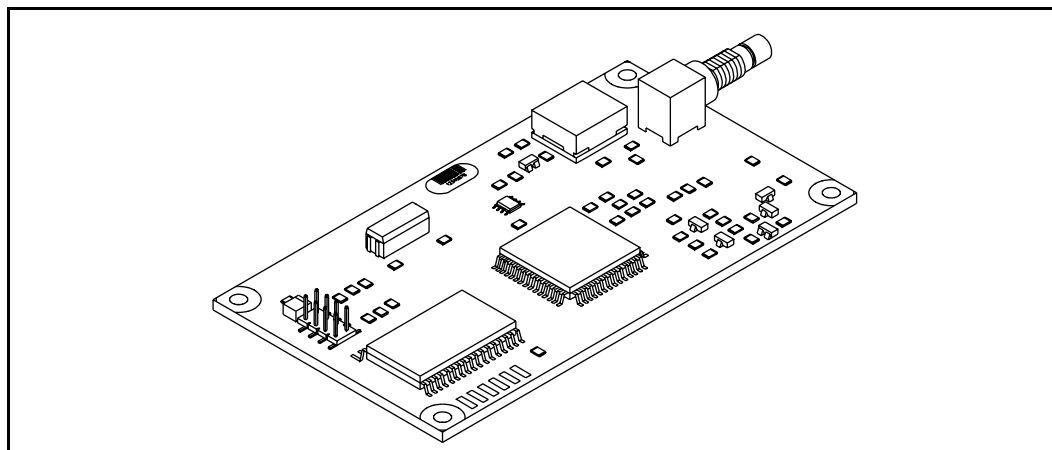
**Figure 1-2      Receiver Module**

✉   **Note –** The receiver included in the Starter Kit contains a socket for the firmware ROM. This socketed board may be used to evaluate future releases of firmware. The standard OEM module is not equipped with a socket.

The interface motherboard includes a 9 to 32 VDC switching power supply which provides a regulated +5 VDC to the receiver. It also converts the TTL-level I/O to RS-232 for a direct interface to a computer. The motherboard provides an open-collector interface for the PPS and also includes a 3.6V lithium backup battery enabling quick hot starts. The Starter Kit includes an AC/DC converter for powering the module from an AC wall socket. The metal enclosure (see Figure 1-3) provides 2 interface port connectors, an antenna connector and a power connector. The mounting plate is secured to the metal enclosure with four screws. The eight pin header on the receiver module plugs into the corresponding 8-pin socket on the motherboard.
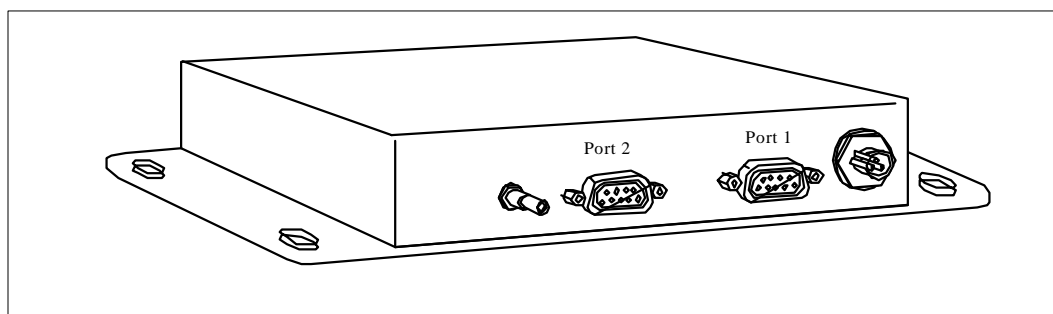


**Figure 1-3      Starter Kit Interface Unit**

### 1.2.1    Starter Kit Serial Port Interface

The GPS receiver is a DCE (Data Communication Equipment) device. To connect to a host computer, or DTE (Data Terminal Equipment) device, use a straight through cable. To connect a Differential Radio (DCE device) to the receiver (DCE Device) use a cross over cable or null modem cable.

**Table 1-4       Serial Port Pinouts**

| Port 1 | |
|---|---|
| Pin | Description |
| 1 | NC |
| 2 | TX |
| 3 | RX |
| 4 | NC |
| 5 | GND |
| 6 | NC |
| 7 | NC |
| 8 | NC |
| 9 | PPS Out |

| Port 2 | |
|---|---|
| Pin | Description |
| 1 | NC |
| 2 | TX |
| 3 | RX |
| 4 | NC |
| 5 | GND |
| 6 | NC |
| 7 | NC |
| 8 | NC |
| 9 | PPS Out |

.
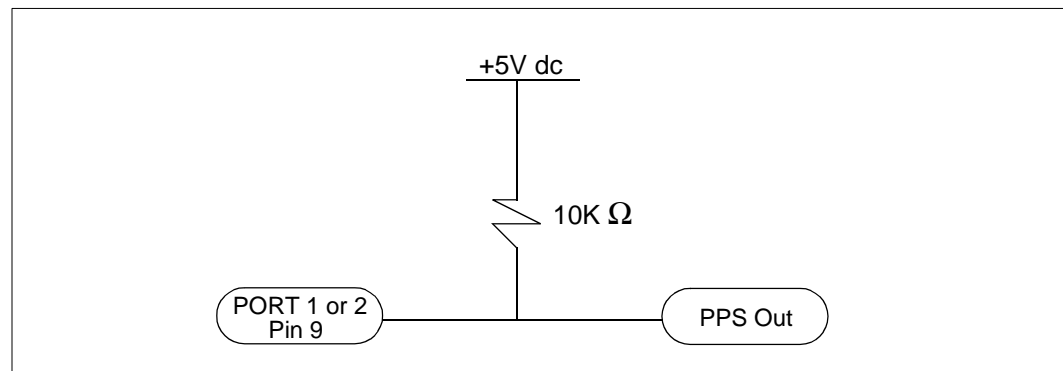


**Figure 1-4      Open Collector PPS**

**Note –** The 1PPS signal is an open collector interface on pin 9 of Ports 1 and 2 on the Starter Kit interface unit. The polarity of the PPS signal is an inverted, 10µs negative going pulse with the falling edge synchronized to UTC.To pull up the 1PPS, use a 10K pull up resistor as illustrated in Figure 1-4.

## 1.3    Antenna

The GPS antenna receives the GPS satellite signals and passes them to the receiver. Because the GPS signals are spread spectrum signals in the 1575 MHz range and do not penetrate conductive or opaque surfaces, the GPS antenna must be located outdoors with a clear view of the sky. The ACE III GPS requires an *active* antenna. The received GPS signals are very low power, approximately -140 dB, at the surface of the earth. Trimble's active antennas include a preamplifier that filters and amplifies the GPS signals before delivery to the receiver.

Trimble offers a variety of antennas for use with the ACE III GPS. The compact magnetic mount GPS antenna and integral cable supplied with the Starter Kit is ideal for portable and mobile applications. A permanent, bulkhead mount antenna is also available. A compact, pole-mount rooftop antenna is available for fixed-site installations. See Appendix F for mechanical outline drawings of the GPS antennas.

**Warning –** When magnetic-mount or permanent-mount GPS antennas are installed on a metal surface for prolonged periods, care must be taken to insulate the antennas in order to prevent galvanic corrosion.
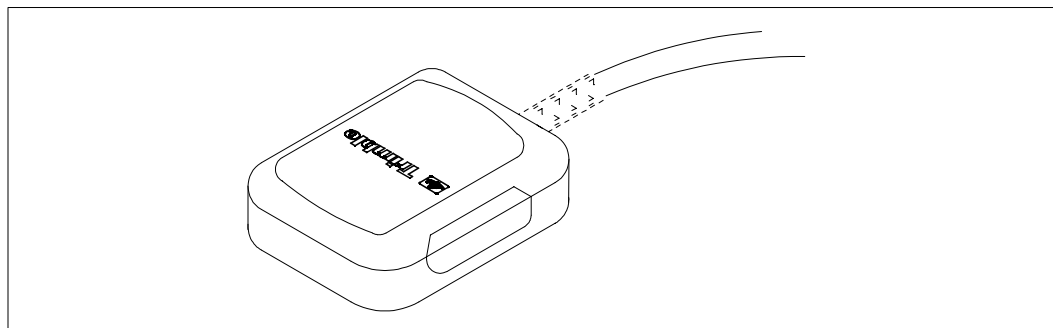


**Figure 1-5      Magnetic Mount GPS Antenna**
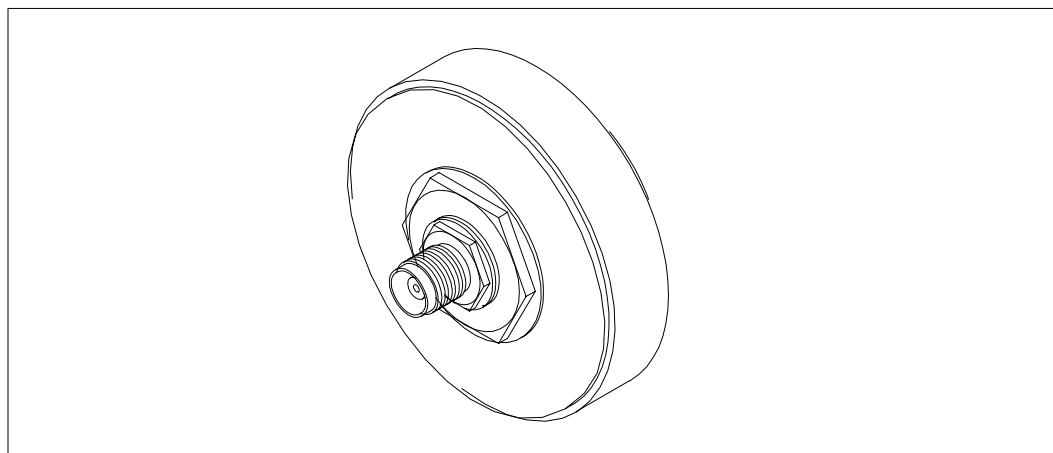


**Figure 1-6      Hard Mount GPS Antenna**
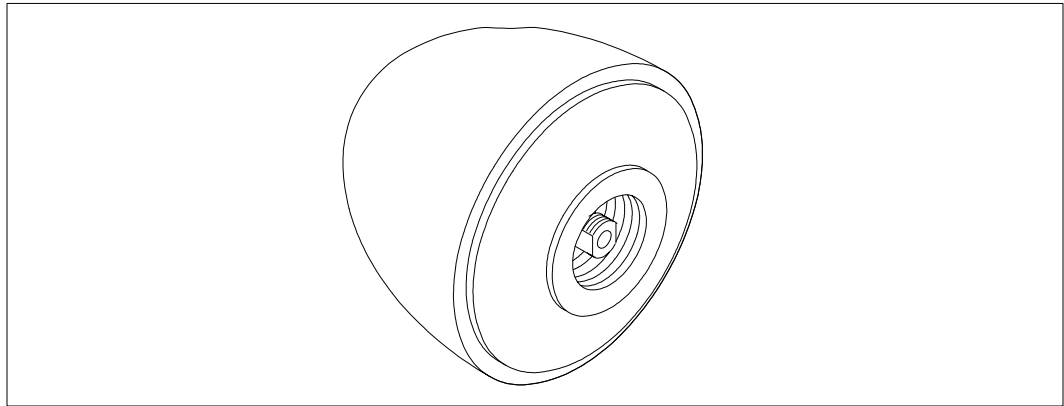
**Figure 1-7      Bullet II GPS Antenna**

## 1.4    Power

The receiver module is designed for embedded applications and requires a regulated +5.0 VDC input (+4.75 to +5.25 VDC). See Power Requirement, page 2-4 for detailed specifications. In the Starter Kit, the motherboard includes a DC power regulator which converts a 9 to 32 VDC input to the regulated 5 VDC required by the module. Power can be applied to the Starter Kit module using one of two options: the DC power cable (see Figure 1-8) or the AC/DC power converter (see Figure 1-9).

The DC power cable is ideal for bench-top or automotive testing environments. The power cable is terminated at one end with a 3-pin plastic connector which mates with the power connector on the metal enclosure. The unterminated end of the cable provides easy connection to a DC power supply. Connect the red power lead to a source of DC positive +9 to +32 VDC, and connect the black power lead to ground. This connection supplies power to both the receiver module and the antenna. The combined power consumption of the receiver module and the antenna is 120 milli-amps.
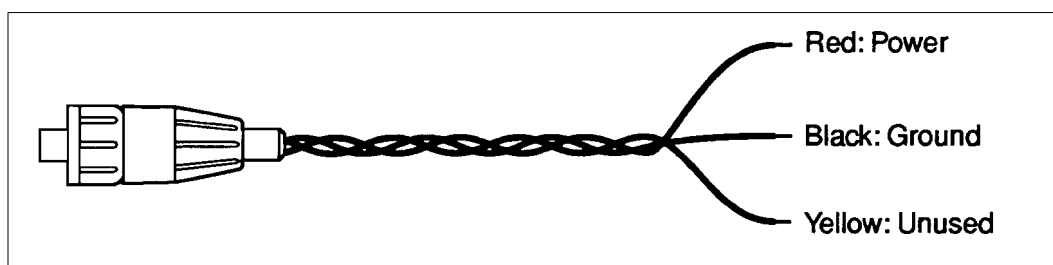


**Figure 1-8      DC Power Cable**

**Note –** The yellow wire is not used in the Starter Kit. Battery back-up is provided by a factory installed 3.6V lithium battery on the motherboard.

The AC/DC power converter may be used as an alternate power source for the Starter Kit module. The AC/DC power converter converts 110 or 220 VAC to a regulated 12 VDC compatible with the Starter Kit module. The AC/DC power converter output cable is terminated with a 3-pin connector compatible with the power connector on the metal enclosure. The AC power cable is not provided in the kit, since this cable is country-specific. The input connector is a standard 3-prong connector used on many desktop PCs.
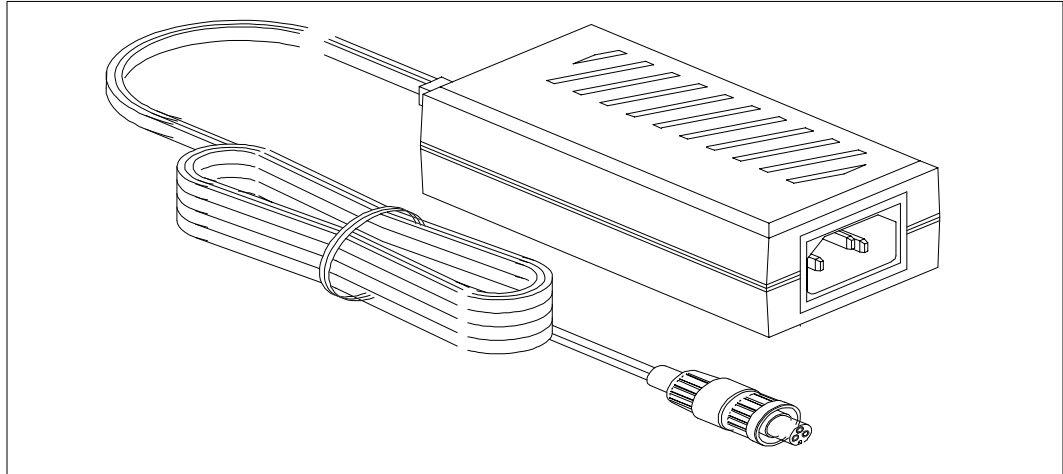


**Figure 1-9      AC/DC Power Converter**

## 1.5 Hardware Setup

The ACE III GPS supports TSIP, TAIP, and NMEA protocols. Port 1 is usually used for TSIP or TAIP I/O and port 2 is used to input RTCM SC-104 corrections and output NMEA messages. Follow the steps below to setup the Starter Kit. Figure 1-10 illustrates the setup.
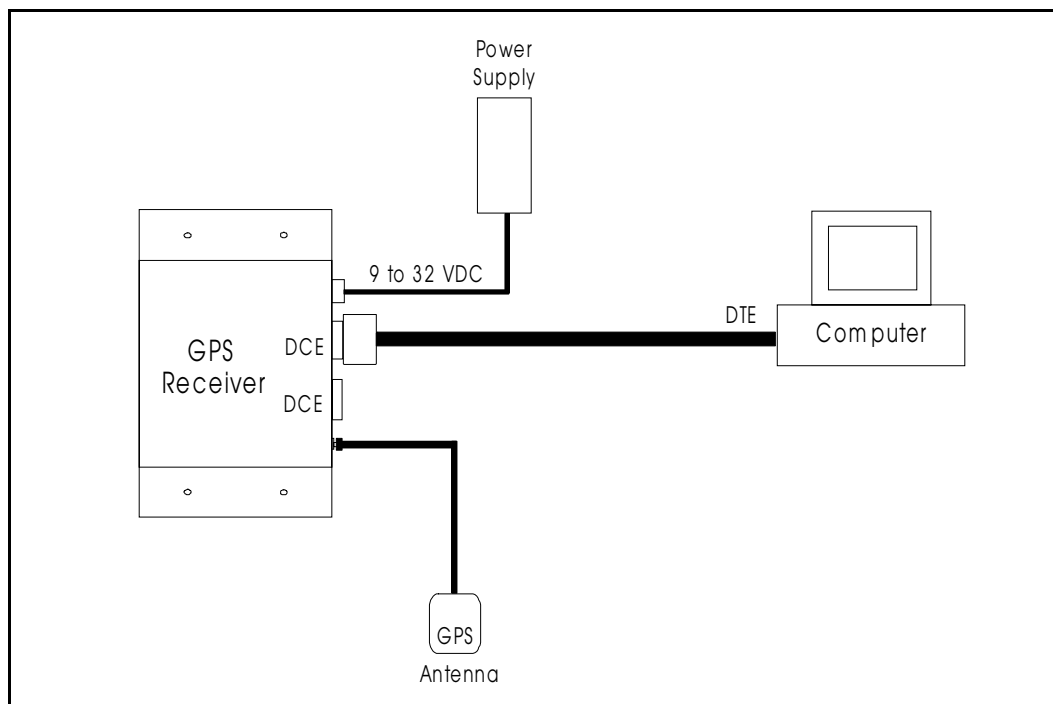


**Figure 1-10    Interconnect Diagram**

1.    For TSIP or TAIP protocols, connect one end of the 9-pin serial interface cable to Port 1 (or Port 2 to view NMEA data) of the receiver module. Connect the other end of the cable to COM1 or COM2 on a PC. A 9-pin-to-25-pin adapter may be required for the serial interface connection to a PC, if your PC has a 25-pin communication port.

2.    Connect the antenna cable to the interface unit. This connection is made by pushing the antenna cable connector onto the SMB connector on the unit (to remove the antenna cable, simply pull the antenna connector off of the SMB connector). Place the antenna so that it has a clear view of the sky.

3.    Using either the DC power cable or AC/DC power converter, connect to the 3-pin power connector on the interface unit.

DC Power Cable — Connect the terminated end of the power cable to the power connector on the interface unit. Connect the red lead to DC positive voltage (+9 to +32 VDC) and black power lead to DC ground. The yellow wire is not used. Switch on the DC power source.

AC/DC Power Converter — Connect the output cable of the converter to the 3-pin power connector on the interface unit. Using the appropriate 3-prong AC power cable (not provided), connect the converter to an AC wall socket (110 VAC or 220 VAC). The AC power cable is not provided in the Starter Kit.

## 1.6      Running the TSIPMonitor32 Interface Program

The Starter Kit includes a disk containing TSIP interface programs which run on a PC-DOS platform, as well as Windows 95/NT platforms. These programs aid system integrators in monitoring the receiver module's performance and in developing the software interface for the GPS module. The TSIP programs are described in detail in Appendix B, TSIP User's Guide.

1. Connect one end of the serial interface cable to Port 1 of the Starter Kit interface unit. Connect the other end of the cable to the serial port of your PC.

2. Turn on the DC power source or plug in the AC/DC converter.

3. Insert the GPS Tool Kit disk in the disk drive.

4. Refer to the Readme.txt file for complete instructions.

5. The TSIPMonitor32 program may be run directly off the diskette or the entire contents of the diskette may be copied onto your computer's hard drive. To run the program off the diskette, type A:TSIPMonitor32.exe.

6. Once the TSIPMonitor32 screen appears, the lower left hand screen will display the TX and RX status. If the receiver is communicating to the host software, a blinking green status will appear depending if the receiver is sending a command, or transmitting a report.

7. Once a GPS antenna is connected to a receiver and the receiver has achieved a position fix, the transmitted position reports will be displayed in the position field, as well as time, velocity, satellites tracked, and GPS receiver status. The receiver will send a health report every few seconds, even when no satellites are being tracked.

If the TSIPMonitor32 program displays a question mark (?), the receiver has not reported a status for this field. If the ? never disappears in the data field, then the GPS module may not be communicating with the computer. If this occurs, re-check the interface cable connections and verify the serial port selection. If the communication failure still occurs after checking all connections and settings, please call the Trimble Technical Assistance Center (TAC) for assistance. 1 (800) 481-8000 ext.8527.

# 2    Hardware Integration

The integration of the ACE III GPS receiver module is discussed in two sections: Hardware Integration and Software Interface. This chapter, Hardware Integration, includes instructions for mounting the GPS module and physically connecting the module to the antenna, the host processor, and the power source. Chapter 3, Software Interface, provides guidelines for configuring the ACE III GPS receiver module to communicate with the host processor.

## 2.1    The ACE III GPS Receiver Module

In the Starter Kit, the ACE III GPS receiver module is installed on the interface motherboard to facilitate testing and evaluation. The receiver module can be detached from the motherboard for installation into a specific device.

The receiver module is connected to the motherboard at four points: the antenna connector, the interface connector, and two standoffs (see Figure 2-1). Follow the steps on the following page to remove the receiver module from the motherboard.

> **Note** – The ACE III GPS motherboard will also accept an SVeeSix-CM3 or ACE II module.
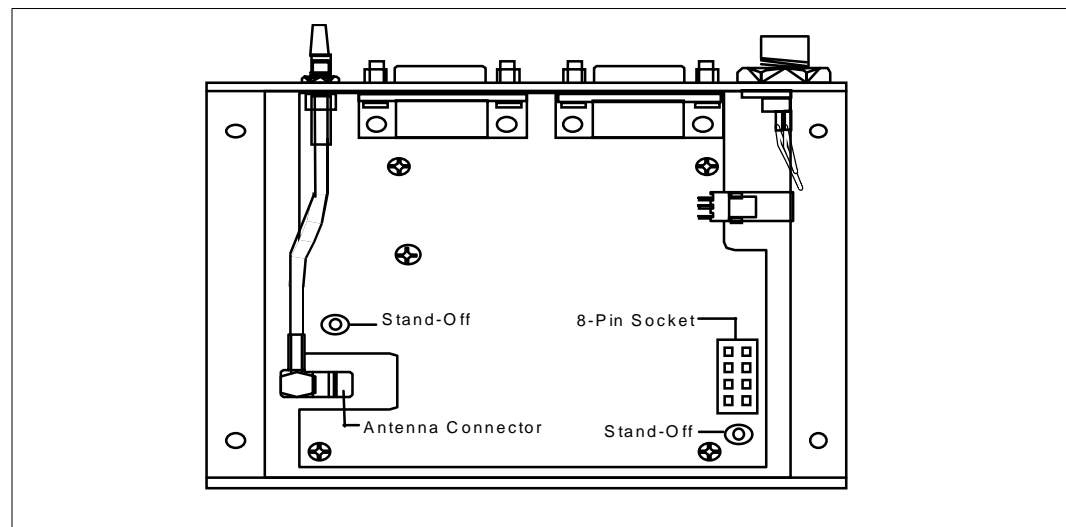


**Figure 2-1    Motherboard Connection Points**

✋

> **Caution –** Before disassembling the interface unit, disconnect the unit from any external power source and confirm that both you and your work surface are properly grounded for ESD protection. The interface unit motherboard contains a 3.6V lithium battery. Exercise caution when removing it from the ACE III GPS unit.

1.   Remove the four screws which secure the bottom plate to the base of the metal enclosure. Set the bottom plate aside.

2.   Remove the two screws securing the ACE III GPS module to the standoffs on the motherboard. These screws are located at opposite ends of the receiver module (see Figure 2-2).
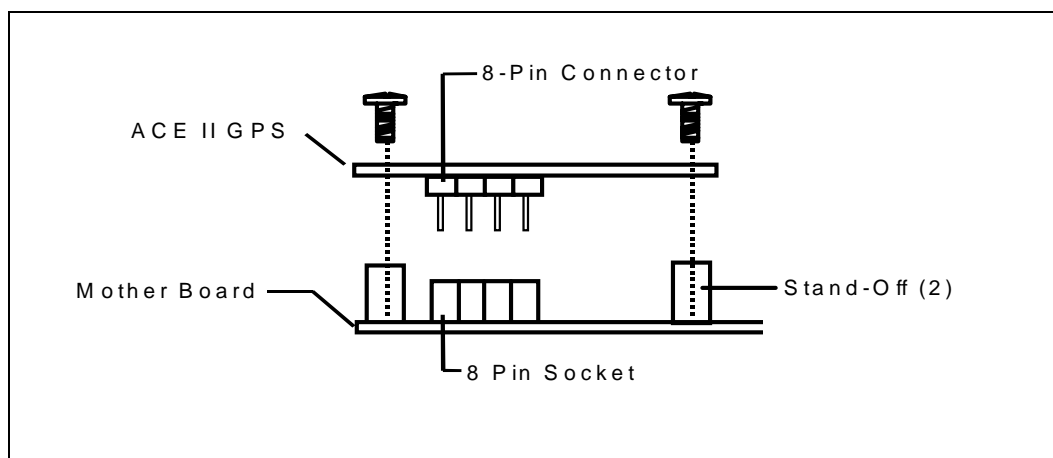


**Figure 2-2      Removing the Receiver Module**

3.   Carefully pull the module straight off the motherboard to disengage the 8-pin header from the 8-pin socket on the motherboard (see Figure 2-2). Do not rotate or flex the module while disengaging the header, since this could damage the connector or the board components. Pull straight up, keeping the ACE III GPS parallel to the motherboard.

4.   Disconnect the RF cable connecting the ACE III GPS module to the SMB connector on the enclosure. This connection was made by pushing the antenna cable connector onto the SMB connector on the receiver. To remove the antenna cable, grasp the cable connector and pull it straight off of the antenna connector. Do not twist the cable or attempt to pull it off at an angle, as this may damage the connector.

5.   To reinstall the ACE III GPS board in the motherboard, follow steps 1 - 4 in reverse order.

✉

> **Note –** The ACE III GPS is designed for embedded applications. The digital I/O lines and power lines are not designed with additional ESD protection as a stand-alone module would be. Use standard CMOS ESD handling precautions when removing and installing the receiver module.

## 2.2      Interface Connector

The ACE III GPS power and data I/O functions are integrated into a single 8-pin header
0787connector, J3. The J3 connector uses 0.150 inch (3.8 mm) pins on 0.0787 inch (2
mm) spacing (See Chapter F, ACE III GPS Specifications and Mechanical Drawings).

**Table 2-1      I/O Connector Signals**

| Pin # | Function | Description |
|-------|----------|-------------|
| 1 | TXD 2 | Port 2 transmit, CMOS/TTL |
| 2 | Prime Power | 5VDC ±5%, 95 mA typical |
| 3 | TXD 1 | Port 1 transmit, CMOS/TTL |
| 4 | Backup Power | +3.2VDC to +5.25VDC, 4µA typical |
| 5 | RXD 1 | Port 1 receive, CMOS/TTL |
| 6 | 1 PPS | Pulse-Per-Second, CMOS/TTL |
| 7 | RXD 2 | Port 2 receive, CMOS/TTL |
| 8 | GND | Ground, Power and Signal |

Pins 3 and 5 on J4 are also referred to as the primary serial port. Pins 1 and 7 are also
referred to as the secondary serial port.

## 2.3     Power Requirement

The ACE III GPS receiver module requires +5 volts DC ±5% at 95 mA, typical excluding the antenna. For power-on surge design considerations, the prime power should be able to source up to a maximum load of 225 mA. The on-board capacitance on prime power is 10 μF. An important design consideration for power is the receiver module's internal clock frequency at 12.504 MHz ± 3 KHz. Interference spurs on prime power in this narrow frequency band should be kept to less than 1mV.

The receiver does not require any special power up or down sequencing. The receiver power is supplied through pin 2 of the I/O connector. Refer to Figure 2-2 for the +5 VDC power specifications.

The ACE III GPS module provides an input for battery back-up (BBU) power to keep the module's RAM memory alive and to power the real-time clock when the receiver's prime power is turned off. RAM memory is used to store the GPS almanac, ephemeris, and last position. User configuration data, including port parameters and receiver processing options, are stored in non-volatile EEROM which does not require back-up power. By using battery back-up, time to first fix is reduced to 20 seconds (typical). Though not required, providing BBU power can reduce power-on time. A 3.6 volt lithium battery used for back-up power can last up to five years.

**Note –** 3.2V is the minimum allowable voltage. When the power output drops below 3.2V, the real-time clock may not operate over the specified full temperature range. This can also significantly extend the time to first fix or cause the device not to operate correctly. Super capacitors shall not be used to provide power for battery backup.

**Table 2-2     Power Requirements**

| Signal | Voltage | Current | J4 Pin |
|---|---|---|---|
| VCC | +4.75 to +5.25 | 95 mA | 2 |
| Battery Backup | +3.2 to +5.25 | 0μA with prime power; 4μA @ 3.5V, 25°C without prime power | 4 |
| Ground | 0 | - | 8 |

The ACE III GPS receiver module will maintain full performance specification when the prime power line is coupled with less than 100 mV of ripple noise, peak to peak from 1Hz to 1MHz.

**Note –** The ACE III GPS Starter Kit motherboard contains a 3.6V lithium battery.

## 2.4      Serial Interface

As an embedded design, the ACE III GPS receiver module provides direct CMOS compatible TTL level serial I/O. The RX and TX signals on the J3 I/O connector are driven directly by the DUART on the ACE III GPS. Interfacing these signals directly to a DUART in your application circuitry provides direct serial communication without the complication of RS-232 or RS-422 line drivers.

**Note –** The serial I/O signals on J3 are TTL level. They are not inverted or driven to RS-232 levels.

## 2.5      Pulse Per Second

A ten microsecond wide, CMOS compatible TTL level pulse is available on Pin 6 of the J3 I/O connector. This pulse is issued once per second with the rising edge of the pulse synchronized with UTC. The pulse will be shaped by the distributed impedance of the attached signal line and input circuit. The rising edge is typically less than 20 nSec. The falling edge should not be used.

The timing accuracy is $\pm$ 100 nanosecond (1$\varepsilon$) and is available only when valid position fixes are being reported. Repeatability checks of 10 sets of 100 one second samples taken over a period of 20 minutes showed an average variation of approximately 100 nanoseconds (not allowing for SA).

## 2.6      Mounting

The ACE III GPS provides four 0.095 inch mounting holes that will accept 3/16 inch round or hex standoffs with 3/8 inch height, and # 2-56 or M2 mounting screws. Space constrained environments may require a different stand-off. Refer to the mechanical outline drawing in Appendix F for dimensions and clearances.

# 3   Software Interface

This chapter describes the ACE III GPS software interface, the start-up characteristics for the interface protocols, a description of the receiver operating modes, and a brief discussion of the interface protocols.

## 3.1   Start-up

ACE III GPS is a complete 8-channel parallel tracking GPS receiver designed to operate with the L1 frequency, standard position service, Coarse Acquisition code. Using two highly integrated Trimble custom integrated circuits, the receiver is designed in a modular format especially suited for embedded applications.

When connected to an external GPS antenna, the receiver contains all the circuitry necessary to automatically acquire GPS satellite signals, track up to 8 GPS satellites, and compute location, speed, heading, and time. The receiver will automatically begin to search for and track GPS satellite signals at power-up.

The performance of a GPS receiver at power-on is determined largely by the availability and accuracy of the satellite ephemeris data and the availability of a GPS system almanac. Refer to Chapter 4 for additional information. The first time the receiver is powered-up, it is searching for satellites from a cold start (no almanac). While the receiver will begin to compute position solutions within the first two minutes, the receiver must continuously track satellites for approximately 15 minutes to download a complete almanac. This initialization process should not be interrupted. With a complete almanac and back-up power, the time to first fix can typically be shortened to less than 45 seconds. The receiver will respond to commands almost immediately after power-up.

## 3.2   Software Tool Kits

The Starter Kit includes a Software Developers Tool Kit to support the TSIP and TAIP protocols. The Kit contains a user-friendly program to communicate with the receiver and includes sample C source code and reusable routines to aid in developing applications. The following Appendices provide additional information:

- Appendix A, Trimble Standard Interface Protocol (TSIP)
- Appendix B, TSIP Toolkit User's Guide
- Appendix C, Trimble ASCII Interface Protocol
- Appendix D, GPSSK User's Guide (TAIP)
- Appendix E, NMEA 0183

## 3.3 Communicating with the ACE III GPS Module

The ACE III GPS supports three message protocols: TSIP, TAIP, and NMEA. The protocols are discussed at the end of this chapter, and are explained in detail in Appendices A through E.

Communication with the ACE III GPS module is through two CMOS compatible, TTL level serial ports. The port characteristics can be changed to accommodate your application requirements. Port parameters are stored in a non-volatile, electrically erasable ROM (EEPROM) that does not require backup power. Table 3-1 lists the default characteristics for each port.

**Table 3-1    Default Serial Port Characteristics**

| Port | Input Protocol | Default Setup | Output Language | Default Setup |
|------|---------------|---------------|-----------------|---------------|
| 1 | TAIP | Baud Rate: 4800<br>Data Bits: 8<br>Parity: None<br>Stop Bits: 1<br>No Flow Control | TAIP | Baud Rate: 4800<br>Data Bits: 8<br>Parity: None<br>Stop Bits: 1<br>No Flow Control |
| 1 | TSIP | Baud Rate: 9600<br>Data Bits: 8<br>Parity: Odd<br>Stop Bits: 1<br>No Flow Control | TSIP | Baud Rate: 9600<br>Data Bits: 8<br>Parity: Odd<br>Stop Bits: 1<br>No Flow Control |
| 2 | RTCM | Baud Rate: 4800<br>Data Bits: 8<br>Parity: None<br>Stop Bits: 1<br>No Flow Control | NMEA | Baud Rate: 4800<br>Data Bits: 8<br>Parity: None<br>Stop Bits: 1<br>No Flow Control |

Any standard serial communications program, such as Windows Terminal or PROCOMM, can be used with the TAIP or NMEA interface protocol. TSIP is a binary protocol and outputs raw binary serial data onto the screen which cannot be read. Trimble encourages the use of the software tool kit provided for TSIP. The serial port drivers in the Trimble tool kit, TSIPCHAT, match the ACE III GPS serial port characteristics. The TSIPPRNT program converts binary data logged with the TSIPCHAT program into text that may be printed and displayed.

**Warning –** When using the TSIP protocol to change port assignments or characteristics, confirm that your changes do not affect the ability to communicate with the receiver module.

## 3.4      Protocol Summary

The ACE III GPS receiver is shipped from the factory with the following configuration:

- TSIP bi-directional

    - Port 1: 9600 baud 8-odd-1

- NMEA 0183 out/RTCM SC-104 V2.1

    - Port 2: 4800 baud 8-none-1

The receiver can easily be reconfigured for different protocols, ports, baud rate and parity settings. These settings are kept in BBRAM (Battery Backed Random Access Memory) and can be saved into non-volatile memory if desired. Use the following commands:

- TSIP command: 0xBC

- TAIP command: PT, PR

Refer to Appendix A, Section A.3, Customizing Receiver Operations, for additional information on protocols.

### 3.4.1      TSIP Data Output

The Trimble Standard Interface Protocol (TSIP) is the native language for the ACE III GPS. TSIP is a binary language with a wide variety of commands and reports. TSIP reports can be output automatically, or they can be output as responses to queries. The format of the automatic reports can be easily configured. The receiver is factory configured for single precision Latitude-Longitude-Altitude. Report formats can be modified and position and velocity formats can be customized. Guidelines for making these modifications are provided in Configuring the ACE III GPS Receiver Protocols, page 3-7, and Appendix A, Trimble Standard Interface Protocol.

The TSIPCHAT program in the ACE III GPS Starter Kit permits using a computer keyboard to send the Request Packets to the GPS receiver. Responses are displayed on a DOS computer screen in ASCII format. C source code routines for TSIPCHAT are also provided in the Starter Kit. C source can be used as a software design guide by programmers who need to communicate system integration information with the ACE III GPS.

### 3.4.2 TAIP Data Output

The Trimble ASCII Interface Protocol (TAIP) is a Trimble-specified digital communication interface based on printable ASCII characters over a serial data link. TAIP interface provides the means to configure the ACE III GPS receiver to output various sentences in response to query or on a scheduled basis. TAIP messages may be scheduled for output at a user specified rate starting on a given epoch from top of the hour. For communication robustness, the protocol optionally supports checksums on all messages. It also provides the user with the option of tagging all messages with the unit's user specified identification number (ID). This greatly enhances the functional capability of the unit in a network environment. This protocol is described in Appendix C, Trimble ASCII Interface Protocol (TAIP).

The receiver can be configured to TAIP with the TSIPCHAT program contained in the Toolkit. (For detailed information on this program, refer to Configuring the ACE III GPS Receiver Protocols, page 3-7.) The program stores these settings, along with all the other defaults, to non-volatile memory. The GPSSK program can now be used to control and re-configure the receiver.

Receiver configurations created in GPSSK can be stored in non-volatile memory using the RT command. As mentioned above, the receiver ports can also be set to TAIP through a TSIP port using TSIPCHAT and the TSIP command 0xBC.

### 3.4.3 NMEA 0183 Data Output

The National Marine Electronics Association (NMEA) protocol is an industry standard data protocol which was developed for the marine industry. Trimble has chosen to adhere stringently to the NMEA 0183 data specification as published by the NMEA.

NMEA data is output in standard ASCII sentence formats. Message identifiers are used to signify what data is contained in each sentence. Data fields are separated by commas within the NMEA sentence. In the ACE III GPS, NMEA is an output only protocol. The NMEA protocol is described in detail in Appendix E, NMEA 0183.

The receiver is shipped from the factory with NMEA output on Port 2. Port 2 settings can be changed using TSIPCHAT and command 0xBC. TSIP command 0x7A changes the NMEA output sentences and output rates. The new settings are saved to BBRAM or they can be saved to non-volatile memory using TSIP command 0x8E-26.

Note – Although the Trimble ACE III GPS supports seven NMEA sentences that contain GPS information, the factory default setting for the ACE III GPS module only outputs the GGA and VTG data strings. To change the output interval or sentence output, use TSIP Command Packet 7A.

## 3.5      Timing Applications

The ACE III GPS is an excellent source for accurate system timing. Two examples of an application requiring accurate time are environmental data acquisition and synchronization of communications networks. The timing functions of the receiver are supported by the TSIP protocol. See Report Packet 41 in Appendix A for a description of the time function reports for TSIP.

**Note –** Note that GPS time differs from UTC (Universal Coordinated Time) by a variable integer number of seconds: UTC = (GPS time) - (GPS UTC Offset)

As of January 1999, the GPS UTC offset was 13 seconds. The offset increases by 1 second approximately every 18 months. System designers should plan to read the offset value as a part of the timing interface to obtain UTC. The GPS week number is in reference to a base week (Week #0), starting January 6, 1980.

The current GPS UTC offset is contained within the almanac transmitted by the GPS system. The ACE III GPS must have a complete almanac before the offset data is valid.

### 3.5.1      Effect of GPS Week Number Roll-over (WNRO)

The ACE III GPS module has been designed to handle WNRO, and there are no problems with either dates or first fix after WNRO through the year 2015.

**Note –** GPS Week Numbers system, as defined by the ICD200 GPS Specification, occupy a range from zero to 1023. The Week Number Roll Over (WNRO) occurs every 1024 weeks, or approximately every 19 years 8 months. August 1999 was the first roll-over for the GPS system since the beginning of GPS time on 06 January 1980.

**Caution –** Trimble OEM GPS receivers have reported the true GPS Week Number in TSIP messages 0x41 and 0x8F-20 as a number between 0 and 1023. The ACE III GPS outputs the Extended GPS Week Number as the absolute number of weeks since the beginning of GPS time or 06 January 1980. If the true GPS Week Number is desired, the system developer should ignore the extra MSBs of the Extended GPS Week Number and use only the 10 LSBs.

## 3.6     Differential GPS

The ACE III GPS module can use differential corrections to compute a Differential GPS position (DGPS). DGPS can provide position accuracy of 2 meters (1 sigma).

RTCM SC-104, the industry standard format for differential corrections, is available from most DGPS reference stations, Coast Guard beacon transmissions, and commercial DGPS subscription services. The ACE III GPS is fully compatible with RTCM SC-104 Version 2.1. The ACE III GPS is factory configured to accept RTCM SC-104 correction data over Port 2 (J4, pin 7) at 4800 baud, 8 data bits, 1 stop bit and no parity. The DGPS operating mode is set to Automatic which means that the receiver will provide differential GPS solutions when valid correction data is available and will output standard GPS solutions when no valid correction data is available.

No setup is required to use RTCM SC-104 differential corrections; however, you may need to reconfigure the serial port characteristics (baud rate, data bits, stop bits and parity) to match the characteristics of your RTCM SC-104 data source using the TSIP packet 0xBC. See Chapter A, Trimble Standard Interface Protocol, for more information on this message. Figure 3-1 summarizes the default characteristics for the ACE III GPS serial ports.

Alternatively, you may use Trimble's TSIP packets 60h and 61h to apply differential corrections through the ACE III GPS Port 1 (J3, pin 5). These packets can be interleaved with the TSIP command stream. Packets 60h and 61h are useful in applications which require the use of a single communications channel between the ACE III GPS and the system. Note that using these messages requires you to reformat the RTCM SC-104 differential correction data into the 60h/61h message format. See Appendix A for more information on these messages.

## 3.7      Configuring the ACE III GPS Receiver Protocols

It is good practice to store the ACE III GPS receiver configuration in non-volatile memory (EEPROM) rather than relying on battery-backed memory. This ensures the availability of the receiver configuration if back-up battery power is accidentally lost.

The configuration process is comprised of three steps. Detailed instructions are provided below.

1.    Configure the receiver port PORT1 to TSIP input/output, as described in Re-configuring PORT1, page 3-7.

2.    Enter a series of configuration commands as described in Entering the Configuration, page 3-8.

3.    Return the receiver port to the original setting (if necessary); and issue a "save configuration command", as described in Saving the Configuration, page 3-10.

### 3.7.1      Re-configuring PORT1

If the PORT1 protocol is currently set to TSIP input/output, the port does not need to be re-configured, and you can proceed to Entering the Configuration, page 3-8. Otherwise, reconfigure PORT1 as described below.

Depending on the current receiver configuration, select from the following three options to set the receiver PORT1 protocol to TSIP input/output.

1.    If the PORT1 protocol is TSIP input but not TSIP output, re-configure PORT1 to TSIP input/output using the TSIP 0xBC command.

2.    If the PORT1 input protocol is TAIP, apply an ">SPR…" command to change the PORT1 protocol to TSIP input/output temporarily. This may be done with TSIPCHAT. Use the 'l' keystroke and type in the following command at the prompt: ">SPR;TSIP=TF;TAIP=FF;NMEA=FO;RTCM=FI<".

3.    If the PORT1 input protocol is RTCM or none, but will eventually be changed to the TAIP or TSIP input protocol, first change the PORT1 protocol by sending a TAIP SPR command or TSIP 0xBC command through PORT2.

**Note –** At least one of the ports must be configured to either the TSIP or the TAIP input protocol at all times.

### 3.7.2        **Entering the Configuration**

The DOS program TSIPCHAT is used to configure the receiver to the desired settings. Table 3-2 lists the TSIPCHAT configuration commands. A complete description of these individual parameters is provided in Chapter A, Trimble Standard Interface Protocol.

1.  Start TSIPCHAT, with "TSIPCHAT –c1" if attached to PC serial port COM1, or with "TSIPCHAT –c2" if attached to PC serial port COM2.

2.  If the PORT1 settings are not set to the TSIP default (9600 8-odd-1), use the keystroke '^i' to set the PC serial port to match the PORT1 settings.

3.  Send all desired configuration commands through PORT1, including the configuration for PORT2 (0xBC). If PORT1 is to be reconfigured to TAIP, or the baud rate, parity, etc. are to change, send the 0xBC command for PORT1 as the last command of the sequence.

4.  Change the PC serial port settings to match the PORT1 settings. A short period of time may be required for the serial port communication to be re-acquired; two seconds is sufficient.

**Table 3-2    TSIPCHAT Commands**

| TSIP Command ID | TSIPCHAT Keystroke | Description | TSIP Response ID |
|---|---|---|---|
| 0x35 | 'O' | TSIP input/output formatting<br>Superpacket output (on/off)<br>Position format (LLA and/or ECEF)<br>Precision (double or single)<br>Altitude format (MSL or HAE)<br>Timetag format (GPS or UTC)<br>SNR format (AMU or $C/N_0$)<br>Automatic Pseudorange output | 0x55 |
| 0x70 | 'l' | Position filter controls<br>Position filter on/off<br>Static filter on/off<br>Altitude filter on/off | 0x70 |
| 0x7A | 'q' | NMEA message formats and schedule<br>NMEA output messages<br>NMEA output interval | 0x7B |
| 0xBB | 'p' | GPS configuration parameters<br>Operating dimension (2D, 3D, ...)<br>DGPS mode<br>Dynamics mode<br>Elevation mask<br>SNR mask<br><br>DOP mask<br>PDOP switch<br>DGPS correction age | 0xBB |
| 0xBC | 'U' | Serial port configuration<br>Protocol: input, output<br>Baud, data bits, parity, stop bits | 0xBC |
| 0x8E-15 | '= t' | Output datum | 0x8F-15 |
| 0x8E-19 | '= f' | UTM output control | 0x8F-19 |
| 0x8E-20 | '= g' | Fixed point superfix control (default = on) | 0x8F-20 |
| 0x8E-40 | '= t' | TAIP configuration<br>Report Mode Flags (command RM)<br>Heartbeat message<br>Heartbeat Top of Hour Offset<br>Heartbeat Interval<br>Vehicle ID Tag | 0x8F-40 |

### 3.7.3    Saving the Configuration

Before writing the configuration to SEEPROM, verify that the receiver has been configured to the desired settings.

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**Warning –** Record the serial port settings. If forgotten, they are difficult to recover.

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1.  If the PORT1 protocol is set to TAIP, send the TAIP command "SRTSAVE_CONFIG". This can be done in TSIPCHAT using the keystroke '|' and typing the string ">SRTSAVE_CONFIG<" at the prompt.

2.  If the PORT1 protocol is set to TSIP, use the TSIP command 0x8E-26 (TSIPCHAT '=' then 's').

3.  Wait two seconds for the SEEPROM to be written.

4.  Use a cold-start to verify that the procedure was successful. A cold-start is a power-cycle with no battery-backed memory. Use either the TSIP or TAIP protocol to initiate a cold-start and confirm that the receiver is initialized to the desired settings. In TSIP protocol, send the "clear RAM and restart" command, 0x1E-4B '(^k' in TSIPCHAT). In TAIP protocol, send the TAIP cold-start command, ">SRTCOLD<".

### 3.7.4    Returning to the Factory Settings

If the SEEPROM settings are incorrect, the board can be returned to the factory settings using the "factory reset" command.

1.  If the input protocol is set to TAIP, use the TAIP entry command in TSIPCHAT, '|', and type the string ">SRTFACTORY<".

2.  If the input protocol is set to TSIP, use the TSIP factory reset command (TSIPCHAT, '^k', clear RAM and SEEPROM).

3.  Wait two seconds for the SEEPROM to be written.

# 4    Operation and Performance

This chapter describes the ACE III GPS satellite acquisition and tracking processes, performance characteristics and system architecture. This discussion assumes that you are familiar with the basic theory of the Global Positioning System. Before proceeding to the detailed discussion of the satellite acquisition and tracking process, please review the GPS satellite message description on the next page.

The ACE III GPS satellite acquisition and tracking algorithms can achieve a position solution without any initialization. The receiver automatically selects and tracks the best combination of satellites to compute position and velocity. As satellites move out of view, the ACE III GPS automatically acquires new satellites and includes them in the solution set as required.

## 4.1    GPS Satellite Message

Every GPS satellite transmits the Coarse/Acquisition (C/A) code and satellite data modulated onto the L1 carrier frequency (1575.42 MHz). The satellite data transmitted by each satellite includes a satellite almanac for the entire GPS system, its own satellite ephemeris and its own clock correction.

The satellite data is transmitted in 30-second frames. Each frame contains the clock correction and ephemeris for that specific satellite, and two pages of the 50-page GPS system almanac. The almanac is repeated every 12.5 minutes. The ephemeris is repeated every 30 seconds.

The system almanac contains information about each of the satellites in the constellation, ionospheric data, and special system messages. The GPS system almanac is updated weekly and is typically valid for months. The ephemeris contains detailed orbital information for a specific satellite. Ephemeris data changes hourly, but is valid for up to four hours. The GPS control segment updates the system almanac weekly and the ephemeris hourly through three ground-based control stations. During normal operation, the ACE III GPS module updates its ephemeris and almanac as needed.

The performance of a GPS receiver at power-on is determined largely by the availability and accuracy of the satellite ephemeris data and the availability of a GPS system almanac.

## 4.2     Satellite Acquisition and Time to First Fix

### 4.2.1     Cold-Start

The term "cold-start" describes the performance of a GPS receiver at power-on when no navigation data is available. "Cold" signifies that the receiver does not have a current almanac, satellite ephemeris, initial position, or time. The cold-start search algorithm applies to a ACE III GPS which has no memory of its previous session (i.e., is powered on without the memory backup circuit connected to a source of DC power). This is the "out of the box" condition of the GPS module as received from the factory.

In a cold-start condition the receiver automatically selects a set of eight satellites and dedicates an individual tracking channel to each satellite, to search the Doppler range frequency for each satellite in the set. If none of the eight selected satellites is acquired after a pre-determined period of time (time-out), the receiver will select a new search set of eight satellites and will repeat the process, until the first satellite is acquired. As satellites are acquired, the receiver automatically collects ephemeris and almanac data. The ACE III GPS uses the knowledge gained from acquiring a specific satellite to eliminate other satellites, those below the horizon, from the search set. This strategy speeds the acquisition of additional satellites required to achieve the first position fix.

The cold-start search sets are established to ensure that at least three satellites are acquired within the first two time-out periods. As soon as three satellites are found, the receiver will compute an initial position fix. The typical time to first fix is less than 2 minutes.

A complete system almanac is not required to achieve a first position fix. However, the availability and accuracy of the satellite ephemeris data and the availability of a GPS almanac can substantially shorten the time to first fix.

**Note –** When installed in the interface unit, the ACE III GPS receives back-up power from a lithium battery. This battery enables the ACE III GPS to always start from either a warm or hot start. To force a cold start, issue the 1E TSIP command (Control + K in the TSIP chat program on the GPS toolkit diskette in the Starter Kit).

### 4.2.2    Warm Start

In a warm start condition, the receiver has been powered down for at least one hour but has a current almanac and an initial position and time stored in memory.

When connected to an external backup battery and power is applied, the ACE III GPS retains the almanac, approximate position, and time to aid in satellite acquisition and reduce the time to first fix. When an external back-up battery is not used, the TSIP protocol allows the almanac, an initial position, and time to be uploaded to the receiver via the serial port, to initiate a warm start.

During a warm start, the ACE III GPS identifies the satellites which are expected to be in view, given the system almanac, the initial position and the approximate time. The receiver calculates the elevation and expected Doppler shift for each satellite in this expected set and directs the eight tracking channels in a parallel search for these satellites.

The warm start time to first fix, when the receiver has been powered down for more than 60 minutes (i.e. the ephemeris data is old), is usually less than 45 seconds.

### 4.2.3    Garage Search Strategy

During a warm start search, the ACE III GPS knows which satellites to search for, based on the system almanac, the initial position (last known position) and the current time. In some cases, the receiver may not be able to acquire the expected satellite signals (e.g., a vehicle parked in a garage or a vessel in a covered berth). Trimble's patented "garage search" strategy, also known as a split search, is designed for such situations.

If the receiver does not acquire the expected set of satellites within 5 minutes of power-on, some of the eight tracking channels will continue to search for the expected satellites (warm search) while the remaining channels are directed in a cold start search. This strategy minimizes the time to first fix in cases where the stored almanac, position and time are invalid. The stored information is flushed from memory, if the cold start search proves effective and the warm search fails.

### 4.2.4    Hot Start

A hot start strategy applies when the ACE III GPS has been powered down for less than 60 minutes, and the almanac, position, ephemeris, and time are valid. The hot start search strategy is similar to a warm start, but since the ephemeris data in memory is considered current and valid, the acquisition time is typically less than 20 seconds.

## 4.3     Satellite Mask Settings

Once the ACE III GPS has acquired and locked onto a set of satellites, which pass the mask criteria listed in this section, and has obtained a valid ephemeris for each satellite, it will output regular position, velocity and time reports according to the protocol selected.

The default satellite masks observed by the ACE III GPS are listed in Table 4-1. These masks serve as the screening criteria for satellites used in fix computations and ensure that position solutions meet a minimum level of accuracy. The ACE III GPS will only output position, course, speed and time when a satellite set can be acquired which meets all of the mask criteria. The satellite masks can be adjusted in GPS receivers accepting the TSIP protocol. (See the section titled *Key Setup Parameters*, located in Appendix A.)

**Table 4-1      Default Satellite Mask Settings**

| Mask | Setting |
|------|---------|
| Elevation | 5° |
| SNR | 2 |
| PDOP | 12 |
| PDOP Switch | 5 |

### 4.3.1     Elevation Mask

Satellites below a 5° elevation are not used in the position solution. Although low elevation satellites can contribute to a lower/better PDOP, the signals from low elevation satellites are poorer quality, since they suffer greater tropospheric and ionospheric distortion than the signals from higher elevation satellites. These signals travel further through the ionospheric and tropospheric layers.

In addition, low elevation satellites can contribute to frequent constellation switches, since the signals from these satellites are more easily obscured by buildings and terrain. Constellation switches can cause noticeable jumps in the position output. Since worldwide GPS satellite coverage is generally excellent, it is not usually necessary to use satellites below a 5° elevation to improve GPS coverage time. In some applications, like urban environments, a higher mask may be warranted to minimize the frequency of constellation switches and the impact of reflected signals.

### 4.3.2    SNR Mask

Although the ACE III GPS is capable of tracking signals with SNRs as low as 0, the default SNR mask is set to 2 to eliminate poor quality signals from the fix computation and minimize constellation switching. Low SNR values may result from:

- Low Elevation Satellites
- Partially Obscured Signals (e.g. Dense Foliage)
- Multi-Reflected Signals (Multi-Path)

The distortion of signals and the frequent constellation switches associated with low-elevation satellites were discussed above. In mobile applications, the attenuation of signals by foliage is typically a temporary condition. Since the ACE III GPS can maintain lock on signals with SNRs as low as 0, it offers excellent performance when traveling through heavy foliage.

Multi-reflected signals, also known as Multi-path, can degrade the position solution. Multi-path is most commonly found in urban environments with many tall buildings and a preponderance of mirrored glass, which is popular in modern architecture. Multi-reflected signals tend to be weak (low SNR value), since each reflection attenuates the signal. By setting the SNR mask to 2 or higher, the impact of multi-reflected signals is minimized.

### 4.3.3    DOP Mask

Position Dilution of Precision (DOP) is a measure of the error caused by the geometric relationship of the satellites used in the position solution. Satellite sets which are tightly clustered or aligned in the sky will have a high DOP and will contribute to a lower position accuracy. For most applications, a DOP mask of 10 offers a satisfactory trade-off between accuracy and GPS coverage time. With world-wide GPS coverage now available, the DOP mask can be lowered even further for many applications without sacrificing coverage. For differential GPS applications, DOP related error can be the major contributor to position error. For differential GPS applications requiring the highest level of accuracy, the DOP mask should be set to 7 or below.

### 4.3.4    PDOP Switch

The default positioning mode for the ACE III GPS is Automatic. In this mode, the receiver attempts to generate a 3-dimensional (3D) position solution, when four or more satellites meeting the mask criteria are visible. If such a satellite set cannot be found, the receiver will automatically switch to 2-dimensional (2D) mode. The PDOP switch establishes the trade-off between 3D positioning and PDOP. With the PDOP Switch set to 6, the receiver will compute a 2D position with a HDOP below 6 rather than a 3D position with a PDOP greater than 6, even when four or more satellites are visible.

**Note –** PDOP Switch is only used in Auto mode.

## 4.4      Standard Operating Modes

The tracking mode controls the allocation of the receiver's tracking channels and the method used for computing position fixes. The output of GPS data is controlled by two operating modes:

- Fix Modes (2D, 3D, or Automatic)
- Differential GPS Mode (On, Off, or Auto)

### 4.4.1      Fix Modes

The ACE III GPS offers three positioning modes: 2D Manual, 3D Manual, and Automatic 2D/3D. Automatic 2D/3D is the default mode for the ACE III GPS. The positioning mode can be modified in receivers accepting TSIP commands. See Appendix A for more information on the TSIP protocol.

#### 2D Manual

In 2D Manual mode, the ACE III GPS will only generate 2-dimensional (2D) position solutions (latitude and longitude only), regardless of the number of visible satellites. If the altitude is not entered, the receiver uses zero as the default altitude. The greater the deviation between the actual and default altitudes, the greater the error in the 2D position. For TSIP applications, enter local altitude in MSL/HAE via TSIP packet 2AH (see Appendix A).

**Note –** 2D Manual mode is not recommended for differential GPS applications since any deviation in altitude will cause a significant error in the latitude and longitude. Only use the 2D Manual mode for flat land or marine applications where the elevation is known or constant. For DGPS applications, the 3D Manual mode is the recommended positioning mode for the highest level of accuracy.

#### 3D Manual

In 3D Manual mode, the ACE III GPS will only generate 3-dimensional (3D) position solutions (latitude, longitude, and altitude). A 3D solution requires at least four visible satellites which pass the mask criteria. If less than four conforming satellites are visible, the ACE III GPS will suspend position data outputs. 3D Manual mode is recommended for differential GPS applications requiring the highest level of accuracy.

#### 2D/3D Automatic

The default operating mode for the ACE III GPS is 2D/3D Automatic. In this mode, the ACE III GPS attempts to generate a 3-dimensional (3D) position solution, if four or more satellites meeting the mask criteria are visible. If only three satellites are visible which meet the mask criteria, the ACE III GPS will automatically switch to 2-dimensional (2D) mode and will use the last calculated altitude, if available, or the default altitude in the position solution. In 2D/3D Automatic mode, the PDOP switch is active.

## 4.5      Differential GPS Operating Modes

The default mode for the ACE III GPS is DGPS Automatic. The ACE III GPS supports three DGPS Modes: On, Off, and Automatic, and the mode may be changed by issuing the appropriate TSIP command. See Appendix A for information on TSIP commands. The three DGPS operating modes are described below.

### 4.5.1      DGPS On

When DGPS On is selected, the ACE III GPS will only provide differential GPS solutions. If the source of correction data is interrupted or becomes invalid, the ACE III GPS will suspend all output of position, course and speed data. When a valid source of correction data is restored, the ACE III GPS will resume outputting corrected data.

### 4.5.2      DGPS Off

When DGPS Off is selected, the ACE III GPS will not provide differential GPS solutions, even if a valid source of correction data is supplied. In this mode, the receiver will only supply standard GPS data.

### 4.5.3      DGPS Automatic

DGPS Automatic is the default operating mode for the ACE III GPS. In this mode, the ACE III GPS will provide differential GPS solutions when valid correction data is available. If a set of differentially correctable satellites cannot be found which meets the satellite mask settings, the receiver will transition to output standard GPS solutions. The ACE III GPS automatically switches between DGPS and standard GPS based on the availability of valid correction data.

### 4.5.4      Differential GPS Operation

The ACE III GPS is capable of accepting and decoding RTCM SC-104 data. RTCM SC-104 is an industry standard protocol for differential correction data. The ACE III GPS is configured to accept RTCM SC-104 correction data over Port 2 (J3, pin 7). Alternatively, you can use TSIP packets 60 and 61 or the TAIP and DD messages to input differential corrections through the primary serial port (J4, pin 5).

## 4.6     Position Accuracy

GPS position accuracy is degraded by atmospheric distortion, satellite and receiver clock errors, and Selective Availability (SA). Effective models for atmospheric distortion of satellite signals have been developed to minimize the impact of tropospheric and ionospheric effects. The impact of satellite clock errors is minimized by incorporating the clock corrections transmitted by each satellite used in the position solution. SA is the most significant contributor to position error and cannot be effectively combated except with differential GPS.

### 4.6.1     Selective Availability (SA)

The U.S. Department of Defense, through a program called Selective Availability, intentionally degrades GPS accuracy for civilian users. The SA program creates position errors by modifying the apparent position of each satellite and introducing random dither into each satellite's clock.

In extreme cases all sources of error (natural, PDOP, and SA) can combine to produce large position errors. The DOD's definition of accuracy under SA is 100 meters 2 dRMS (horizontal 2 dimensional, 95% of the time). In April 1996, the U.S. government approved plans for disabling SA.

### 4.6.2     Differential GPS (DGPS)

Differential GPS is an effective technique for overcoming the effects of SA and other sources of position error. DGPS relies on GPS error corrections transmitted by a reference station placed at a known location. The reference station compares its GPS position solution to its precisely surveyed position and calculates the error in each satellite's range measurement. The industry standard protocol for GPS correction data is RTCM SC-104.

The GPS corrections are broadcast to mobile GPS receivers in neighboring areas. The mobile receivers incorporate the GPS corrections in their position solution to achieve excellent accuracy. For marine applications, corrections are typically modulated on marine radio beacon broadcasts. For land-based applications, the correction data can be transmitted over FM sub-carrier, cellular telephone or dedicated UHF or VHF radio links.

DGPS can reduce position error to under 5 meters, 95% of the time under steady state conditions. The DGPS accuracy is highly dependent on the quality and age of the differential corrections and the proximity of the mobile receiver to the reference site.

## 4.7      Coordinate Systems

Once the ACE III GPS achieves its first fix, it is ready to commence output of position, velocity, and time information.

This information is output over serial communication channel in either the TSIP, TAIP, or NMEA protocol, as determined by the settings of the receiver. These protocols are defined in the following Appendices:

- •      TSIP - Appendix A, Trimble Standard Interface Protocol (TSIP)

- •      TAIP - Appendix A, Trimble ASCII Interface Protocol (TAIP)

- •      NMEA - Appendix E, NMEA 0183

 To change from one protocol to another, please see "Configuring your Receiver" in Appendix A, Trimble Standard Interface Protocol (TSIP).

### 4.7.1      TSIP Coordinate Systems

TSIP has the widest choice of coordinate systems. The output format is chosen by TSIP command 0x35. The output formats include the following:

- •      LLA position — Latitude, longitude, altitude (LLA) according to the WGS ellipsoid or one of over a hundred other datums. See Appendix A, Table A-86 for a list of available datums. Altitude can be chosen to be height above ellipsoid (HAE) or height above mean sea level (MSL).

- •      ENU velocity — ENU velocity is the velocity in East, North, and Up coordinates. These coordinates are easily converted to speed and heading.

- •      ECEF position and velocity — ECFF position and velocity is Earth-Centered, Earth-Fixed frame is a Cartesian coordinate frame with its center at the earth's center, the z-axis through the North Pole, and the x-axis through longitude 0 degrees, latitude 0 degrees. Velocity is reported relative to the same axes.

- •      UTM — Universal Transverse Mercator (UTM) is a mapping coordinate system used by many government agencies.

There are also two time coordinate systems:

- •      GPS time — GPS time is determined by an ensemble of atomic clocks operated by the Department of Defense (DOD).

- •      UTC time — UTC time is the world standard maintained by an ensemble of atomic clocks operated by government organizations around the world.

GPS time is steered relative to Universal Coordinated Time (UTC). GPS does not recognize leap seconds resulting in a situation where GPS time is currently 13 seconds ahead of UTC time. Time tags for most output messages can be in either UTC time or GPS time, as chosen by TSIP command 0x35.

### 4.7.2    NMEA 0183

The NMEA 0183 protocol only supports LLA format and UTC time. Velocity is always described as horizontal speed and heading; vertical speed is not output.

### 4.7.3    TAIP

The TAIP protocol only supports LLA position output. Timetags are GPS, except for the TM time mark message.

## 4.8      Performance Characteristics

### 4.8.1      Update Rate

The ACE III GPS computes and outputs position solutions once per second, on the second. NMEA outputs can be scheduled at a slower rate using TSIP command 7Ah. Refer to Appendix A.

### 4.8.2      Dynamic Limits

The dynamic operating limits for the ACE III GPS are listed below. These operating limits assume that the GPS module is correctly embedded and that the overall system is designed to operate under the same dynamic conditions.

**Table 4-2      ACE III GPS Operating Limits**

| Operation | Limit |
|-----------|-------|
| Acceleration | 4 g (39.2 m/s$^2$) |
| Jerk | 20 m/s$^3$ |
| Speed | 500 m/s |
| Altitude | 18,000 m |

**Note –** The ACE III GPS firmware contains an algorithm that allows the speed limit or altitude limit to be exceeded but not both. This allows the receiver to be used in high altitude (research balloon) applications without a special factory configuration.

### 4.8.3      Re-Acquisition

Re-acquisition time for a momentary signal blockages is typically under 2 seconds.

When a satellite signal is momentarily interrupted during normal operation, the receiver continues to search for the lost signal at the satellite's last known Doppler frequency. If the signal is available again within 15 seconds, the receiver will normally re-establish track within two seconds. If the lost signal is not re-acquired within 15 seconds, the receiver initiates a broader frequency search. The receiver will continue to search for the satellite until it falls below the elevation mask.

## 4.9     GPS Timing

In many timing applications, such as time/frequency standards, site synchronization systems and event measurement systems, GPS receivers are used to discipline local oscillators.

The GPS constellation consists of 24 orbiting satellites. Each GPS satellite contains a highly-stable atomic (Cesium) clock, which is continuously monitored and corrected by the GPS control segment. Consequently, the GPS constellation can be considered a set of 24 orbiting clocks with worldwide 24-hour coverage.

GPS receivers use the signals from these GPS "clocks" to correct its internal clock, which is not as stable or accurate as the GPS atomic clocks. GPS receivers like the ACE III GPS output a highly accurate timing pulse (PPS) generated by its internal clock, which is constantly corrected using the GPS clocks. This timing pulse is synchronized to UTC within ±500 ns.

In addition to serving as a highly accurate stand-alone time source, GPS receivers are used to synchronize distant clocks in communication or data networks. This synchronization is possible since all GPS satellite clocks are corrected to a common master clock. Therefore, the relative clock error is the same, regardless of which satellite or satellites are used. For timing applications requiring a "common clock", GPS is the ideal solution.

GPS time accuracy is bounded by the same major source of error affecting position accuracy, Selective Availability. The position and time errors are related by the speed of light. Therefore, a position error of 100 meters corresponds to a time error of approximately 333 ns. The hardware and software implementation affects the GPS receiver's PPS accuracy level. The receiver's clocking rate determines the PPS steering resolution.

The ACE III GPS clocking rate is 3.126 MHz. This rate corresponds to a steering resolution of ±160 ns. Software techniques such as over-determined clock algorithm can achieve PPS accuracy better than Selective Availability because more satellites are used to give a higher timing accuracy.

### 4.9.1     Serial Time Output

Both the TSIP, TAIP, and NMEA protocols include time messages. Refer to Report Packet 41 in Appendix A or the ZDA descriptions in Appendix D for a description of the time reports for each protocol and the TAIP TM message.

**Note –** GPS time differs from UTC (Universal Coordinated Time) by a variable, integer number of seconds UTC = (GPS time) - (GPS UTC offset).

As of January 1999, the GPS UTC offset was 13 seconds. The offset has historically increased by 1 second about every 18 months. System designers should plan to read the offset value as a part of the timing interface to obtain UTC. The GPS week number is in reference to a base week (Week #0), starting January 6, 1980.

### 4.9.2    Timing Pulse Output (PPS)

A pulse-per-second (PPS), ten microsecond wide pulse is available on the ACE III GPS 8-pin interface connector. The pulse is sent once per second and the rising edge of the pulse is synchronized with UTC. The pulse shape is affected by the distributed capacitance of the attached cabling and input circuit. The rising edge is typically less than 20 ns wide. The falling edge should never be used for timing applications.

**Note –** The PPS signal output by the ACE III GPS is a CMOS/TTL level signal. If this signal must be furnished to a remote location, the system designer should provide an RS-422 driver for the timing pulse.

When the ACE III GPS is installed on the interface motherboard (supplied in the Starter Kit), the PPS signal is connected to an open collector circuit and the polarity of the signal is inverted.

## 4.10    System Architecture

The ACE III GPS module (see Figure 4-1) uses eight processing channels operating on the L1 frequency of 1575.42 MHz and using the coarse acquisition (C/A) code. The module uses custom integrated circuitry designed by Trimble to track the GPS satellite signals. These ICs also contain support circuitry to the navigation processor. An integrated 32-bit microprocessor is used for tracking, computing a position, and performing the I/O operations.

The module receives the GPS satellite signals through the antenna feed line connector, amplifies the signals, and then passes them to the RF down converter. A highly stable crystal reference oscillator operating at 12.504 MHz is used by the down converter to produce the signals used by the 8-channel signal processor. The 8-channel signal processor tracks the GPS satellite signals and extracts the carrier code information as well as the navigation data at 50 bits per second.

Operation of the tracking channels is controlled by the navigation processor. The tracking channels are used to track the highest eight satellites above the horizon. The navigation processor will then use the optimum satellite combination to compute a position. The navigation processor also manages the ephemeris and almanac data for all of the satellites, and performs the data I/O.
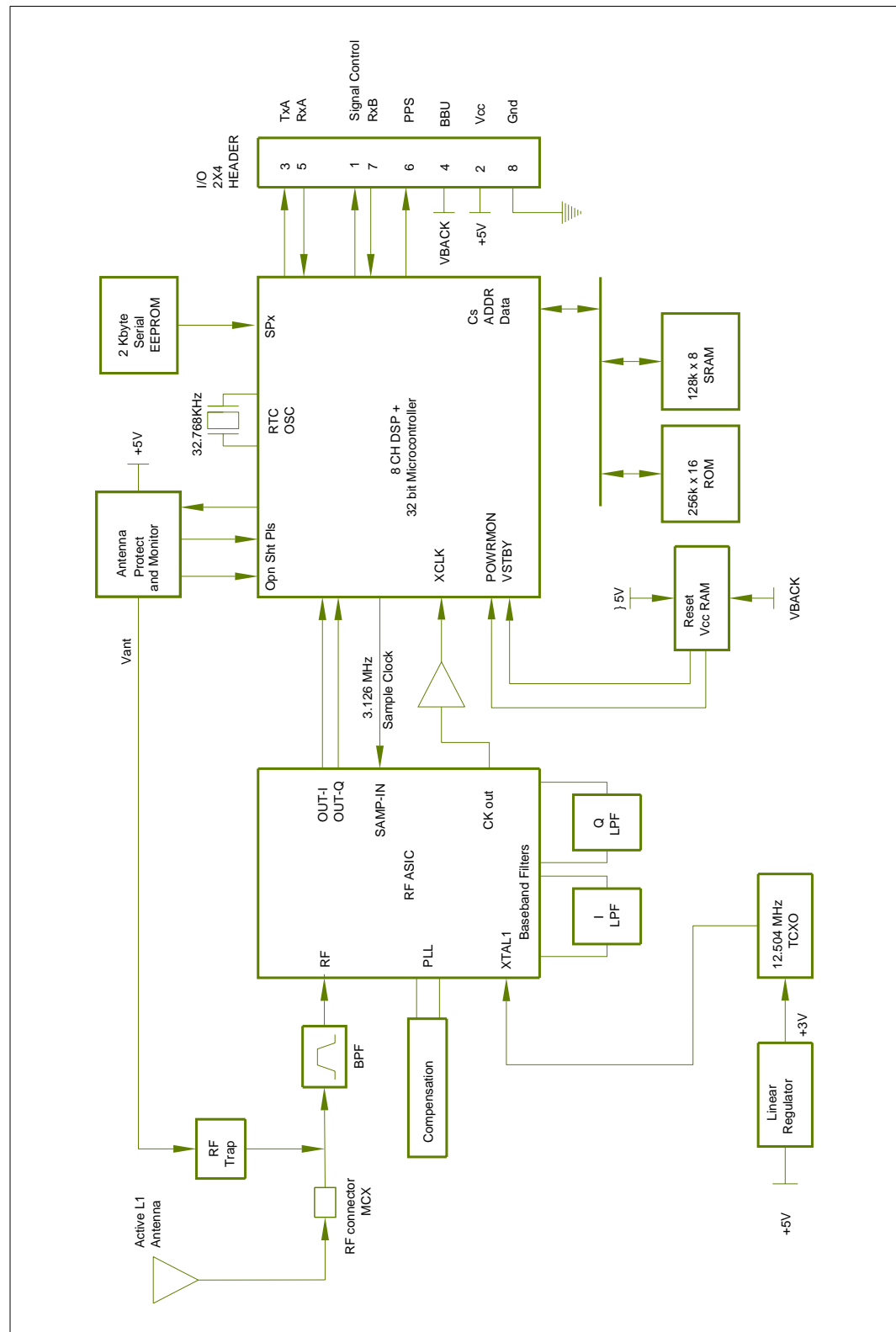
**Figure 4-1      ACE III GPS Block Diagram**

# A     Trimble Standard Interface Protocol

The Trimble Standard Interface Protocol (TSIP) provides the system designer with over 75 commands that may be used to configure a GPS receiver for optimum performance in a variety of applications. TSIP enables the system designer to customize the configuration of a GPS module to meet the requirements of a specific application.

This appendix provides the information needed to make judicious use of the powerful features TSIP has to offer, to greatly enhance overall system performance and to reduce the total development time. The reference tables beginning on page A-3 will help you determine which packets apply to your application. For those applications requiring customizing, see page A-4. For a detailed description of the key setup parameters see page A-16. Application guidelines are provided for each TSIP Command Packet, beginning on page A-21.

## A.1     Interface Scope

The Trimble Standard Interface Protocol is used in Trimble 6-channel and 8-channel receiver designs. The protocol was originally created for the Trimble Advanced Navigation Sensor (TANS) and is colloquially known as the TANS protocol even though the protocol applies to many other devices.

The ACE III GPS module has two independently configurable serial I/O communication ports. Port 1 is a bi-directional control and data port utilizing a Trimble Standard Interface Protocol (TSIP) or Trimble ASCII Interface Protocol (TAIP). Port 2 is a bi-directional port used to receive differential GPS (DGPS) corrections in the industry standard RTCMSC-104 format and for output of industry standard ASCII NMEA sentences. Port 1 can also be configured to TAIP I/O using TSIP commands. The dual data I/O port characteristics and other options are user programmable and stored in non-volatile memory.

The TSIP protocol is based on the transmission of packets of information between the user equipment and the unit. Each packet includes an identification code that identifies the meaning and format of the data that follows. Each packet begins and ends with control characters.

This document describes in detail the format of the transmitted data, the packet identification codes, and all available information over the output channel to allow the user to choose the data required for his particular application. As will be discussed, the receiver transmits some of the information (position and velocity solutions, etc.) automatically when it is available, while other information is transmitted only on request. Additional packets may be defined for particular products and these will be covered in the specifications for those products as necessary.

The TSIPCHAT utility, part of the GPS Tool Kit, is designed to exercise many of the TSIP packets. The GPSSK Utility, part of the GPS Took Kit, is designed to exercise many of the TSIP messages

## A.2    Automatic Output Packets

The ACE III GPS receiver module is configured to automatically output the following packets. For minimal system implementations, these output packets provide all of the information required for operation including time, position, velocity, and receiver and satellite status and health. Position and velocity are reported using one or more of the packets listed below, depending on the selected I/O options. While there are other packets automatically output, the following packets provide the information most commonly used. No input packets are required.

**Table A-1    Automatic Output Packets**

| Output Packet ID | Description | Reporting Interval |
|---|---|---|
| 0x40 | Almanac | When decoded |
| 0x41 | GPS time | With position fix every 150 seconds No position fix every 15 seconds |
| 0x42, 0x83, 0x4A, 0x84, 0x43, 0x56, 0x8F-17, 0x8F-18, 0x8F-20 | position (choose packet with I/O options) | 1 second |
| 0x43, 0x56, 0x8F-20 | velocity (choose packet with I/O options) | 1 second |
| 0x46 | health of receiver | 30 seconds (Note 1.) |
| 0x4B | machinecode/status (includes antenna fault detect) | 30 seconds (Note 1.) |
| 0x5B | Ephemeris status | When decoded |
| 0x6D | all-in-view satellite selection | 30 second (Note 1.) |
| 0x82 | DGPS position fix mode (only in DGPS mode) | 30 second (Note 1.) |
| 0x5A, 0x6F | Pseudorange | 1 second |

**Note 1. –** See Key Setup Parameters, page A-16 for a detailed description of the key receiver setup parameters.

## A.3 Customizing Receiver Operations

For information on customizing receiver operations, see page 3-7, Configuring the ACE III GPS Receiver Protocols.

## A.4 Automatic Position and Velocity Reports

The receiver automatically outputs position and velocity reports at set intervals. Automatic report packets are controlled by Packet 35. Setting the control bits as indicated in the table below allows you to control which position and velocity packets are output.

**Table A-2    Automatic Position and Velocity Reports Control Setting Bits**

| Packet ID | Description | Byte 0 | | | | Byte 1 | |
|---|---|---|---|---|---|---|---|
| | | Bit 0 | Bit 1 | Bit 4 | Bit 5 | Bit 0 | Bit 1 |
| 0x42 | single precision XYZ position | 1 | | 0 | | | |
| 0x83 | double-precision XYZ position | 1 | | 1 | | | |
| 0x4A | single-precision LLA position | | 1 | 0 | | | |
| 0x84 | double-precision LLA position | | 1 | 1 | | | |
| 0x43 | velocity fix (XYZ, ECEF) | | | | | 1 | |
| 0x56 | velocity fix (ENU) | | | | | | 1 |
| 0x8F-17 | single precision UTM | | | 0 | 1 | | |
| 0x8F-18 | double precision UTM | | | 1 | 1 | | |
| 0x8F-20 | LLA & ENU | | | | 1 | | |

## A.5    Initialization Packets to Speed Start-up

If you are not supplying the receiver with battery power when main power is off, you can still "warm-start" the receiver by sending the following commands after the receiver has completed its internal initialization and has sent Packet 82 (see Table A-4).

**Table A-3       Receiver Initialization Commands**

| Input | | Description |
|-------|---------|-------------|
| **Byte** | **Subcode** | |
| 0x2B | | initial position |
| 0x2E | | initial time |
| 0x38 | 02 | almanac (for each SV) |
| 0x38 | 03 | almanac health |
| 0x38 | 04 | ionosphere page |
| 0x38 | 05 | UTC correction |

## A.6    Packets Output at Power-Up

The following table lists the messages output by the receiver at power-up. After completing its self-diagnostics, the receiver automatically outputs a series of packets which indicate the initial operating condition of the receiver. Messages are output in the following order. After Packet 82 is output, the sequence is complete and the receiver is ready to accept commands.

**Table A-4       Output Packets at Power-up**

| Output ID | Description | Notes |
|-----------|-------------|-------|
| 0x46 | Receiver health | -- |
| 0x4B | Machine code/status | -- |
| 0x4A | Position output | As chosen, see Appendix A-2, Automatic Position and Velocity Reports Control Setting Bits |
| 0x56 | Velocity fix | As chosen, seeAppendix A-2, Automatic Position and Velocity Reports Control Setting Bits |
| 0x41 | GPS time | This Packet is only output if GPS time is available. |
| 0x82 | DGPS position fix mode | -- |

## A.7 Differential GPS Packets

For differential GPS applications you may need to implement the following TSIP control commands.

**Table A-5      Differential GPS Packet TSIP Control Commands (DGPS)**

| Input ID | Description | Output ID |
|---|---|---|
| 0x60 | differential GPS corrections (types 1 and 9) | -- |
| 0x61 | differential GPS corrections (type 2) | -- |
| 0x65 | differential correction data request | 0x85 |
| 0xBB | differential Auto or Manual operating mode. | 0xBB |
| 0xBB | Maximum age that differential corrections will be used | 0xBB |
| 0xBC | port configuration | 0xBC |

## A.8 Timing Packets

If you are using the ACE III GPS as a timing system, you may need to implement the following TSIP control commands.

**Table A-6      Timing Packet TSIP Control Commands**

| Input ID | Description | Output ID |
|---|---|---|
| 0x21 | get the current GPS time | 0x41 |
| 0x38-05 | request UTC parameters | 0x58-05 |

## A.9 Satellite Data Packets

The following packets contain a variety of GPS satellite data.

**Table A-7      Satellite Date Packet Data I/O Descriptions**

| Input ID | Description | Output ID |
|---|---|---|
| 0x27 | request signal levels | 0x47 |
| 0x28 | request GPS system message | 0x48 |
| 0x38 | request/load satellite system data | 0x58 |
| 0x39 | set/request satellite disable or ignore health | 0x59 |
| 0x3A/auto | request last raw measurement | 0x5A |
| 0x3C | request tracking status | 0x5C |
| auto | synchronized measurement packet | 0x6F |

## A.10   Background Packets

The receiver automatically outputs a set of packets that the user may want to monitor for changes in receiver operations. These messages are output at the rates indicated in the table below.

**Table A-8        Background Packet Output Messages**

| Output ID | Description | Notes |
|---|---|---|
| 0x40 | almanac | As new almanacs are decoded. See 0x58 message for more information. |
| 0x41 | GPS time | If the receiver's GPS clock is set and the receiver is not outputting positions, time is output approximately every 15 seconds. After tracking occurs this packet ever 150 seconds |
| 0x46, 0x4B | receiver health messages | Receiver health messages are output every 30 seconds. |
| 0x5B | ephemeris status | As new ephemerides are decoded. See 0x58 message for more information. |
| 0x6D | mode packets | Mode packets are output every 30 seconds. |

## A.11 Backwards Incompatibility of ACE III GPS Packets with Previous Versions of CM3 and SVeeSix

Several new TSIP command packets have been made available with the release of the ACE III GPS receiver module, and some existing packets have been modified or are no longer supported. Table A-10 identifies the backwards compatibility of auto-output packets. Table A-11 identifies the backwards compatibility of the TSIP command packets. Unless otherwise noted, the commands and their corresponding output packets are still supported in the firmware.

**Table A-9    Supported Auto-Output Packet Command Backward Incompatibility**

| Old Packet | New Packet |
|---|---|
| 0x44 | 0x6D |
| 0x5E | |
| 0x8F-01, 0x8F-02 | 0x8F-20 |

**Table A-10    TSIP Command Backward Incompatibility**

| Old Packet | | New Packet | | Notes |
|---|---|---|---|---|
| Input | Output | Input | Output | |
| 0x20 | 0x40 | 0x38-02 | 0x58-02 | |
| 0x22 | | 0xBB | 0xBB | |
| 0x29 | 0x49 | 0x38-03 | 0x58-03 | |
| 0x2A | none | 0x2A | 0x4A (9 byte) | |
| 0x2C | 0x4C | 0xBB | 0xBB | |
| 0x2F | 0x4F | 0x38-05 | 0x58-05 | |
| 0x34 | 0x44, 0x6D | | | 0x34 not supported |
| 0x36 | | | | 0x36 not supported |
| 0x3B | 0x5B | 0x38-06 | 0x58-06 | |
| 0x3D | 0x3D | 0xBC | 0xBC | |
| 0x3E | 0x5E | | | 0x3E not supported |
| 0x62 (set mode) | 0x82 | 0xBB | 0xBB | use 0x62 for query of current mode |
| 0x75 | 0x76 | 0xBB | 0xBB | 0x75 not properly supported |
| 0x77 | 0x78 | 0xBB | 0xBB | |
| 0x79 | 0x79 | | | 0x79 not supported |
| 0x8E-01, 0x8E-02 | 0x8F-01, 0x8F-02 | 0x8E-20 | 0x8F-20 | 0x8E-01 and 0x8E-02 not supported |
| 0x8E-03 | 0x8F-03 | 0xBB | 0xBB | |
| 0x8E-14 | 0x8F-14 | 0x8E-15 | 0x8F-15 | |

## A.12   Recommended TSIP Packets

**Table A-11     Recommended TSIP Packet Data**

| Function | Description | Input | Output |
|---|---|---|---|
| Protocol and port setup | set/query port configuration | 0xBC | 0xBC |
| | set/query NMEA configuration | 0x7A | 0x7B |
| | set/query I/O options (autoreport and format options) | 0x35 | 0x55 |
| | packet output control | 0x6E | 0x6E |
| | Set TAIP protocol | 0x8E-40 | 0x8F-40 |
| Receiver settings | query software version | 0x1F | 0x45 |
| | set/query datum values | 0x8E-15 | 0x8F-15 |
| | query receiver ID & error status | 0x26 | 0x4B, 0x46 |
| | set/query satellite flags | 0x39 | 0x59 |
| | | | |
| | set/query receiver configuration | 0xBB | 0xBB |
| | set altitude for 2D mode | 0x2A | 0x4A |
| | disable PV/altitude filters | 0x70 | 0x70 |
| Initialization | full reset (clear battery backup and/or non-volatile settings) | 0x1E | -- |
| | soft reset | 0x25 | -- |
| | set GPS time | 0x2E | 0x4E |
| | set exact LLA | 0x32 | -- |
| | set approx. XYZ | 0x23 | -- |
| | set approx. LLA | 0x2B | -- |
| | set exact XYZ | 0x31 | -- |
| Navigation | GPS time | 0x21 | 0x41 |
| | position & velocity (superpacket) | 0x8E-20 or 0x37 or auto | 0x8F-20 |
| | double-precision LLA | 0x37/auto | 0x84 |
| | double-precision XYZ | 0x37/auto | 0x83 |
| | ENU velocity | 0x37/auto | 0x56 |
| | XYZ velocity | 0x37/auto | 0x43 |
| Satellite and tracking information | query receiver state (health) | 0x26 | 0x46, 0x4B |
| | query current satellite selection | 0x24 | 0x6D |
| | query signal levels | 0x27 | 0x47 |
| | query satellite information (azimuth, elevation, etc.) | 0x3C | 0x5C |
| | synchronized measurement packet | auto | 0x6F |
| | set/query positioning mode (2D v. 3D) | 0xBB | 0xBB |

**Table A-11    Recommended TSIP Packet Data (Continued)**

| Function | Description | Input | Output |
|---|---|---|---|
| DGPS | query DGPS corrections | 0x65 | 0x85 |
| | query DGPS operating mode & status | 0x62 | 0x82 |
| | load DGPS Type 1 correction | 0x60 | -- |
| | load DGPS Type 2 correction | 0x61 | -- |
| GPS system | query/load GPS system data | 0x38 | 0x58 |
| | GPS system message | 0x28 | 0x48 |

## A.13   Command Packets Sent to the Receiver

The table below summarizes the command packets sent to the receiver. The table includes the input Packet ID, a short description of each packet, and the associated response packet. In some cases, the response packets depend on user-selected options. These selections are covered in the packet descriptions in Section A-18.

**Table A-12     Standard TSIP Command Packets**

| Input ID | CM3 | ACE III | Packet Description | Output ID |
|----------|-----|---------|--------------------|-----------|
| 0x1D | X | X | Clear Oscillator Offset | -- |
| 0x1E | X | X | Clear Battery Backup | (Note 1) |
| 0x1F | X | X | Software Version | 0x45 |
| 0x20 | X | X | Almanac | 0x40 |
| 0x21 | X | X | Current Time | 0x41 |
| 0x22 | X | X | Mode Select (3D, 2D, Auto) | 0x44 or 0x6D (Note 2) |
| 0x23 | X | X | Initial Position (XYZ ECEF) | -- |
| 0x24 | X | X | Request receiver position fix mod | 0x6D |
| 0x25 | X | X | Soft reset / Self test | (Note 1) |
| 0x26 | X | X | Receiver Health | 0x46, 0x4B |
| 0x27 | X | X | Signal Levels | 0x47 (Note 2) |
| 0x28 | X | X | GPS System Message | 0x48 |
| 0x29 | X | X | Almanac health page | 0x49 |
| 0x2A | X | X | Altitude for 2D mode | -- |
| 0x2B | X | X | Initial Position (Lat, Long, Alt) | -- |
| 0x2C | X | X | Operating parameters | 0x4C |
| 0x2D | X | X | Show Oscillator Offset | 0x4D |
| 0x2E | X | X | Set GPS time | 0x4E |
| 0x2F | X | X | UTC parameters | 0x4F |
| 0x31 | X | X | Accurate Initial position (XYZ ECEF) | -- |
| 0x32 | X | X | Accurate Initial position | -- |
| 0x34 | X |   | Satellite # for 1-sat mode | -- |
| 0x35 | X | X | I/O options | 0x55 |
| 0x36 | X |   | Velocity aiding of acquisition | -- |
| 0x37 | X | X | Status and values of last position and velocity | 0x57 (Note 1) |
| 0x38 | X | X | Load satellite system data | 0x58 |
| 0x39 | X | X | Satellite disabled | 0x59 (Note 3) |
| 0x3A | X | X | Last raw measurement | 0x5A (Note 3) |

**Table A-12    Standard TSIP Command Packets**

| Input ID | CM3 | ACE III | Packet Description | Output ID |
|----------|-----|---------|--------------------|-----------|
| 0x3B | X | X | Satellite ephemeris status | 0x5B |
| 0x3C | X | X | Tracking Status | 0x5C (Note 2) |
| 0x3D | X | X | Main port configuration | 0x3D |
| 0x3E | X |   | Additional fix parameters | 0x5E |
| 0x60 | X | X | Type 1 differential GPS position fix mode | -- |
| 0x61 | X | X | Set differential correction | -- |
| 0x62 | X | X | Set / Request differential GPS position fix mode | 0x82 |
| 0x65 | X | X | Differential correction status | 0x85 (Note 2) |
| 0x6E |   | X | Synchronized measurement parameters | 0x6E |
| 0x70 |   | X | Filter configuration | 0x70 |
| 0x71 | X | X | Position filter parameters | 0x72 |
| 0x73 | X | X | Height filter control | 0x74 |
| 0x75 | X |   | Best 4 / High 6 (Over-determined) control | 0x76 |
| 0x77 | X | X | Maximum rate of DGPS corrections | 0x78 |
| 0x7A |   | X | Set / Request NMEA output configuration | 0x7B |
| 0xBB |   | X | Set receiver configuration | 0xBB |
| 0xBC |   | X | Set port configuration | 0xBC |



**Note 1. –** Output is determined by packet 35 settings.



**Note 2. –** No response sent if data is not available.



**Note 3. –** Not all packet 0x39 operations have a response.

**Table A-13    TSIP Super Command Packets**

| Input ID | CM3 | ACE III | Packet Description | Output ID |
|---|---|---|---|---|
| 0x8E 03 | X | X | auxiliary port configuration | 0x8F-03 |
| 0x8E 14 | X | X | datum | 0x8F-14 |
| 0x8E 15 | X | X | datum | 0x8F-15 |
| 0x8E 19 | X | X | UTM Enabled / Disabled | 0x8F-19 |
| 0x8E 20 | X | X | last fix with extra information (fixed point) | 0x8F-20 |
| 0x8E 26 | | X | SEEPROM write status | 0x8F-26 |
| 0x8E 40 | | X | TAIP configuration | 0x8F-40 |

## A.14   Report Packets Sent by the GPS Receiver to the User

The table below summarizes the packets output by the receiver. The table includes the output Packet ID, a short description of each packet, and the associated input packet. In some cases, the response packets depend on user-selected options. These selections are covered in the packet descriptions beginning at Packet Descriptions, page A-21

**Table A-14     Standard TSIP Report Packets**

| Output ID | Packet Description | Input ID |
|-----------|-------------------|----------|
| 0x41 | GPS time | 0x21, auto |
| 0x42 | single-precision XYZ position | 0x37, auto, power-up |
| 0x43 | velocity fix (XYZ ECEF) | 0x37, auto |
| 0x45 | software version information | 0x1F, power-up |
| 0x46 | health of Receiver | 0x26, auto, power-up |
| 0x47 | signal level for all satellites | 0x27 |
| 0x48 | GPS system message | 0x28 |
| 0x4A | single-precision LLA position | 0x37, auto |
| 0x4B | machine code/status | 0x26, auto, power-up |
| 0x4D | oscillator offset | 0x2D |
| 0x4E | response to set GPS time | 0x2E |
| 0x55 | I/O options | 0x35 |
| 0x56 | velocity fix (ENU) | 0x37, auto |
| 0x57 | information about last computed fix | 0x37 |
| 0x58 | GPS system data/acknowledge | 0x38 |
| 0x59 | sat enable/disable & health heed | 0x39 |
| 0x5A | raw measurement data | 0x3A |
| 0x5C | satellite tracking status | 0x3C |
| 0x6D | all-in-view satellite selection | 0x24, auto |
| 0x6F | synchronized measurement output | 0x6E |
| 0x72 | PV filter parameters | 0x71 |
| 0x74 | Altitude filter parameters | 0x73 |
| 0x78 | Max DGPS correction age | 0x77 |
| 0x7B | NMEA message schedule | 0x7A |
| 0x82 | differential position fix mode | 0x62, auto |
| 0x83 | double-precision XYZ | auto, 0x37 |
| 0x84 | double-precision LLA | auto, 0x37 |
| 0x85 | differential correction status | 0x65 |
| 0x8F-20 | last fix with extra information (fixed point) | auto, 0x37, 0x8E-20 |
| 0x8F-17 | UTM single precision | auto, 0x37 |
| 0x8F-18 | UTM double precision | auto, 0x37 |

**Table A-14    Standard TSIP Report Packets**

| Output ID | Packet Description | Input ID |
|-----------|-------------------|----------|
| 0x8F-26 | SEEPROM write status | 8E-26 |
| 0x8F-40 | TAIP configuration | 8E-40 |

## A.15  Key Setup Parameters

### A.15.1  Packet BB

Selecting the correct operating parameters has significant impact on receiver performance. Packet 0xBB (set receiver configuration) controls the key setup parameters.

The default operating parameters allow the receiver to perform well in almost any environment. The user can optimize the receiver to a particular application if the vehicle dynamics and expected level of obscuration are understood. If the receiver is then taken out of this environment, the specifically tuned receiver may not operate as well as a receiver with the default options.

The Table A-16 lists suggested parameter selections as a function of obscuration and whether accuracy or fix density is important. In this table, N/A indicates that the operating parameter is not applicable, DC (don't care) indicates that the user may choose the operating parameter.

**Table A-15    Setup Parameters**

| Packet | Parameter | Accuracy | Fixes | Factory Default |
|--------|-----------|----------|-------|-----------------|
| 0xBB | Fix mode | Man 3D | AUTO | AUTO |
| 0xBB | Dynamics code | Land | Land | Land |
| 0xBB | Elevation mask | 10° | 5° | 5° |
| 0xBB | Signal mask | 6.0 | 4.0 | 2.0 |
| 0xBB | DOP mask | 6.0 | 12.0 | 12.0 |
| 0xBB | DOP switch | N/A | 8.0 | 5.0 |
| 0xBB | DGPS mode | manual on | manual off | auto |
| 0xBB | DGPS correction age | 10 Seconds | N/A | 30 Seconds |

The default values in Table A-17 allow the receiver to operate well under the most varied and demanding conditions. A user may choose to change the default parameters if the receiver is only required to perform in a specific or limited environment. The user should be warned that when the receiver is exposed to operating conditions which are different from the conditions described by the user setup, then the performance may be degraded.

Initially, the user must consider the environment in which the receiver is expected to operate. There is a trade-off between how frequently a position fix is output versus the absolute accuracy of the fix. The user must decide which takes priority and then make the appropriate selections. This becomes increasingly important when frequent satellite blockages are expected, as in downtown "urban canyon" environments and heavily foliated areas.

Following is a description of the key fields in Packet 0xBB.

### Set Fix Mode

Packet 0xBB is used to choose the appropriate position fix mode for your application: 2D, 3D or AUTO. The default mode is AUTO 2D/3D, where the receiver first attempts to obtain a 3D solution with a PDOP below both the DOP mask and DOP switch. If this is not possible, then the receiver attempts to obtain a 2D solution with a DOP less than the DOP mask. This mode supplies fairly continuous position fixes even when there is frequent obscuration. This mode is preferable for most land or air applications, where altitude changes are occurring and there is occasional obscuration.

The highest accuracy fix mode is 3D manual, where altitude is always calculated along with the latitude, longitude, and time. However, this requires four satellites with a PDOP below the DOP mask set in Packet BB in order to obtain a position. Normally, this will provide the most accurate solution. Thus, if only 3D solutions are desired, then the user should request 3D manual mode. Depending on how the PDOP mask is set, this may be restrictive when the receiver is subjected to frequent obscuration, or when the geometry is poor due to an incomplete constellation.

Alternatively, if the user only wants a 2D solution, then 2D manual should be requested. In this case, the receiver uses either the last altitude obtained in a 3D fix, or the altitude supplied by the user. However, any error in the assumed altitude will affect the accuracy of the latitude and longitude solution.

High accuracy users should avoid the 2D mode and should expect fixes with accuracies which are at best as accurate as the supplied altitude. If a marine user enters sea-level as the altitude, then small errors in the horizontal solution will occur when the sea state is rough or there are high tidal variations. However, these errors may be smaller than the altitude errors induced by SA, so 2D may be preferable for a marine user who does not want to observe "unusual" altitudes.

### Dynamics Code

The feature default is LAND mode, where the receiver assumes a moderate dynamic environment. In this case, the satellite search and re-acquisition routines are optimized for vehicle type environments. In SEA mode, the search and re-acquisition routines assume a low acceleration environment and reverts to user entered altitude in 2D auto. In AIR mode, the search and re-acquisition routines are optimized for high acceleration conditions.

### Elevation Mask

This is the minimum elevation angle for satellites to be used in a solution output by the receiver. Satellites which are near the horizon are typically more difficult to track due to signal attenuation, and are also generally less accurate due to higher variability in the ionospheric and tropospheric corruption of the signal. When there are no obstructions, the receiver can generally track a satellite down to near the horizon. However, when this mask is set too low, the receiver may experience frequent constellation switching due to low elevation satellites being obscured.

Frequent constellation switching is undesirable because position jumps may be experienced when SA is present and DGPS is not available to remove these effects. The benefit of a low elevation mask is that more satellites are available for use in a solution and a better PDOP may be yielded. The current mask is set to five degrees and provides a reasonable trade-off of the benefits and drawbacks. High accuracy users may prefer a mask angle around ten degrees, where the ionosphere and troposphere begin to be more predictable

### Signal Level Mask

This mask defines the minimum signal strength for a satellite used in a solution. There is some internal hysteresis on this threshold which allows brief excursions below the threshold if lock is maintained and the signal was previously above the mask. The factory default mask has been set to 2.0. High accuracy users may use a slightly higher mask of 6.0-8.0, since weaker measurements may be slightly noisier and are often caused by reflected signals which provide erroneous ranges.

One should also resist the temptation to set the elevation and SNR masks too low. The satellite geometry is sometimes improved considerably by selecting low elevation satellites. They are, however, subject to significant signal degradation by the greater ionospheric and tropospheric attenuation that occurs. They are also subject to more obscuration by the passing scenery when the receiver is in a moving vehicle. The code phase data from those satellites is therefore more difficult to decode and therefore has more noise.

**Note –** A level of hysteresis in the signal level mask is allowed in the core operating software. The hysteresis allows the receiver to continue using satellite signals which fall slightly below the mask and prevents the receiver from incorporating a new signal until the signal level slightly exceeds the mask. This feature minimizes constellation changes caused by temporary fluctuations in signal levels.

### DOP Mask and Switch

The DOP mask is the maximum DOP limit for any 2D or 3D position solution that will be made. The DOP switch is the level at which the receiver stops attempting a 3D solution, and tries for a 2D solution when in automatic 2D/3D mode. The switch level has no effect in either manual mode. Raising the DOP mask will generally increase the fix density during obscuration, but the fixes with the higher DOP will be less accurate (especially with SA present). Lowering the mask will improve the average accuracy at the risk of lowering the fix density.

### Set DGPS Mode

Packet 0xBB is used to set the differential GPS operating mode. The factory default mode is DGPS Auto. In this mode, the receiver computes differentially corrected positions whenever valid corrections are available. Otherwise, the receiver computes non-differentially corrected positions.

In manual DGPS mode, the receiver computes solutions only if corrections are available for the selected satellites. This is the most accurate mode but it is also the most selective, since the fix density is dependent on the availability of corrections. The applicability of corrections is determined by the maximum age which can be set using Packet 0xBB.

The AUTO mode avoids the fix density problem but opens the possibility of going in and out of DGPS mode, potentially resulting in position and velocity jumps. If accuracy is critical, use MANUAL DGPS mode. If fix density is critical, AUTO DGPS is the recommended mode.

In differential OFF mode, the receiver will not use corrections even if they are valid.

## A.16   Packet Structure

TSIP packet structure is the same for both commands and reports. The packet format is:

```
<DLE> <id> <data string bytes> <DLE> <ETX>
```

Where:

- <DLE> is the byte 0x10

- <ETX> is the byte 0x03

- <id> is a packet identifier byte, which can have any value excepting <ETX> and <DLE>.

The bytes in the data string can have any value. To prevent confusion with the frame sequences <DLE> <ID> and <DLE> <ETX>, every <DLE> byte in the data string is preceded by an extra <DLE> byte ('stuffing'). These extra <DLE> bytes must be added ('stuffed') before sending a packet and removed after receiving the packet. Notice that a simple <DLE> <ETX> sequence does not necessarily signify the end of the packet, as these can be bytes in the middle of a data string. The end of a packet is <ETX> preceded by an odd number of <DLE> bytes.

Multiple-byte numbers (integer, float, and double) follow the ANSI / IEEE Std. 754 IEEE Standard for binary Floating-Point Arithmetic. They are sent most-significant byte first. This may involve switching the order of the bytes as they are normally stored in Intel based machines. Specifically:

- UINT8 = Byte: An 8 bit unsigned integer.

- UINT16 = Word : A 16 bit unsigned integer.

- INT16 = Integer: A 16 bit integer.

- INT32 = Long: A 32 bit integer.

- UINT32 = ULong: A 32 bit unsigned integer.

- Single — Float, or 4 byte REAL has a precision of 24 significant bits, roughly 6.5 digits.

- Double — 8 byte REAL has a precision of 52 significant bits. It is a little better than 15 digits.

## A.17    Packet Descriptions

### A.17.1    Report Packet 0x13 - Packet Received

If a packet is received and it cannot be parsed, the packet is returned through the output port with a 0x13 inserted between the leading DLE and the input TSIP identification code. Two common causes of command failure are improper DLE stuffing and serial link noise.

### A.17.2    Command Packet 0x1D - Clear Oscillator Offset

This packet commands the GPS receiver to set or clear the oscillator offset in battery backed memory. This is normally used for servicing the unit.

To clear the oscillator offset, one data byte is sent: The ASCII letter "C" = 0x43.

To set the oscillator offset, four data bytes are sent: The oscillator offset is expressed in Hertz as a single, real value.

### A.17.3    Command Packet 0x1E - Clear Battery Backup, then Reset

This packet commands the GPS receiver to clear all battery back-up data and to perform a software reset. This packet contains one data byte, and will output packet 0x4B.

**Table A-16     Command Packet 0x1E Format**

| Byte | Item | Type | Value | Definition |
|------|------|------|-------|------------|
| 0 | Reset mode | UINT8 | 0x4B | Cold start: Erase BBRAM and restart |
|  |  |  | 0x46 | Factory reset: Erase BBRAM and SEEPROM and restart |

**Caution –** All almanac, ephemeris, current position, mode, and communication port setup information is lost when executing the reset full factory configuration command. In normal use this packet should not be sent.

**Caution –** It is very helpful to keep a fresh copy of the current almanac, which is stored in the file GPSALM.DAT collected by the TSIPCHAT command "!". This allows near-instantaneous recuperation by the receiver in case of power loss or clearing of battery-backed memory by using the TSIPCHAT command "@" to load it back into the receiver memory.

### A.17.4    Command Packet 0x1F - Request Software Versions

This packet requests information about the version of software running in the Navigation and Signal Processors. This packet contains no data. The GPS receiver returns Packet 0x45.

### A.17.5    Command Packet 0x20 - Request Almanac

This packet requests almanac data for one satellite from the GPS receiver. This packet contains one data byte specifying the satellite PRN number. The GPS receiver returns packet 0x40.

### A.17.6    Command Packet 0x21 - Request Current Time

This packet requests current GPS time. This packet contains no data. The GPS receiver returns Packet 0x41.

### A.17.7    Command Packet 0x22 - Position Fix Mode Select

This packet commands the GPS receiver to operate in a specific position fix mode. This packet contains one data byte indicating the mode, as follows.

**Table A-17    Command Packet 0x22 Position Fix Mode Select**

| Byte | Type | Value | Definition |
|------|------|-------|------------|
| 0 | UINT8 | 0<br>3<br>4 | Auto (3D / 2D)<br>Horizontal only (2D)<br>3D only |

In auto 3D/2D, the receiver tries for a 3D fix that meets the PDOP switch criteria set in the TSIP operating parameters packet. If the 3D DOP switch is exceeded, then the 2D HDOP is compared to the DOP mask. If this HDOP satisfies the DOP mask, then a 2D fix is allowed. Otherwise, no fixing is allowed until tracking conditions change favorably.

Likewise, in Horizontal 2D only mode, the receiver is asked to perform 2D solutions only (using fixed or reference altitude) with a HDOP less than the DOP mask. If this criteria is not satisfied, then no fixing is allowed for the current tracking conditions.

In 3D mode the receiver tries to obtain a 3D fix. However if the PDOP is greater than the DOP mask, fixing will not occur.

### A.17.8    Command Packet 0x23 - Initial Position (XYZ Cartesian ECEF)

This packet provides the GPS receiver with an approximate initial position in XYZ coordinates. This packet is useful if the user has moved more than about 1,000 miles after the previous fix. (Note that the GPS receiver can initialize itself without any data from the user; this packet merely reduces the time required for initialization.) This packet is ignored if the receiver is already calculating positions. The data format is shown below.

To initialize with latitude-longitude-altitude, use Command Packet 0x2B.

**Table A-18    Command Packet 0x23 Data Format**

| Byte | Item | Type | Units |
|------|------|------|-------|
| 0-3 | X | Single | Meters |
| 4-7 | Y | Single | Meters |
| 8-11 | Z | Single | Meters |

### A.17.9    Command Packet 0x24 - Request GPS Receiver Position Fix Mode

This packet requests current position fix mode of the GPS receiver. This packet contains no data. The GPS receiver returns Packet 0x6D.

### A.17.10   Command Packet 0x25 - Initiate Soft Reset & Self Test

This packet commands the GPS receiver to perform a software reset. This is equivalent to cycling the power. The GPS receiver performs a self-test as part of the reset operation. This packet contains no data. Following completion of the reset, the receiver will output the start-up messages (see Table A-5). The GPS receiver sends Packet 0x45 only on power-up and reset (or on request); thus if Packet 0x45 appears unrequested, then either the GPS receiver power was cycled or the GPS receiver was reset.

### A.17.11   Command Packet 0x26 - Request Health

This packet requests health and status information from the GPS receiver. This packet contains no data. The GPS receiver returns packet 0x46 and 0x4B.

### A.17.12   Command Packet 0x27 - Request Signal Levels

This packet requests signal levels for all satellites currently being tracked. This packet contains no data. The GPS receiver returns Packet 0x47.

### A.17.13   Command Packet 0x28 - Request GPS Systems Message

This packet requests the most recent GPS system ASCII message sent with the navigation data by each satellite. This packet contains no data. The GPS receiver returns Packet 0x48 only if a GPS message has been received.

### A.17.14   Command Packet 0x29 - Request Almanac Health Page

This packet requests the GPS receiver to send the health page from the almanac. This packet contains no data. The GPS receiver returns packet 49 hex.

### A.17.15  Command Packet 0x2A - Altitude for 2D Mode

Reference Altitude is the altitude used for manual 2D positions if the altitude flag is set. Altitude is in units of HAE WGS-84 or MSL depending on the selected I/O options for the position. See section Appendix A.17.23, Command Packet 0x35 - Set/Request I/O Options. The Altitude Flag determines whether or not the Reference Altitude will be used. If set, it will be used. If cleared, altitude hold (last 3D altitude) is used.

**Note –** With no data bytes, this packet requests the current values of these altitude parameters. In this case, the GPS receiver returns Packet 4A.

This packet sets or requests the altitude parameters used for the Manual 2D mode: Reference Altitude and Altitude Flag. Packet 0x4A (type 2) is returned.

**Table A-19     Packet 0x2A Set Reference Altitude Description**

| Byte | Item | Type | Definition |
|------|------|------|------------|
| 0-3 | Altitude | Single | Reference altitude for 2D |

**Table A-20     Packet 0x2A Clear Reference Altitude Only Description**

| Byte | Item | Type | Value | Definition |
|------|------|------|-------|------------|
| 0 | Altitude Flag | UINT8 | 0 x FF | Clear Altitude flag |

**Note –** With no data bytes, this packet requests the current values of these altitude parameters. In this case, the GPS receiver returns Packet 4A.

### A.17.16   Command Packet 0x2B - Initial Position (Latitude, Longitude, Altitude)

This packet provides the GPS receiver with an approximate initial position in latitude and longitude coordinates (WGS-84). This packet is useful if the user has moved more than about 1,000 miles after the previous fix. (Note that the GPS receiver can initialize itself without any data from the user; this packet merely reduces the time required for initialization.) This packet is ignored if the receiver is already calculating positions. The data format is shown in Table A-23:

**Table A-21     Command Packet 0x2B Data Format**

| Byte | Item | Type | Units |
|------|------|------|-------|
| 0-3 | Latitude | Single | Radians, north |
| 4-7 | Longitude | Single | Radians, east |
| 8-11 | Altitude | Single | Meters |

**Note –** To initialize with ECEF position, use Command Packet 0x23.

### A.17.17 Command Packet 0x2C - Set/Request Operating Parameters

> **Note –** This Command Packet has been replaced by Command Packet 0xBB. Although the ACE III GPS retains compatibility with this command, it is recommended that you use the 0xBB Command Packet.

This packet sets the operating parameters of the GPS receiver or requests the current values. The data format is shown below. The GPS receiver returns packet 0x4C. See Section Appendix A.15, Key Setup Parameters for a complete description of the key setup parameters.

The dynamics code indicates the expected vehicle dynamics and is used to set the search bandwidths.

The elevation angle mask determines the lowest angle at which the GPS receiver will attempt to track a satellite and use it in a position solution.

The signal level mask sets the required signal level for a satellite to be used for position fixes.

The DOP mask sets the maximum DOP with which position fixes are calculated. The DOP switch selects the PDOP at which a receiver in automatic 2D/3D mode will switch from 3D to 2D position solutions. If 4 or more satellites are available and the resulting PDOP is not greater than the DOP switch value, then 3D fixes are calculated. Otherwise, 2D fixes are calculated. The DOP switch is effective only in the automatic 2D/3D mode.

**Table A-22     Command Packet 0x2C Data Format**

| Byte | Item | Type | Units | Default | Definition |
|------|------|------|-------|---------|------------|
| 0 | Dynamics code | UINT8 | --- | 1 - Land | (0) current value left unchanged<br>(1) land/<120 knots<br>(2) sea/<50 knots<br>(3) air/<800 knots |
| 1-4 | Elevation angle mask | Single | radians | 5° | |
| 5-8 | Signal level mask | Single | --- | 4 | Minimum signal strength |
| 9-12 | PDOP mask | Single | --- | 12 | Maximum PDOP setting |
| 13-16 | PDOP switch (3D or 2D) | Single | --- | 5 | 2D / 3D switch |

A negative value in a "single" field leaves that current setting unchanged. This information is held in battery-backed memory.

To query current values, send the 0x2C command with the data field values of 0, for byte 1 and -1.0 for all other values.

### A.17.18 Command Packet 0x2D - Request Oscillator Offset

This packet requests the calculated offset of the GPS receiver master oscillator. This packet contains no data. The GPS receiver returns Packet 0x4D. This packet is used mainly for service. The permissible oscillator offset varies with the particular GPS receiver unit.

### A.17.19 Command Packet 0x2E - Set GPS Time

This packet provides the approximate GPS time of week and the week number to the GPS receiver. The GPS receiver returns Packet 0x4E. The data format is shown below. The GPS week number reference is Week # 0 starting January 6, 1980. The seconds count begins at the midnight which begins each Sunday morning. This packet is usually not required when the battery back-up voltage is applied as the internal clock keeps time to sufficient accuracy. This packet is ignored if the receiver has already calculated the time from tracking a GPS satellite.

**Note –** See Report Packet 0x41 - GPS Time, page A-36, for information on the Extended GPS week number.

**Table A-23     Command Packet 0x2E Data Formats**

| Byte | Item | Type | Units |
|------|------|------|-------|
| 0-3 | GPS time of week | Single | Seconds |
| 4-5 | Extended GPS week number | INT16 | Weeks |

### A.17.20 Command Packet 0x2F - Request UTC Parameters

This packet requests the current UTC-GPS time offset (leap seconds). The packet has no data. The receiver returns packet 0x4F.

### A.17.21 Command Packet 0x31 - Accurate Initial Position (XYZ Cartesian ECEF)

This packet is identical in content to Packet 0x23. This packet provides an initial position to the GPS receiver in XYZ coordinates. However, the GPS receiver assumes the position provided in this packet to be accurate. This packet is used for satellite acquisition aiding in systems where another source of position is available. For acquisition aiding, the position provided by the user to the GPS receiver in this packet should be accurate to a few kilometers. For high-accuracy time transfer, position should be accurate to a few meters.

**Table A-24     Command Packet 0x31 Data Format**

| Byte | Item | Type | Units |
|------|------|------|-------|
| 0-3 | X-axis | Single | Meters |
| 4-7 | Y-axis | Single | Meters |
| 8-11 | Z-axis | Single | Meters |

### A.17.22  Command Packet 0x32 - Accurate Initial Position (Latitude, Longitude, Altitude)

This packet is identical in content to Packet 0x2B. This packet provides the GPS receiver with an accurate initial position in latitude, longitude, and altitude coordinates. However, the GPS receiver assumes the position provided in this packet to be accurate. This packet is used for satellite acquisition aiding in systems where another source of position is available. For acquisition aiding, the position provided by the user to the GPS receiver in this packet should be accurate to a few kilometers. For high-accuracy time transfer, position should be accurate to a few meters.

**Table A-25     Command Packet 0x32 Data Format**

| Byte | Item | Type | Units |
|------|------|------|-------|
| 0-3 | Latitude | Single | Radians, North |
| 4-7 | Longitude | Single | Radians, East |
| 8-11 | Altitude | Single | Meters |

### A.17.23  Command Packet 0x35 - Set/Request I/O Options

This packet requests the current I/O option states and optionally allows the I/O option states to be set as desired.

To request the option states without changing them, the user sends the packet with no data bytes included. To change any option states, the user includes 4 data bytes with the values. The I/O options, their default states, and the byte values for all possible states are shown below. These option states are held in battery-backed memory and can be set into non-volatile RAM (EEPROM) with the 0x8E-26 command. The GPS receiver returns Packet 0x55. See Table A.3 for information on saving the settings to non-volatile memory.

These abbreviations apply to the following table: ALT (Altitude), ECEF (Earth-centered, Earth-fixed), XYZ (Cartesian coordinates), LLA (latitude, longitude, altitude), HAE (height above ellipsoid), WGS-84 (Earth model (ellipsoid)), MSL geoid (mean sea level), and UTC (coordinated universal time).

**Table A-26     Command Packets 0x35 and 0x55 Data Descriptions**

| Byte | Bit | Item | Type | Value | Definition | Associated Packet |
|------|-----|------|------|-------|------------|-------------------|
| Position |||||||
| 0 | 0 (LSB) | XYZ ECEF | Bit | 0<br>1 | XYZ ECEF output off<br>XYZ ECEF output on | 0x42 or 0x83 |
| | 1 | LLA Output | Bit | 0<br>1 | LLA output off<br>LLA output on | 0x4A or 0x84 |
| | 2 | LLA ALT Output | Bit | 0<br>1 | HAE (WGS-84 datum)<br>MSL geoid | 0x4A / 0x84, 0x8F-17, 0x8F-18<br>See Note 3. |
| | 3 | ALT input | Bit | 0<br>1 | HAE (WGS-84 datum)<br>MSL geoid. | 0x2A<br>See Note 3. |
| | 4 | Precision-of-position output | Bit | 0<br><br>1 | Send single-precision packet.<br>Send double-precision packet. | 0x42/0x4A/8F-17, 0x83/84/ 8F-18 |
| | 5 | Super Packet Output | Bit | 0<br>1 | Output no Super Packets.<br>Output all enabled Super Packets. | 0x8F-17, 0x8F-18 0x8F-20<br>See Note 1. |
| | 6-7 | reserved |||||
| Velocity |||||||
| 1 | 0 | XYZ ECEF | Bit | 0<br>1 | XYZ ECEF output off<br>XYZ ECEF output on | 0x43 |
| | 1 | ENU output | Bit | 0<br>1 | ENU output off<br>ENU output on | 0x56 |
| | 2-7 | reserved |||||
| Timing |||||||
| 2 | 0 | Time Type | Bit | 0<br>1 | GPS time<br>UTC | 0x42, 0x43, 0x4A, 0x83, 0x84, 0x56, 0x8F-17, 0x8F-18 |
| | 1-7 | reserved |||||
| Auxiliary / Pseudo Range Measurements |||||||
| 3 | 0 | Raw measuring | Bit | 0<br>1 | Raw measurements off<br>Raw measurements on | 0x5A |
| | 1 | Raw / Filtered | Bit | 0<br>1 | Raw PR's in 5A<br>Filtered PR's in 5A | 0x5A<br>See Note 2. |
| | 2 | reserved |||||
| | 3 | Output dB Hz instead of AMU | Bit | 0<br>1 | Output dB Hz<br>Output AMU's | 0x5A, 0x5C, 0x47, 0x6F |
| | 4-7 | reserved |||||

**Note 1. –** See the associated superpacket output, described in Section A.19. Packet 8E must be used to specify which superpacket is to be output.

**Note 2. –** Automatic output of 0x5A messages is supported in the ACE III GPS for backwards compatibility with older TSIP applications.

**Note 3. –** Output HAE altitude is in chosen datum. Input HAE altitude is always in WGS-84 datum.

### A.17.24 Command Packet 0x37 - Request Status and Values of Last Position and Velocity

This packet requests information regarding the last position fix and is only used when the receiver is not automatically outputting positions. The GPS receiver returns Report Packet 0x57 followed by the position/velocity packets specified in Command Packet 0x35.

### A.17.25   Command Packet 0x38 - Request/Load Satellite System Data

This packet requests current satellite data (almanac, ephemeris, etc.) or permits loading initialization data from an external source (for example, by extracting initialization data from an operating GPS receiver unit via a data logger or computer and then using that data to initialize a second GPS receiver unit). The GPS receiver returns Packet 0x58. (Note that the GPS receiver can initialize itself without any data from the user; it merely requires more time.)

To request data without loading data, use only bytes 0 through 2; to load data, use all bytes. Before loading data, observe the caution notice below. The data formats are located in Report Packet 0x58.

**Table A-27    Command Packet 0x38 Data Formats**

| Byte | Item | Type | Value | Definition |
|------|------|------|-------|------------|
| 0 | Operation | UINT8 | 1<br>2 | Request data from ACE III GPS;<br>Load data into ACE III GPS |
| 1 | Type of data | UINT8 | 2<br>3<br>4<br>5<br>6 | Almanac<br>Health page, T_oa, WN_oa<br>Ionosphere<br>UTC<br>Ephemeris; request only |
| 2 | Sat PRN# | UINT8 | 0<br><br>1 - 32 | Data that is not satellite - ID specific<br>Satellite PRN number |
| 3 | Length (n) | UINT8 | | Number of bytes of data to be loaded |
| 4 to n+3 | Data | UINT8 | | Satellite data |

**Caution –** Proper structure of satellite data is critical to ACE III GPS operation. Requesting data is not hazardous; Loading data improperly is hazardous. Use this packet only with extreme caution. The data should not be modified in any way. It should only be retrieved and stored for later download.

**Note –** Ephemeris cannot be loaded into the receiver.

### A.17.26   Command Packet 0x39 - Set/Request Satellite Disable or Ignore Health

Normally the GPS receiver selects only healthy satellites (based on transmitted values in the ephemeris and almanac) which satisfy all mask values used in the position solution. This packet allows you to override the internal logic and force the receiver to either unconditionally disable a particular satellite, or to ignore a bad health flag. The GPS receiver returns Packet 0x59 for operation modes 3 and 6 only.

It should be noted that when viewing the satellite disables list, the satellites are not numbered but are in numerical order. The disabled satellites are signified by a "1" and enabled satellites are signified by a "0".

**Table A-28     Command Packet 0x39 Data Formats**

| Byte | Item | Type | Value | Definition |
|------|------|------|-------|------------|
| 0 | Operation | UINT8 | 1<br>2<br>3<br><br>4<br>5<br>6 | Enable SV (default)<br>Disable SV selection<br>List enable - or - disable<br>  status of all 32 satellites<br>Heed SV health on satellite(default)<br>Ignore SV health on satellite<br>List heed - or - ignore health on all 32 satellites |
| 1 | Satellite # | UINT8 | 0<br>1 - 32 | All 32 satellites<br>Any one satellite PRN number |

This information is not held in battery-backed memory. At power-on and after a reset the default values are set for all satellites.

✋      **Caution –** Improperly ignoring health can cause the GPS receiver software to lock up, as an unhealthy satellite may contain defective data. Use extreme caution in ignoring satellite health.

### A.17.27   Command Packet 0x3A - Request Last Raw Measurement

This packet requests the most recent raw measurement data for one specified satellite. The GPS receiver returns packet 0x5A if data is available.

**Table A-29     Command Packet 0x3A Data Format**

| Byte | Item | Type | Value | Definition |
|------|------|------|-------|------------|
| 0 | Satellite # | UINT8 | 0<br>1-32 | All satellites in the current tracking set.<br>Desired satellite. |

### A.17.28 Command Packet 0x3B - Request Current Status Of Satellite Ephemeris Data

This packet requests the current status of satellite ephemeris data. The GPS receiver returns packet 0x5B if data is available.

**Table A-30 Command Packet 0x3B Data Format**

| Byte | Item | Type | Value | Definition |
|---|---|---|---|---|
| 0 | Satellite # | UINT8 | 0<br>1-32 | All satellites<br>Desired satellite. |

### A.17.29 Command Packet 0x3C - Request Current Satellite Tracking Status

This packet requests the current satellite tracking status. The GPS receiver returns Packet 0x5C if data is available.

**Table A-31 Command Packet 0x3C Data Format**

| Byte | Item | Type | Value | Definition |
|---|---|---|---|---|
| 0 | Satellite # | UINT8 | 0<br><br>1 - 32 | All satellites in the current tracking set<br>Desired satellite |

## A.17.30  Command / Report Packet 0x3D - Primary Port Configuration

**Note –** This Command Packet has been replaced by Command Packet 0xBC. Although the ACE III GPS retains compatibility with this command, it is recommended that you use the 0xBC Command Packet.

This packet requests and optionally sets the primary port (port 1) configuration. This configuration includes the baud rate, number of bits, parity, and number of stop bits and also the language mode. When this packet is used only to request the configuration the packet contains no data bytes. When this packet is used to set the configuration, the packet contains the 5 data bytes shown below.

A 0x3D input packet, with or without data, is responded to with a 0x3D output packet. The language mode is defined as follows: For transmission, the language mode specifies whether TSIP packets or NMEA are output on primary port. For reception, the language mode specifies whether packets or RTCM data are received on the primary port. See Note 1.

The baud rate for the transmitter and the receiver can be set independently, but for TSIP, the number of bits, parity, and the stop bits are common between them. The default mode is packets for both transmission and reception at 9,600 baud with 8 data bits, odd parity, and one stop bit. For TAIP and NMEA, the default factory setting is 4800 baud, 8 data bits, no parity, 1 stop bit.

When the language mode for reception is set to RTCM (SC-104), raw RTCM (SC-104) data is accepted on the primary port for differential GPS corrections. These corrections are used only if the mode is set to Differential Auto or Manual DGPS (Differential On) with packet 0x62.

**Table A-32     Command/Report Packet 0x3D Data Format**

| Byte | Bit | Item | Type | Value | Definition |
|------|-----|------|------|-------|------------|
| 0 | | Output Baud Rate | UINT8 | 4<br>5<br>6<br>8<br>9<br>11<br>28<br>12 | 300 baud<br>600 baud<br>1200 baud<br>2400 baud<br>4800 baud<br>9600 baud<br>19200 baud<br>38400 baud |
| 1 | | Input Baud Rate | UINT8 | As Above | As Above |
| 2 | 0-1 | Data bits code | | 2<br>3 | 7 data bits<br>8 data bits |
| 2 | 2-4 | Parity code | | 0<br>1<br>4 | even parity<br>odd parity<br>no parity |
| 3 | | Stop bits code | UINT8 | 7<br>15 | 1 stop bit<br>2 stop bits |
| 4 | | Language mode for Transmission | UINT8 | 0<br>1<br>5 | TSIP<br>Off<br>NMEA (Note 2.) |
| 5 | | Language mode for Reception | UINT8 | 0<br>1 | TSIP<br>RTCM SC-104<br>(Notes 1, 3.) |

This information is held in battery-backed memory. After loss of battery-backed memory, the receiver will reset to the default values.

**Note 1. –** RTCM input for the secondary port is the default mode at power-on to allow for direct connection to a radio modem. The default speed is 4800,8,none,1.

**Note 2. –** The default NMEA output is GGA and VTG at 1 second intervals.

**Note 3. –** Before the main port language for reception can be set to RTCM SC-104, the auxiliary port language for reception must be set to packets (using command 0xBC). Only one port may be set to receive RTCM at a time, not both.

### A.17.31   Report Packet 0x40 - Almanac Data Page

**Table A-33     Report Packet 0x40 Data Format**

| Byte | Item | Type | Units |
|------|------|------|-------|
| 0 | satellite | UNIT8 | (identification number) |
| 1 | T_zc | single | seconds |
| 5 | week number | INT16 | weeks |
| 7 | eccentricity | single | (dimensionless) |
| 11 | T_oa | single | seconds |
| 15 | i_o | single | radians |
| 19 | OMEGA_dot | single | radians/second |
| 23 | square root A | single | $(meters)^{1/2}$ |
| 27 | OMEGA o | single | radians |
| 31 | omega | single | radians |
| 35 | $M_o$ | single | radians |

The symbols are defined in ICD-200.

T_zc is normally positive. If no almanac data is available for this satellite, then T_zc is negative. T_zc and the week number in this packet refer to the Z-count time and week number at the time the almanac was received. The remaining items are described in the ICD-GPS-200.

### A.17.32 Report Packet 0x41 - GPS Time

This packet provides the current GPS time of week and the week number. The GPS receiver sends this packet in response to Packet 0x21 and during an update cycle. Update cycles occur approximately every 5 seconds. The data format is shown below.

**Table A-34   Report Packet 0x41 Data Formats**

| Byte | Item | Type | Units |
|------|------|------|-------|
| 0-3 | GPS time of week | Single | seconds |
| 4-5 | Extended GPS week number | INT16 | weeks |
| 6-9 | GPS UTC offset | Single | seconds |

**Note –** UTC time lags behind GPS time by an integer number of seconds;
UTC = (GPS time) - (GPS UTC offset).

**Caution –** GPS week number runs from 0 to 1023 and then cycles back to week #0. Week # 0 began January 6, 1980. There was another week #0 beginning August 22, 1999. The extended GPS week number however, does not cycle back to 0. For example, August 22, 1999 starts week number 1024.

The seconds count begins with "0" each Sunday morning at midnight GPS time. A negative indicated time-of-week indicates that time is not yet known; in that case, the packet is sent only on request. The following table shows the relationship between the information in Packet 0x41, and the Packet 0x46 status code.

**Table A-35   Packets 0x41 and 0x46 Status Code Relationships**

| Approximate Time Accuracy | Time Source | Sign (TOW) | Packet 46 Status Code |
|---------------------------|-------------|------------|-----------------------|
| none | no time at all | - | 0x01 |
| unknown | approximate time from real-time clock or Packet 2E | + | 0x01 |
| 20-50 msec + clock drift | time from satellite | + | 0x02 - 0x0C |
| full accuracy | time from GPS solution | + | 0x00 |

**Note –** Before using the GPS time from Packet 0x41, verify that the Packet 0x46 status code is 00 ("Doing position fixes"). This will ensure the most accurate GPS time.

### A.17.33   Report Packet 0x42 - Single-Precision Position Fix, XYZ ECEF

This packet provides current GPS position fix in XYZ ECEF coordinates. If the I/O
"position" option is set to "XYZ ECEF" and the I/O "Precision-of-Position output" is set
to single-precision, then the GPS receiver sends this packet each time a fix is computed.
The data format is shown below.

**Table A-36     Report Packet 0x42 Data Formats**

| Byte | Item | Type | Units |
|------|------|------|-------|
| 0-3 | X | Single | meters |
| 4-7 | Y | Single | meters |
| 8-11 | Z | Single | meters |
| 12-15 | Time-of-fix | Single | seconds |

The time-of-fix is in GPS time or UTC as selected by the I/O "timing" option. Packet 83
provides a double-precision version of this information.

### A.17.34   Report Packet 0x43 - Velocity Fix, XYZ ECEF

This packet provides current GPS velocity fix in XYZ ECEF coordinates. If the I/O
"velocity" option is set to "XYZ ECEF, then the GPS receiver sends this packet each time
a fix is computed. The data format is shown below.

**Table A-37     Report Packet 0x43 Data Formats**

| Byte | Item | Type | Units |
|------|------|------|-------|
| 0-3 | X velocity | Single | meters/second |
| 4-7 | Y velocity | Single | meters/second |
| 8-11 | Z velocity | Single | meters/second |
| 12-15 | bias rate | Single | meters/second |
| 16-19 | time-of-fix | Single | seconds |

The time-of-fix is in GPS time or UTC as selected by the I/O "timing" option.

### A.17.35  Report Packet 0x45 - Software Version Information

This packet provides information about the version of software in the Navigation and Signal Processors. The GPS receiver sends this packet after power-on and in response to Packet 0x1F.

**Table A-38    Report Packet 0x45 Data Formats**

| Byte | Item | Type |
|------|------|------|
| 0 | Major version number | UINT8 |
| 1 | Minor version number | UINT8 |
| 2 | Month | UINT8 |
| 3 | Day | UINT8 |
| 4 | Year number minus 1900 | UINT8 |
| 5 | Major revision number | UINT8 |
| 6 | Minor revision number | UINT8 |
| 7 | Month | UINT8 |
| 8 | Day | UINT8 |
| 9 | Year number minus 1900 | UINT8 |

The first 5 bytes refer to the Navigation Processor and the second 5 bytes refer to the Signal Processor.

### A.17.36   Report Packet 0x46 - Health of Receiver

This packet provides information about the satellite tracking status and the operational health of the Receiver. The receiver sends this packet after power-on or software-initiated resets, in response to Packet 0x26 and, during an update cycle. Packet 0x4B is always sent along with this packet.

**Note –** If receiver status changes between five-second outputs, no notification is given until the next cycle.

**Table A-39     Report Packet 0x46 Data Formats**

| Byte | Bit | Item | Type | Value | Definition |
|------|-----|------|------|-------|------------|
| 0 | | Status code | UINT8 | 0x00 | Doing position fixes |
| | | | | 0x01 | Don't have GPS time yet |
| | | | | 0x02 | Need initialization |
| | | | | 0x03 | PDOP is too high |
| | | | | 0x08 | No usable satellites |
| | | | | 0x09 | Only 1 usable satellite |
| | | | | 0x0A | Only 2 usable satellites |
| | | | | 0x0B | Only 3 usable satellites |
| | | | | 0x0C | The chosen satellite is unusable |
| 1 | 0 | Battery backup | Bit | 0 | OK |
| | | | | 1 | BBRAM not available at start-up |
| 1 | 4 | Antenna feedline fault | | 0 | OK |
| | | | | 1 | short or open detected |
| 1 | 5 | Type of fault | | 0 | open detected |
| | | | | 1 | short detected |

The status codes in Byte 1 of Packet 0x46 are encoded into individual bits within the byte. The battery backup bit, once set, will remain set until the receiver is reset.

**Note –** After status is detected, its bit remains set until the receiver is reset.

### A.17.37   Report Packet 0x47 - Signal Levels for all Satellites

This packet provides received signal levels for all satellites currently being tracked or on which tracking is being attempted (i.e., above the elevation mask and healthy according to the almanac). The receiver sends this packet only in response to Packet 0x27. The data format is shown below.

**Table A-40      Report Packet 0x47 Data Formats**

| Byte | Item | Type |
|------|------|------|
| 0 | Count | UINT8 |
| 1 | Satellite number 1 | UINT8 |
| 2- 5 | Signal level 1 | Single |
| 6 | Satellite number 2 | UINT8 |
| 7-10 | Signal level 2 | Single |
| (etc.) | (etc.) | (etc.) |

Up to 8 satellite number/signal level pairs may be sent, indicated by the count field. Signal level is normally positive. If it is zero then that satellite has not yet been acquired. If it is negative then that satellite is not currently in lock. The absolute value of signal level field is the last known signal level of that satellite.

**Note –** The signal level provided in this packet is a linear measurement of the signal strength after correlation or de-spreading. Units, either AMU or dBHz, are controlled by Packet 0x35.

### A.17.38   Report Packet 0x48 - GPS System Message

This packet provides the most recent 22-byte ASCII message broadcast in the GPS satellite navigation message. The receiver sends this packet in response to Packet 0x28.

The message effectively is a bulletin board from the Air Force to GPS users. The format is free-form ASCII and is often encrypted. The message may be blank.

### A.17.39   Report Packet 0x49 - Almanac Health Page

This packet provides health information on 32 satellites. Packet data consists of 32 bytes each containing the 6-bit health from Almanac page 25. The receiver sends this packet in response to packet 29 hex and when this data is received from a satellite. A value of 0 indicates the satellite is healthy. If all values are 0, this indicates that the health page is not yet available.

**Table A-41     Report Packet 0x49 Almanac Health Page Data Formats**

| Byte | Item | Type |
|------|------|------|
| 0 | health of satellite #1 | UINT8 |
| 1 | health of satellite #2 | UINT8 |
| --- | --- | --- |
| --- | --- | --- |
| --- | --- | --- |
| 32 | health of satellite #32 | UNIT8 |

### A.17.40   Report Packet 0x4A - 20 Byte Format

This packet provides current GPS position fix in LLA (latitude, longitude, and altitude) coordinates. If the I/O "position" option is set to "LLA" and the I/O "precision-of-position output" is set to single-precision, then the receiver sends this packet each time a fix is computed. Command Packet 35 controls position output (XYZ or LLA) and (single or Double) output precision. The data format is shown below:

**Table A-42     Report Packet 0x4A Data Formats**

| Byte | Item | Type | Units |
|------|------|------|-------|
| 0-3 | Latitude | Single | radians; + for north, - for south |
| 4-7 | Longitude | Single | radians; + for east, - for west |
| 8-11 | Altitude | Single | meters (HAE or MSL) |
| 2-15 | Clock Bias | Single | meters |
| 6-19 | Time-of-Fix | Single | seconds (GPS or UTC) |

The LLA conversion is done according to the datum selected using Packet 0x8E-15. The default is WGS-84. Altitude is referred to the datum ellipsoid or the MSL Geoid, depending on which I/O "LLA altitude" option is selected. The time-of-fix is in GPS time or UTC, depending on which I/O "timing" option is selected.

This packet also is sent at start-up with a negative time-of-fix to report the current known position. Packet 0x84 provides a double-precision version of this information

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**Caution –** When converting from radians to degrees, significant and readily visible errors will be introduced by use of an insufficiently precise approximation for the constant PI). The value of the constant PI as specified in ICD-GPS-200 is 3.1415926535898.

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### A.17.41 Report Packet 0x4A - 9 Byte Format

Report Packet 0x4A is also sent in response to the setting or requesting of the Reference Altitude Parameters using Command Packet 0x2A. These parameters can be used in the Manual 2D mode.

**Reference Altitude**

The altitude used for manual 2D positions if the altitude flag is set. Altitude is in units of HAE WGS-84 or MSL depending on the selected I/O options set for positioning with Command Packet 35.

**Altitude Flag**

A flag that determines whether or not the Reference Altitude will be used. If set, it will be used. If cleared, altitude hold (last 3D altitude) will be used. The data format is shown in the following table.

**Table A-43    Reference Altitude**

| Byte | Item | Type | Units |
|------|------|------|-------|
| 0-3 | Reference Altitude | Single | Meters |
| 4-7 | Reserved | Single | |
| 8 | Altitude flag | UINT8 | |

### A.17.42    Report Packet 0x4B - Machine/Code ID and Additional Status

The receiver transmits this packet in response to packets 0x25 and 0x26 and following a change in state. In conjunction with Packet 0x46, "health of receiver," this packet identifies the receiver and may present status messages. The machine ID can be used by equipment communicating with the receiver to determine the type of receiver to which the equipment is connected. Then the interpretation and use of packets can be adjusted accordingly.

**Table A-44    Report Packet 0x4B Data Formats**

| Byte | Item | Type/ | Definition |
|------|------|-------|------------|
| 0 | Machine ID | UINT8 | Receiver dependent |
| 1 | Status 1 | UINT8 | See Table A-46 |
| 2 | Status 2 | UINT8 | Bit 0 = Super packets supported |

The status codes are encoded into individual bits within the bytes. The bit positions and their meanings are shown in Table A-46.

**Table A-45    Report Packet 0x4B Bit Positions and Descriptions**

| Status 1 Bit Positions | Meaning if bit value = 1 |
|------------------------|--------------------------|
| 0 (LSB) | Not used |
| 1 | Real-time Clock is not available at power-up. |
| 2 | Not used |
| 3 | The almanac stored in the receiver is not complete and current. |
| 4-7 | Not used |

### A.17.43    Report Packet 0x4C - Report Operating Parameters

**Note –** This Command Packet has been replaced by Command Packet 0xBB. Although the ACE III GPS retains compatibility with this command, it is recommended that you use the 0xBB Command Packet.

This packet provides several operating parameter values of the receiver. The receiver sends this packet in response to packet 2C hex. The dynamics code indicates the expected vehicle dynamics and is used to assist the initial solution. The elevation angle mask determines the lowest angle at which the SVeeSix series receiver tries to track a satellite. The signal level mask sets the required signal level for a satellite to be used for position fixes.

The PDOP mask sets the maximum PDOP with which position fixes are calculated. The PDOP switch sets the threshold for automatic 3D/2D mode. If four or more satellites are available and the resulting PDOP is not greater than the PDOP mask value, then 3Dimensional fixes are calculated.

**Table A-46    Report Packet 0x4C Data Formats**

| Byte | Item | Type | Default | Value |
|------|------|------|---------|-------|
| 0 | Dynamics code | UINT8 | 6-channel<br><br>(1) land<br>(2) sea<br>(3) air | <br><br><120 knots<br><50 knots<br><800 knots |
| 1-4 | Elevation angle mask | single/<br>radians | $5^o$ = .08 radians | |
| 5-8 | Signal level mask | single | 2.0 | |
| 9-12 | DOP mask | single | 12.0 | |
| 13-16 | PDOP switch (3D or 2D) | single | 5.0 | |

This information is held in battery-backed memory.

### A.17.44    Report Packet 0x4D - Oscillator Offset

This packet provides the current value of the receiver master oscillator offset in Hertz at carrier. This packet contains one single number. The receiver sends this packet in response to Packet 0x2D. The permissible offset varies with the receiver unit.

### A.17.45 Report Packet 0x4E - Response to Set GPS Time

Indicates whether the receiver accepted the time given in a Set GPS time packet. the receiver sends this packet in response to Packet 0x2E. This packet contains one byte.

**Table A-47     Report Packet 0x4E Data Formats**

| Value | Meaning |
|-------|---------|
| ASCII "Y" | The receiver accepts the time entered via Packet 2E. The receiver has not yet received the time from a satellite. |
| ASCII "N" | The receiver does not accept the time entered via Packet 2E. The receiver has received the time from a satellite and uses that time. The receiver disregards the time in Packet 0x 2E. |

### A.17.46 Report Packet 0x4F - UTC parameters

This packet is sent in response to Command Packet 2F and contains 26 bytes. It reports the UTC information broadcast by the GPS system. For details on the meanings of the following parameters, consult ICD-200, Sections 20.3.3.5.2.4., 20.3.3.5.1.8, and Table 20-IX. On the simplest level, obtain the correct UTC offset from the 0x41 or 8F-20 message.

**Table A-48     Report Packet 0x4F Data Formats**

| Byte | Item | Type |
|------|------|------|
| 0-7 | A0 | double |
| 8-11 | A1 | single |
| 12-13 | $\Delta T_{LS}$ | INT16 |
| 14-17 | $T_{OT}$ | single |
| 18-19 | $WN_T$ | INT16 |
| 20-21 | $WN_{LSF}$ | INT16 |
| 22-23 | DN | INT16 |
| 24-25 | $\Delta T_{LSF}$ | INT16 |

### A.17.47 Report Packet 0x55 - I/O Options

These abbreviations apply to the following table: ALT (Altitude), ECEF (Earth-centered, Earth-fixed), XYZ (Cartesian coordinates), LLA (latitude, longitude, altitude), HAE (height above ellipsoid), WGS-84 (Earth model (ellipsoid)), MSL geoid (Earth (mean sea level) mode), and UTC (coordinated universal time).

**Table A-49    Command Packets 0x55 and 0x35 Data Descriptions**

| Byte | Bit | Item | Type | Value | Definition |
|------|-----|------|------|-------|------------|
| **Position** | | | | | |
| 0 | 0 | XYZ ECEF | Bit | 0<br>1 | XYZ ECEF output off<br>XYZ ECEF output on |
| 0 | 1 | LLA Output | Bit | 0<br>1 | LLA output off<br>LLA output on |
| 0 | 2 | LLA ALT Output | Bit | 0<br>1 | HAE (WGS-84 datum)<br>MSL geoid |
| 0 | 3 | ALT input | Bit | 0<br>1 | HAE (WGS-84 datum).<br>MSL geoid. |
| 0 | 4 | Precision-of-position output | Bit | 0<br>1 | Send single-precision packet.<br>Send double-precision packet. |
| 0 | 5 | Super Packet Output | Bit | 0<br>1 | Output no Super Packets.<br>Output all enabled Super Packets. |
| 0 | 6-7 | reserved | | | |
| **Velocity** | | | | | |
| 1 | 0 | XYZ ECEF | Bit | 0<br>1 | XYZ ECEF output off<br>XYZ ECEF output on |
| 1 | 1 | ENU output | Bit | 0<br>1 | ENU output off<br>ENU output on |
| 1 | 2-7 | reserved | | | |
| **Timing** | | | | | |
| 2 | 0 | Time Type | Bit | 0<br>1 | GPS time<br>UTC |
| 2 | 1-7 | reserved | | | |
| **Auxiliary / Range Measurements** | | | | | |
| 3 | 0 | Raw measuring | Bit | 0<br>1 | Raw measurements off<br>Raw measurements on |
| 3 | 1 | Raw / Filtered | Bit | 0<br>1 | Raw PR's in 5A<br>Filtered PR's in 5A |
| 3 | 2 | reserved | | | |
| 3 | 3 | Output dB Hz instead of AMU | Bit | 0<br>1 | Output dB Hz<br>Output AMU's |
| 3 | 4-7 | reserved | | | |

**Note 1. –** See the associated superpacket output, described later in this appendix. Packet 8E must be used to specify which superpacket is to be output.

**Note 2. –** Automatic output of 0x5A messages is supported in the ACE III GPS for backwards compatibility with older TSIP applications.

### A.17.48   Report Packet 0x56 - Velocity Fix, East-North-Up (ENU)

If East-North-Up (ENU) coordinates have been selected for the I/O "velocity" option, the receiver sends this packet under the following conditions:

- Each time that a fix is computed

- In response to Packet 0x37 (last known fix)

The data format is shown below.

**Table A-50      Report Packet 0x56 Data Formats**

| Byte | Item | Type | Units |
|------|------|------|-------|
| 0-3 | East Velocity | Single | m/s; + for east, - for west |
| 4-7 | North Velocity | Single | m/s; + for north, - for south |
| 8-11 | Up Velocity | Single | m/s; + for up, - for down |
| 12-15 | Clock Bias Rate | Single | m/s |
| 16-19 | Time-of-Fix | Single | seconds (GPS or UTC) |

The time-of-fix is in GPS or UTC time as selected by the I/O "timing" option.

### A.17.49   Report Packet 0x57 - Information About Last Computed Fix

This packet provides information concerning the time and origin of the previous position fix. The receiver sends this packet, among others, in response to Packet 0x37. The data format is shown below.

**Table A-51      Report Packet 0x57 Data Formats**

| Byte | Item | Type | Units | Byte 0 Value/Velocity |
|------|------|------|-------|----------------------|
| 0 | Source of information | UINT8 | -- | 00 temporary no fix<br>01 good current fix |
| 1 | Mfg. diagnostic | UINT8 | -- | |
| 2-5 | Time of last fix | Single | seconds, GPS time | |
| 6-7 | Week of last fix | INT16 | weeks, GPS time | |

### A.17.50 Report Packet 0x58 - Satellite System Data/Acknowledge from Receiver

This packet provides GPS data (almanac, ephemeris, etc.). The receiver sends this packet in response to Packet 0x38 (acknowledges the loading of data).

The data format is shown below.

**Table A-52     Report Packet 0x58 Data Formats**

| Byte | Item | Type | Value | Definition |
|------|------|------|-------|------------|
| 0 | Operation | UINT8 | 1<br>2 | Request data from receiver;<br>Load data into receiver |
| 1 | Type of data | UINT8 | 2<br>3<br>4<br>5<br>6 | Almanac<br>Health page, T_oa, WN_oa<br>Ionosphere<br>UTC<br>Ephemeris; request only |
| 2 | Sat PRN# | UINT8 | 0<br>1 - 32 | Data that is not satellite - ID specific<br>satellite PRN number |
| 3 | Length (n) | UINT8 | | Number of bytes of data to be loaded |
| 4 to n+3 | Data | | | |

**Note –** If data is not available, byte 3 is set to 0 and "no" data is sent.

The binary almanac, health page, and UTC data streams are similar to Report Packets 0x40, 0x49, and 0x4F respectively, but these reports are preferred. To get ionosphere or ephemeris, this report must be used.

**Note –** Ephemeris cannot be loaded into the ACE III GPS.

**Table A-53        Report Packet 0x58 Almanac Data**

| Byte | Item | Type | Definition / ICD-GPS-200 |
|------|------|------|--------------------------|
| 4 | t_oa_raw | UINT8 | Sec 20.3.3.5.1.2 |
| 5 | SV_HEALTH | UINT8 | Sec 20.3.3.5.1.2 |
| 6-9 | e | Single | Sec 20.3.3.5.1.2 |
| 10-13 | t_oa | Single | Sec 20.3.3.5.1.2 |
| 14-17 | i_o | Single | Sec 20.3.3.5.1.2 |
| 18-21 | OMEGADOT | Single | Sec 20.3.3.5.1.2 |
| 22-25 | sqrt_A | Single | Sec 20.3.3.5.1.2 |
| 26-29 | OMEGA_0 | Single | Sec 20.3.3.5.1.2 |
| 30-33 | omega | Single | Sec 20.3.3.5.1.2 |
| 34-37 | M_0 | Single | Sec 20.3.3.5.1.2 |
| 38-41 | a_f0 | Single | Sec 20.3.3.5.1.2 |
| 42-45 | a_f1 | Single | Sec 20.3.3.5.1.2 |
| 46-49 | Axis | Single | Sec 20.3.3.5.1.2 |
| 50-53 | n | Single | Sec 20.3.3.5.1.2 |
| 54-57 | OMEGA_n | Single | Sec 20.3.3.5.1.2 |
| 58-61 | ODOT_n | Single | Sec 20.3.3.5.1.2 |
| 62-65 | t_zc | Single | Sec 20.3.3.5.1.2. see Note 2. |
| 66-67 | weeknum | INT16 | Sec 20.3.3.5.1.2 |
| 68-69 | wn_oa | INT16 | Sec 20.3.3.5.1.2 |

**Note 1. –** All angles are in radians.

**Note 2. –** If data is not available, t_zc is set to -1.0.

**Table A-54        Report Packet 0x58 Almanac Health Data**

| Byte | Item | Type | Definition/ ICD-GPS-200 |
|------|------|------|-------------------------|
| 4 | week # for health | UINT8 | Sec 20.3.3.5.1.3 |
| 5-36 | SV_health | UINT8 | Sec 20.3.3.5.1.3 |
| 37 | t_oa for health | UINT8 | Sec 20.3.3.5.1.3 |
| 38 | current t_oa | UINT8 | units = seconds/2048 |
| 39-40 | current week # | INT16 | |

**Table A-55     Report Packet 0x58 Ionosphere Data**

| Byte | Item | Type | Definition / ICD-GPS-200 |
|------|------|------|--------------------------|
| 4-11 | --- | --- | not used |
| 12-15 | alpha_0 | Single | Sec 20.3.3.5.1.9 |
| 16-19 | alpha_1 | Single | Sec 20.3.3.5.1.9 |
| 20-23 | alpha_2 | Single | Sec 20.3.3.5.1.9 |
| 24-27 | alpha_3 | Single | Sec 20.3.3.5.1.9 |
| 28-31 | beta_0 | Single | Sec 20.3.3.5.1.9 |
| 32-35 | beta_1 | Single | Sec 20.3.3.5.1.9 |
| 36-39 | beta_2 | Single | Sec 20.3.3.5.1.9 |
| 40-43 | beta_3 | Single | Sec 20.3.3.5.1.9 |

**Table A-56     Report Packet 0x58 UTC Data**

| Byte | Item | Type | Definition / ICD-GPS-200 |
|------|------|------|--------------------------|
| 4-16 | --- | --- | not used |
| 17-24 | A_0 | Double | Sec 20.3.3.5.1.8 |
| 25-28 | A_1 | Single | Sec 20.3.3.5.1.8 |
| 29-30 | delta_t_LS | Integer | Sec 20.3.3.5.1.8 |
| 31-34 | t_ot | Single | Sec 20.3.3.5.1.8 |
| 35-36 | WN t | Integer | Sec 20.3.3.5.1.8 |
| 37-38 | WN_LSF | Integer | Sec 20.3.3.5.1.8 |
| 39-40 | DN | Integer | Sec 20.3.3.5.1.8 |
| 41-42 | delta_t_LSF | Integer | Sec 20.3.3.5.1.8 |

**Table A-57     Ephemeris**

| Byte | Item | Type | Definition / ICD -GPS-200 |
|------|------|------|---------------------------|
| 4 | sv_number | UINT8 | SV PRN number |
| 5-8 | t_ephem | Single | time of collection |
| 9-10 | weeknum | INT16 | Sec 20.3.3.3, Table 20-I |
| 11 | codeL2 | UINT8 | Sec 20.3.3.3, Table 20-I |
| 12 | L2Pdata | UINT8 | Sec 20.3.3.3, Table 20-I |
| 13 | SVacc_raw | UINT8 | Sec 20.3.3.3, Table 20-I |
| 14 | SV_health | UINT8 | Sec 20.3.3.3, Table 20-I |
| 15-16 | IODC | INT16 | Sec 20.3.3.3, Table 20-I |
| 17-20 | T_GD | Single | Sec 20.3.3.3, Table 20-I |
| 21-24 | t_oc | Single | Sec 20.3.3.3, Table 20-I |
| 25-28 | a_f2 | Single | Sec 20.3.3.3, Table 20-I |
| 29-32 | a_f1 | Single | Sec 20.3.3.3, Table 20-I |
| 33-36 | a_f0 | Single | Sec 20.3.3.3, Table 20-I |
| 37-40 | SVacc | Single | Sec 20.3.3.3, Table 20-I |
| 41 | IODE | UINT8 | Sec 20.3.3.4 |
| 42 | fit_interval | UINT8 | Sec 20.3.3.4 |
| 43-46 | C_rs | Single | Sec 20.3.3.4 |
| 47-50 | delta_n | Single | Sec 20.3.3.4 |
| 51-58 | M_0 | Double | Sec 20.3.3.4 |
| 59-62 | C_uc | Single | Sec 20.3.3.4, radians |
| 63-70 | e | Double | Sec 20.3.3.4 |
| 71-74 | C_us | Single | Sec 20.3.3.4, radians |
| 75-82 | sqrt_A | Double | Sec 20.3.3.4 |
| 83-86 | t_oe | Single | Sec 20.3.3.4 |
| 87-90 | C_ic | Single | Sec 20.3.3.4, radians |
| 91-98 | OMEGA_0 | Double | Sec 20.3.3.4 |
| 99-102 | C_is | Single | Sec 20.3.3.4, radians |
| 103-110 | i_0 | Double | Sec 20.3.3.4 |
| 111-114 | C_rc | Single | Sec 20.3.3.4 |
| 115-122 | omega | Double | Sec 20.3.3.4 |
| 123-126 | OMEGADOT | Single | Sec 20.3.3.4 |
| 127-130 | IDOT | Single | Sec 20.3.3.4 |
| 131-138 | Axis | Double | $= (sqrt\_A)^2$ |
| 139-146 | n | Double | derived from delta_n |
| 147-154 | r1me2 | Double | $= sqrt(1.0-e^2)$ |
| 155-162 | OMEGA_n | Double | derived from OMEGA_0, OMEGADOT |
| 163-170 | ODOT_n | Double | derived from OMEGADOT |

**Note –** All angles are in radians.

### A.17.51  Report Packet 0x59 - Status of Satellite Disable or Ignore Health

Normally the GPS receiver selects only healthy satellites (based on transmitted values in the ephemeris and almanac) which satisfy all mask values, for use in the position solution. This packet allows you to override the internal logic and force the receiver to either unconditionally disable a particular satellite or to ignore a bad health flag. The GPS receiver returns Packet 0x59 for operation modes 3 and 6 only. The data format is shown below.

**Table A-58    Report Packet 0x59 Data Formats**

| Byte | Item | Type | Value | Definition |
|------|------|------|-------|------------|
| 0 | Operation | UINT8 | 3 | The remaining bytes tell whether receiver is allowed to select each satellite. |
| | | | 6 | The remaining bytes tell whether the receiver heeds or ignores each satellite's health as a criterion for selection. |
| 1 to 32 | Status | 32 Bytes (1 byte per satellite) | 0 | Enable satellite selection or heed satellite's health. Default value. |
| | | | 1 | Disable satellite selection or ignore satellite's health |

This information is not held in battery-backed memory. At power-on and after a reset, the default values are reset for all satellites.

### A.17.52  Report Packet 0x5A - Raw Measurement Data

This packet provides raw GPS measurement data. If the I/O "auxiliary" option has been selected, the receiver sends this data automatically as measurements are taken. The data format is shown below.

**Note –** A new Report Packet, 0x6F, has full pseudo-ranges and integrated Doppler.

**Table A-59     Report Packet 0x5A Data Formats**

| Byte | Item | Type | Units |
|------|------|------|-------|
| 0 | Satellite PRN Number | UINT8s | ----- |
| 1 | reserved | | |
| 5 | Signal Level | Single | AMU or dBHz |
| 9 | Code phase | Single | 1/16th chip |
| 13 | Doppler | Single | Hertz |
| 17 | Time of Measurement | Double | sec |

**Note –** Packet 0x5A provides the raw satellite signal measurement information used in computing a fix.

Satellite PRN (Byte 0) is a unique identification number or each of the 32 GPS satellites.

The codephase (Byte 9) value is the average delay over the sample interval of the received C/A code and is measured with respect to the receiver's millisecond timing reference. Thus, it includes all receiver, satellite, and propagation biases and errors. It is expressed in 1/16th of a C/A code chip.

The Doppler (Byte 13) value is apparent carrier frequency offset averaged over the sample interval. It is measured with respect to the nominal GPS L1 frequency of 1575.42 MHz, referenced to the receiver's internal oscillator. Thus, it includes all receiver and satellite clock frequency errors. It is expressed in Hertz at the L1 carrier.

The time of measurement (Byte 17) is the center of the sample interval adjusted by adding the receiver supplied codephase (modulo mS) to a user determined integer number of mS between user and satellite.

The receiver codephase is expressed in 1/16th of a C/A code chip, this corresponds to:

$$1/16 \text{ x C/A code chip} \quad \approx \quad 977.517\text{ns}/16 \quad \approx \quad 61.0948 \text{ ns}$$
$$\approx \quad 61.0948 \text{ x speed of light, m/s}$$
$$\approx \quad 18.3158 \text{ meter}$$

The integer millisecond portion of the pseudo-range must then be derived by utilizing the approximate user and satellite positions. Rough user position (within a few hundred kilometers) must be known; the satellite position can be found in its almanac / ephemeris data.

Each mS integer corresponds to:

C/A code epoch x speed of light   =   1 ms x speed of light, m/s

≈   300km (approx.)

≈   299.792458 km (precise)

The satellite time-of-transmission for a measurement can be reconstructed using the code phase, the time of measurement, and the user-determined integer number of milliseconds.

**Note –** The receiver occasionally adjusts its clock to maintain time accuracy within 1 msec. At this time, all pseudorange values for all satellites are adjusted upward or downward by one millisecond. Report packet 0x6F shows this clearly. Report packet 0x5A, check packet 0x83 or 0x84 for clock bias.

### A.17.53   Report Packet 0x5B - Satellite Ephemeris Status

This packet is sent in response to packet 3B and when a new ephemeris (based on IODE) is received. In contains information on the status of the ephemeris in the receiver for a given satellite. The structure of packet 5B is as follows:

**Table A-60     Report Packet 0x5B Data Formats**

| Byte | Item | Type | Units |
|------|------|------|-------|
| 0 | SV PRN Number | UNIT8 | |
| 1-4 | Time of Collection | single | seconds |
| 5 | Health | UNIT8 | |
| 6 | IODE | UINT8 | |
| 7-10 | toe | single | seconds |
| 11 | Fit Interval Flag | UINT8 | |
| 12-15 | SV Accuracy (URA) | single | meters |

### A.17.54   Report Packet 0x5C - Satellite Tracking Status

This packet provides tracking status data for a specified satellite. Some of the information is very implementation-dependent and is provided mainly for diagnostic purposes. The receiver sends this packet in response to Packet 0x3C. The data format is shown in Table A-61.

**Table A-61     Report Packet 0x5C Data Formats**

| Byte | Bit | Item | Type | Value | Definition |
|---|---|---|---|---|---|
| 0 | | Satellite PRN number | UINT8 | number 1 - 32 | |
| 1 | 0-2 | reserved | Bits | reserved | |
| 1 | 3-5 | Channel | Bits | 0-7 | |
| 1 | 6-7 | reserved | Bits | reserved | |
| 2 | | Acquisition flag | UINT8 | 0<br>1<br>2 | Never acquired<br>Acquired<br>Re-opened search |
| 3 | | Ephemeris flag | UINT8 | 0<br>1 | Flag not set<br>Good ephemeris for this satellite (<4 hours old, good health) |
| 4-7 | | Signal level | Single | Same as in Packet 0x47 | |
| 8-11 | | GPS time of last measurement | Single | <0<br>>0 | No measurements have been taken. Center of the last measurement taken from this satellite. |
| 12-15 | | Elevation | Single | radians | Approximate elevation of this satellite above the horizon. Updated about every 15 sec.s. Used for searching and computing measurement correction factors. |
| 16-19 | | Azimuth | Single | radians | Approximate azimuth from true north to this satellite. Updated typically about every 3 to 5 minutes. Used for computing measurement correction factors. |
| 20-23 | | reserved | UINT8 | 0 | |

### A.17.55 Command Packet 0x60 -Type 1 Differential GPS Corrections

This packet provides the ACE III GPS with differential corrections from RTCM SC-104 record types 1 and 9, in the TSIP format. There is no response to this packet. If bit 6 is set, the corrections are as in RTCM Type 9 records. The format for this packet is shown in Table A-62.

**Table A-62     Report Packet 0x60 Data Formats**

| Byte | Bit | Item | Type | Range | Units |
|------|-----|------|------|-------|-------|
| 0 - 1 | | Modified z-count | UINT16 | 0-5999 | .6 SEC |
| 2 | | Station health | UINT8 | -- | |
| 3 | 0 - 5 | Number of SVs in packet | Bits | 0-31 | 0 - 5 |
| 3 | 6 | Type 9 flag | Bit | 0<br>1 | type 1<br>type 9 |
| 3 | 7 | Version 2 flag | Bit | 1 | must be set |

The next 5 bytes are repeated as a group for each satellite. The SV PRN and scale factor contains the SV PRN in the lower 5 bits, and the scale factor in the upper 3 bits. Range corrections are scaled by 0.02 meters times 2 raised to the scale factor power. Range-rate corrections are scaled by 0.002 meters per second times 2 raised to the scale factor power. The format is shown in Table A-63.

**Table A-63     Report Packet 0x60 Data Formats for Health and Power**

| Byte | Bit | Item | Type | Value | Definition |
|------|-----|------|------|-------|------------|
| 4+ (N*5) | 0-4 | SV PRN | | 0-31 | "0" Is SV 32 |
| 4+ (N*5) | 5-7 | Scale factor | | 0<br><br>4<br><br>7 | Low Scale factor (.02m,.002 m/s)<br>High Scale factor (.32m, .032 m/s)<br>Correction not usable |
| 5+ (N*5) | | Range correction | UINT16 | | RTCM-104 |
| 7+ (N*5) | | Range-rate correction | UINT8 | | RTCM-104 |
| 8+ (N*5) | | IODE | UINT8 | | |

### A.17.56  Command Packet 0x61 - Set Differential GPS Corrections

This TSIP packet provides the delta differential corrections from RTCM-104 record type 2. There is no response to this packet. Scale factors are version 1 unless the version 2 flag is set. The format for this packet is shown in Table A-64.

**Table A-64     Command Packet 0x61 Data Formats**

| Byte | Bit | Item | Type | Value | Definition |
|------|-----|------|------|-------|------------|
| 0 - 1 | | Modified Z-count | UINT16 | 0-5999 | .6 SEC |
| 2 | 0-6 | Number of SVs | | 0-31 | |
| 2 | 7 | Version 2 flag | Bit | 1 | must be set |
| The next 3 bytes are repeated as a group for each satellite: | | | | | |
| 3+(N*2) | 0-4 | SV PRN | | 0-31 | "0" Is SV 32 |
| 3+(N*2) | 5-7 | Scale factor | | 0 <br><br> 4 <br><br> 7 | Low Scale factor (.02m, .002 m/s) <br> High Scale factor (.32m, .032 m/s) <br> Correction not usable |
| 4+(N*2) | | Range correction | UINT16 | | RTCM-104 |

The units and scale factors are as defined by Packet 0x60. Delta range correction rates are not entered.

### A.17.57  Command Packet 0x62 - Request/Set Differential Position Fix Mode

**Note –** This Command Packet has been replaced by Command Packet 0xBB. Although the ACE III GPS retains compatibility with this command, it is recommended that you use the 0xBB Command Packet to set the differential fix mode.

This packet requests the differential position fix mode of the GPS receiver. A single data byte is sent.

To request Report Packet 0x82, the data byte is set to 0xFF.

### A.17.58  Command Packet 0x65 - Request Differential Correction Status

This packet requests the status of differential corrections for a specific satellite or for all satellites for which data is available. This packet contains only one byte specifying the PRN number of the desired satellite or zero to request all available. The response is a Packet 0x85 for each satellite if data is available. If the receiver has no valid data for any satellite, no reply will be sent.

### A.17.59   Report Packet 0x6D - All-In-View Satellite Selection

This packet provides a list of satellites used for position fixes by the GPS receiver. The packet also provides the PDOP, HDOP, and VDOP of that set and provides the current mode (automatic or manual, 3D or 2D). This packet has variable length equal to 16+nsvs where "nsvs" is the number of satellites used in the solution

The GPS receiver sends this packet in response to Packet 0x24 when the receiver is doing an overdetermined fix. The data format is shown in Table A-65.

**Table A-65      Report Packet 0x6D Data Formats**

| Byte | Bit | Item | Type | Value | Definition |
|------|-----|------|------|-------|------------|
| 0 | 0-2 | Dimension | UINT8 | 3<br>4 | 2D<br>3D |
| 0 | 3 | | | 0<br>1 | Auto\|<br>Manual |
| 0 | 4-7 | | | - | nsvs |
| 1-4 | | PDOP | Single | | PDOP |
| 5-8 | | HDOP | Single | | HDOP |
| 9-12 | | VDOP | Single | | VDOP |
| 13-16 | | TDOP | Single | | TDOP |
| (16+nsvs) | | SV PRN | UINT8 | | |

### A.17.60   Command Packet 0x6E - Set or Request Synchronized Measurement Parameters

Packet 6E sets or requests the Synchronized Measurement parameters. The synchronized measurement reports are sent by the GPS receiver in Packet 0x6F.

#### Enable / Disable Synchronized Measurements

Controls whether synchronized measurements will be output at the output interval.

**Note –** Synchronized measurement outputs will only be available after the GPS receiver has made a position fix once the receiver is turned on or reset by Command Packet 0x25. This ensures that information within the synchronized measurement packet will be valid.

#### Output Level

The period of the synchronized measurement outputs is synchronized to the GPS time of week. For example, outputs occur when the GPS time of week equals (INT*N), where INT is the selected output interval and N is an integer.

Two forms of this packet are shown in Table A-66 and Table A-67. The response for both forms of this packet is Packet 0x6E, Synchronized Measurement Parameters.

**Table A-66     Set Synchronized Measurement Parameters**

| Byte # | Item | Type | Value | Definition |
|--------|------|------|-------|------------|
| 0 | Subcode | UINT8 | 1 | DSM format |
| 1 | Enable Output | UINT8 | 0<br>1 | Disable outputs<br>Enable output |
| 2 | Output interval | UINT8 | 1-255 | Output interval in seconds, synchronized to the GPS time of week |

**Table A-67     Request Synchronized Measurement Parameters**

| Byte # | Item | Type | Value | Definition |
|--------|------|------|-------|------------|
| 0 | Subcode | UINT8 | 1 | Synchronized measurement parameters |

### A.17.61    Report Packet 0x6E — Synchronized Measurements

Report Packet 0x6E reports the setting of synchronized measurement parameters. The values are shown in Table A-68. See Command Packet 0x6E for more information.

**Table A-68      Set Synchronized Measurement Parameters**

| Byte # | Item | Type | Value | Definition |
|--------|------|------|-------|------------|
| 0 | Subcode | UINT8 | 1 | DSM Unfiltered pseudorange |
| | | | 3 | DSM filtered pseudorange |
| 1 | Enable Output | UINT8 | 0<br>1 | Disable outputs<br>Enable output |
| 2 | Output Interval | UINT8 | 1-255 | Output interval in seconds, synchronized to the GPS time of week |

### A.17.62   Report Packet 0x6F, Subcode 1

**Table A-69    Synchronized Measurements Report**

| Byte # | Item | Type | Value | Definition |
|---|---|---|---|---|
| 0 | Subcode | UINT8 | 1 | DSM format |
| *Begin Preamble* | | | | |
| 1 | Preamble | UINT8 | 2 | Begin preamble |
| 2–3 | Length | INT16 | | Number of bytes: preamble to postamble inclusive |
| 4–11 | Receive Time | Double | *msecs* | Time of GPS week |
| 12–19 | Clock Offset | Double | *msecs* | Receiver clock offset |
| 20 | # of SVs | UINT8 | | Number of satellites |
| *Begin Packet Data (bytes = number of SVs times 27 bytes per SV)* | | | | |
| 21,48,... | SV PRN | UINT8 | 1–32 | Pseudorandom number of satellite |
| 22, 49,... | FLAGS1 | UINT8 | Table 0-2 | Flag values show synchronized measurement status of satellite |
| 23, 50,... | FLAGS2 | UINT8 | 0 | Reserved (set to zero) |
| 24, 51,... | Elevation Angle | UINT8 | *degrees* | Satellite elevation angle |
| 25–26, 52–53,... | Azimuth | INT16 | *degrees* | Satellite azimuth |
| 27, 54,... | SNR | UINT8 | *AMUs/4* | Number of AMUs times four |
| 28–35, 55–62,... | Pseudorange | Double | *meters* | Full L1 C/A Pseudorange, filtered |
| 36–43, 63–70,... | Carrier Phase | Double | *cycles* | L1 band Continuous Phase (truncated to integer value) |
| 44–47, 71–74,... | Doppler | Single | *hertz* | L1 band Doppler |
| *End of the packet data* | | | | |
| 21+27n 22+27n | Checksum | INT16 | — | Sum of bytes before checksum starting with preamble |
| 23+27n | Postamble | UINT8 | 3 | |

✉  **Note –** The sign convention provides for a carrier-phase decrease when the pseudorange increases and the Doppler is negative.

**Table A-70    FLAGS1 Bit Assignments**

| Bit | Item | Type | Value | Definition |
|---|---|---|---|---|
| 0 (LSB) | Reserved (set to zero) | Bit | | |
| 1 | L1 Carrier-phase Cycle Slip | Bit | 0 | No |
| | | | 1 | Yes |
| 2 | Reserved (set to zero) | Bit | 0 | Reserved |
| 3 | Reserved (set to zero) | Bit | 0 | Reserved |
| 4 | Valid L1 Carrier-phase: I | Bit | 0 | No |
| | | | 1 | Yes |
| 5 | Reserved (set to zero) | Bit | 0 | Reserved (set to zero) |
| 6 | Reserved (set to zero) | Bit | 0 | Reserved (set to zero) |
| 7 (MSB) | New position calculated | Bit | 0 | No |
| | | | 1 | Yes |

### A.17.63   Command Packet 0x70 - Filter Control

Trimble OEM receivers have a number of filters. Command 0x70 provides control for these filters. It returns Report 0x70. There are three filters associated with 0x70:

- Position-Velocity (PV) Filter
- Static Filter
- Altitude Filter

The Position-Velocity (PV) Filter is the main filter and is used to "soften" the effect of constellation switches on position fixes. The filter has no effect on velocity output and there is no lag due to vehicle dynamics. There may be a small increase in accuracy however.

A feature of the PV filter is the "Static Filter" which engages when the receiver is moving very slowly. This feature improves accuracy in the urban environment. The static filter should be turned off for the following applications:

- Slow-moving environments such as walking or drifting with the current
- When rooftop testing of receivers for moving applications

The altitude filter is a simple averaging filter with a time constant of a few seconds. It should be left on in marine and land applications.

To query for the current settings, use Command Packet 0x70 with no databytes. To input new settings, Command Packet 0x70 is sent with four data bytes, as shown in Table A-71. Also see Table A.3 for information on saving the settings to non-volatile memory.

**Table A-71     Command Packet 70 Data Formats**

| Byte | Item | Type | Value | Definition |
|------|------|------|-------|------------|
| 0 | Position Velocity Filter | UINT8 | 0<br>1 | Off<br>On |
| 1 | Static Filter | UINT8 | 0<br>1 | Off<br>On |
| 2 | Altitude Filter | UINT8 | 0<br>1 | Off<br>On |
| 3 | Reserved | UINT8 | reserved | |

### A.17.64   Report Packet 0x70

This report is sent as a response to Command Packet 0x70 as either a query or a set. It contains four bytes, as shown in Table A-71.

### A.17.65 Command Packet 0x71 - Set/Request/Disable Position Filter

**Note –** To simply turning filters on and off, use Command Packet 0x70.

This command sets position filter parameters, enables/disables the filter, and requests the position filter parameters. The receiver returns Report Packet 0x72. To request filter parameters, this command is sent with no data bytes.

This packet controls two filters: a dynamic filter used when the unit is in motion, and a static filter. To turn both filters off, set byte 0 to 0. The filters can also be turned off individually. To turn off the static filter only, set byte 25 to 255. To turn off the dynamic filter only, set the single value of byte 1 - 4 to 1.0. In both cases, leave byte 0 set to 1. To set the parameters or enable/disable the filter, the data string contains 26 bytes. The message format is shown below.

**Table A-72     Command Packet 0x71 Data Formats**

| Byte | Type | Value |
|------|------|-------|
| 0 | UINT8 | 0=disable<br>1=enable |
| 1-4 | Single | 0.0625 |
| 5 | UNIT8 | 1 |
| 6 | UNIT8 | 1 |
| 7 | UNIT8 | 0 |
| 8 | UNIT8 | 6 |
| 9-12 | Single | 0.1 |
| 13-16 | Single | 100.0 |
| 17-20 | Single | 1.21 |
| 21-24 | Single | 1,000,000.0 |
| 25 | UNIT8 | 2 |

**Note –** When the filter is being disabled, the parameters are reset as well. Consequently, when the filter is enabled, care should be taken to reset all parameters to their desired values. Documentation on the effect of the individual position filter parameters on position is currently not available.

**Table A-73     Report Packet 0x72 - Position Filter Parameters**

| Byte | Type | Value |
|------|------|-------|
| 0-1 | UINT8 | 0=disable<br>1=enable |
| 2-5 | Single | 0.0625 |
| 6-7 | INT16 | 1 |
| 8-9 | INT16 | 1 |
| 10-11 | INT16 | 0 |
| 12-13 | INT16 | 6 |
| 14-17 | Single | 0.1 |
| 18-21 | Single | 100.0 |
| 22-25 | Single | 1.21 |
| 26-29 | Single | 1,000,000.0 |
| 30-31 | INT16 | 2 |

### A.17.66   Command Packet 0x73 - Set/Request/Disable Altitude Filter

**Note –** To simply turning filters on and off, use Command Packet 0x70.

This command sets or requests the averaging count of the altitude filter. The receiver returns Report Packet 0x74.

To request altitude filter parameters, the command is sent with no data bytes.

To set the altitude filter parameters or disable the filter, the data string format is listed below.

**Table A-74     Command Packet 0x73 Report**

| Byte | Item | Type | Value | Definition |
|------|------|------|-------|-----------|
| 0 - 3 | Altitude Filter<br>Constant | Single | 0<br>1<br>>1 | Resets value to default<br>Disables filter<br>Sets value to input |

The old altitude average is always discarded and the averaging process is re-started with this command.

The default value depends on the dynamics code set in packet 0x2C.

### A.17.67	Report Packet 0x74 - Altitude Filter Parameters

This packet is in response to Command Packet 73 and provides the parameter used in the altitude filter. The data string has one single byte, equal to the number of fixes averaged in the altitude filter. If the values is -1, the altitude filter is currently disabled

**Table A-75	Report 0x74 Field Descriptions**

| Byte | Item | Type | Value | Definition |
|------|------|------|-------|------------|
| 0 - 3 | Altitude Filter Constant | Single | -1<br>>1 | Altitude filter off<br>Sets value to input |

### A.17.68	Command Packet 0x75

Not available in ACE III GPS.

### A.17.69	Report Packet 0x76

Not available in the ACE III GPS.

### A.17.70	Command Packet 0x77 - Set/Request Maximum Age of Differential Corrections

**Note –** This Command Packet has been replaced by Command Packet 0xBB. Although the ACE III GPS retains compatibility with this command, it is recommended that you use the 0xBB Command Packet.

This command sets the maximum age at which differential corrections will still be used by the receiver. The default is 30 seconds. For best accuracy, 20 seconds is preferred if it is supported by the differential link. The receiver returns packet 78.

A differential reference station will output corrections at a specified rate, normally between 1 per second and 1 per 30 seconds. The corrections contain a time tag so when they arrive at the receiver (via radio link or some other means) their age can be determined. This command allows the maximum usable age to be set. Older corrections tend to be less accurate therefore a trade-off will need to be made based on available bandwidth and correction age as well temporary signal blockages. For high accuracy implementations this number can be set as well as 2 times the reference station output frequency. This age limit applies to corrections received in RTCM format (all types), TSIP packets 0x60 and 0x61 as well as TAIP DC and DD messages. To request the current setting, the packet is sent with no data bytes. To set the maximum age, 2 data bytes are sent containing an integer.

**Table A-76	Command Packet 0x77 Report**

| Byte | Item | Type | Value | Definition |
|------|------|------|-------|------------|
| 0-1 | Max Age of Differential Corrections | INT16 | 2-90 | Maximum Age (seconds) |

### A.17.71  Report Packet 0x78 - Maximum Age of Differential Corrections

This packet contains a 2 byte integer representing the maximum age in seconds which the receiver will consider differential corrections to still be valid. The default is 60 seconds and can be changes with packet 0x77. See Table A-70.

### A.17.72  Command Packet 0x7A

The NMEA message determines whether or not a given NMEA message will be output. If the bit for a message is set, the message will be sent every "interval" seconds. Use the values shown in Table A-77 to determine the NMEA interval and message mask. While fixes are being generated, the output order is: ZDA, GGA, GLL, VTG, GSA, GSV, RMC. Some firmware versions output GGA at 1 second intervals until fixes begin.

**Table A-77      Command Packet 0x7A and Report Packet 0x7B Data Formats**

| Byte | Bit | Item | Type | Value | Definition |
|------|-----|------|------|-------|------------|
| 0 | | Subcode | UINT8 | 0 | |
| 1 | | Interval | UINT8 | 1-255 | Fix interval in seconds |
| 2 | | Reserved | UINT8 | 0 | |
| 3 | | Reserved | UINT8 | 0 | |
| 4 | 0 | RMC | Bit | 0<br>1 | Off<br>On |
| 4 | 1-7 | Reserved | Bit | 0 | |
| 5 | 0 | GGA | Bit | 0<br>1 | Off<br>On |
| 5 | 1 | GLL | Bit | 0<br>1 | Off<br>On |
| 5 | 2 | VTG | Bit | 0<br>1 | Off<br>On |
| 5 | 3 | GSV | Bit | 0<br>1 | Off<br>On |
| 5 | 4 | GSA | Bit | 0<br>1 | Off<br>On |
| 5 | 5 | ZDA | Bit | 0<br>1 | Off<br>On |
| 5 | 6-7 | Reserved | Bit | 0 | |

### A.17.73  Report Packet 0x7B

This packet provides the NMEA settings and interval. See Table A-77 for the data format.

### A.17.74  Report Packet 0x82 - Differential Position Fix Mode

This packet provides the differential position fix mode of the receiver. This packet contains only one data byte to specify the mode. The packet is sent in response to Packet 0x62 and whenever a satellite selection is made and the mode is Auto GPS / DGPS (modes 2 and 3). The receiver switches automatically between modes 2 and 3 based on the availability of differential corrections for a constellation which meets all other masks. If such a constellation is not available, then the receiver stays in its current automatic mode (2 or 3), and does not do position solutions.

Valid modes are:

Mode 0       Manual GPS (Differential off) — The receiver does position solutions without differential corrections, even if the differential corrections are available.

Mode 1       Manual DGPS (Differential on) — The receiver only does position solutions if valid differential correction data are available.

Mode 2       Auto DGPS (Differential currently off) — The receiver is not receiving differential correction data for all satellites in constellation which meets all other masks, and is doing non-differential position solutions.

Mode 3       Auto DGPS (Differential currently on) — The receiver is receiving differential correction data for all satellites in a constellation which meets all other masks, and is doing differential position solutions.

**Note –** The ACE III GPS sends this packet automatically after every position fix except when in Mode 0.

### A.17.75  Report Packet 0x83 - Double-Precision XYZ Position Fix and Bias Information

This packet provides current GPS position fix in XYZ ECEF coordinates. If the I/O "position" option is set to "XYZ ECEF" and the I/O double position option is selected, the receiver sends this packet each time a fix is computed. The data format is shown in Table A-78.

**Table A-78     Report Packet 0x83 Data Formats**

| Byte  | Item        | Type   | Units   |
|-------|-------------|--------|---------|
| 0-7   | X           | Double | meters  |
| 8-15  | Y           | Double | meters  |
| 16-23 | Z           | Double | meters  |
| 24-31 | clock bias  | Double | meters  |
| 32-35 | time-of-fix | Single | seconds |

The time-of-fix is in GPS time or UTC, as selected by the I/O "timing" option.

Packet 42 provides a single-precision version of this information.

### A.17.76 Report Packet 0x84 - Double-Precision LLA Position Fix and Bias Information

This packet provides current GPS position fix in LLA coordinates. If the I/O "position" option is set to "LLA" and the double position option is selected, the receiver sends this packet each time a fix is computed. The data format is shown in Table A-80.

**Table A-79    Report Packet 0x84 Data Formats**

| Byte | Item | Type | Units |
|------|------|------|-------|
| 0-7 | latitude | Double | radians; + for north, - for south |
| 8-15 | longitude | Double | radians; + for east, - for west |
| 16-23 | altitude | Double | meters |
| 24-31 | clock bias | Double | meters |
| 32-35 | time-of-fix | Single | seconds |

The time-of-fix is in GPS time or UTC, as selected by the I/O "timing" option.

**Caution** – When converting from radians to degrees, significant and readily visible errors will be introduced by use of an insufficiently precise approximation for the constant p (PI). The value of the constant PI as specified in ICD-GPS-200 is 3.1415926535898.

### A.17.77 Report Packet 0x85 - Differential Corrections Status

This packet provides the status of differential corrections for a specific satellite. It is sent in response to Packet 0x65. The format of this packet is shown in Table A-80.

**Table A-80    Report Packet 0x85 Data Formats**

| Byte | Item | Type | Units | Values |
|------|------|------|-------|--------|
| 0 | Satellite PRN number | UINT8 | | |
| 1 | reserved | UINT8 | | 0xFF |
| 2 | reserved | UINT8 | | 0xFF |
| 3 | Satellite health (UDRE) | UINT8 | | |
| 4 | IODE 1 | UINT8 | | |
| 5 | IODE 2 | UINT8 | | |
| 6 | Z-count as Time-of-Week | Single | seconds | |
| 10 | Range correction | Single | meters | |
| 14 | Range-rate correction | Single | m/sec | |
| 18 | Delta range correction | Single | meters | |

### A.17.78 Packets 0x8E and 0x8F - Superpacket

Refer to Section A.19 for information on Packets 0x8E and 0x8F.

### A.17.79  Command Packet 0xBB - Navigation Configuration

In query mode, Packet 0xBB is sent with a single data byte and returns Report Packet 0xBB.

**Note –** This Command Packet replaces packets 0x2C, 0x62, 0x75, and 0x77.

**Table A-81    Command Packet 0xBB Query Mode Data Format**

| Byte # | Item | Type | Value | Definition | Default |
|--------|------|------|-------|------------|---------|
| 0 | Subcode | UINT8 | 0x00 | Query mode | |

TSIP Packet 0xBB is used to set GPS Processing options. The table below lists the individual fields within the 0xBB Packet. See Section A.3 for information on saving the settings to non-volatile memory.

**Table A-82    Command and Report Packet 0xBB Field Descriptions**

| Byte # | Item | Type | Value | Definition | Default |
|--------|------|------|-------|------------|---------|
| 0 | Subcode | UINT8 | 0x00 | Query mode | 0x03 |
| 1 | Operating Dimension | UINT8 | 0*<br>3<br>4 | Automatic (2D/3D)<br>Horizontal (2D)<br>Full Position (3D) | Automatic |
| 2 | DGPS Mode | UINT8 | 0<br>1<br>2 or 3 | DGPS off<br>DGPS only<br>DGPS auto | DGPS auto |
| 3 | Dynamics Code | UINT8 | 1<br>2<br>3<br>4 | Land<br>Sea<br>Air<br>Stationary | Land |
| 4 | reserved | | | | |
| 5-8 | Elevation Mask | Single | 0.0 - 1.57 | Lowest satellite elevation for fixes | 0.0873 (5) |
| 9-12 | AMU Mask | Single | 0-25 | Minimum signal level for fixes | 2.0 |
| 13-16 | DOP Mask | Single | 0.2-100 | Maximum DOP for fixes | 12.0 |
| 17-20 | DOP Switch | Single | 0.2-100 | Selects 2D/3D mode | 5.0 |
| 21 | DGPS Age Limit | UINT8 | 2-90 | Maximum time to use a DGPS correction (seconds) | 30 |
| 22-39 | reserved | | | | |

### A.17.80   Command Packet 0xBC - Protocol Configuration

TSIP Packet 0xBC is used to query the port characteristics. In query mode, Packet 0xBC is sent with a single data byte and returns Report Packet 0xBC. (See Table A.3 for information on saving the settings to non-volatile memory.)

**Note –** This Command Packet replaces packets 0x3D and 0x8E-03.

TSIP Packet 0xBC is used to set the communication parameters on Port 1 and Port 2. The table below lists the individual fields within the Packet 0xBC and provides query field descriptions.

**Table A-83    Command Packet 0xBC Port Characteristics**

| Byte | Bit | Item | Type | Value | Definition |
|------|-----|------|------|-------|------------|
| 0 | | Port to Set | UINT8 | 0<br>1<br>0xFF | Port 1<br>Port 2<br>Current port |
| 1 | | Input Baud Rate | UINT8 | 2<br>3<br>4<br>5<br>6<br>7<br>8<br>9 | 300 baud<br>600 baud<br>1200 baud<br>2400 baud<br>4800 baud<br>9600 baud<br>19200 baud<br>38400 baud |
| 2 | | Output Baud Rate | UINT8 | As above | As above |
| 3 | | # Data Bits | UINT8 | 2<br>3 | 7 bits<br>8 bits |
| 4 | | Parity | UINT8 | 0<br>1<br>2 | None<br>Odd<br>Even |
| 5 | | # Stop Bits | UINT8 | 0<br>1 | 1 bit<br>2 bits |
| 6 | | Flow Control | UINT8 | 0 | 0 = none |
| 7 | 0 | TAIP input | Bit | 0/1 | off/on |
| | 1 | TSIP input | Bit | 0/1 | off/on |
| | 2 | reserved | Bit | 0/1 | off/on |
| | 3 | RTCM input | Bit | 0/1 | off/on |
| | 4-7 | reserved | Bit | 0/1 | off/on |
| 8 | 0 | TAIP output | Bit | 0/1 | off/on |
| | 1 | TSIP output | Bit | 0/1 | off/on |
| | 2 | NMEA output | Bit | 0/1 | off/on |
| | 3-7 | reserved | UINT8 | 0 | None |
| 9 | | reserved | UINT8 | 0 | None |

**Note 1. –** To set port 1 configuration, use port 2; to set port 2 configuration, use port 1.

**Note 2. –**  The BC command settings are retained in battery-backed RAM.

**Caution –** TSIP input or output must have 8 databits (byte 3).

**Caution –** At least one port must be either TSIP input or TAIP input at all times.

## A.18    TSIP Superpackets

Several packets have been added to the core TSIP protocol to provide additional capability for OEM receivers. In OEM packets 0x8E and their 0x8F responses, the first data byte is a sub-code which indicates the superpacket type. For example, in Packet 0x8E-15, 15 is the sub-code that indicates the superpacket type. Therefore the ID code for OEM packets is 2 bytes long followed by the data.

### A.18.1    Command Packet 0x8E-03 - Set / Request Auxiliary Configuration

**Note –** This Command Packet has been replaced by Command Packet 0xBC. Although the ACE III GPS retains compatibility with this command, it is recommended that you use the 0xBC Command Packet.

This packet requests and optionally sets the AUX Port configuration. This configuration includes the baud rate, number of bits, parity, and number of stop bits and also the language mode. When this packet is used only to request the configuration the packet contains no data bytes. When this packet is used to set the configuration, the packet contains the 6 data bytes shown below.

A 0x8E-03 input packet, with or without data, is responded to with a 0x8F-03 output packet. The language mode is defined as follows. For reception, the language mode specifies whether packets or RTCM data are received on the AUX Port.

 The default mode is RTCM for reception at 4800 baud with 8 data bits, no parity, and 1 stop bit. For NMEA transmission, the default mode is 4800 baud, 8 data bits, no parity and 1 stop bit. RTCM corrections are used only if the mode is set to Differential Auto or Manual DGPS (Differential On) with packet 0x62.

**Table A-84    Command Packet 0x8E-03 Data Formats**

| Byte | Bit | Item | Type | Value | Definition |
|------|-----|------|------|-------|------------|
| 0 | | Subcode | UINT8 | 0x03 | |
| 1 | | Output Baud Rate | UINT8 | 4<br>5<br>6<br>8<br>9<br>11<br>28<br>12 | 300 baud<br>600 baud<br>1200 baud<br>2400 baud<br>4800 baud<br>9600 baud<br>19200 baud<br>38400 baud |
| 2 | | Input Baud Rate | UINT8 | As Above | As Above |
| 3 | 0-1 | Data bits code | | 2<br>3 | 7 data bits<br>8 data bits |
| 3 | 2-4 | Parity code | | 0<br>1<br>4 | even parity<br>odd parity<br>no parity |
| 4 | | Stop bits code | UINT8 | 7<br>15 | 1 stop bit<br>2 stop bits |
| 5 | | Language mode for Transmission | UINT8 | 0<br>1<br>5 | TSIP<br>Off<br>NMEA (Note 1) |
| 6 | | Language mode for Reception | UINT8 | 0<br>1 | TSIP<br>RTCM SC-104 (Note 2) |

**Note 1. –** The default NMEA output is GGA and VTG at 1 second intervals.

**Note 2. –** Before the main port language for reception can be set to RTCM SC-104, the auxiliary port language for reception must be set to TSIP (using command 0x8E-03). Only one port may be set to receive RTCM at a time, not both.

This information is held in battery-backed memory. After loss of battery-backed memory, the default values are set.

### A.18.2    Report Packet 0x8F-03 - Request Auxiliary Port Configuration

See Table A-85 for a description of this packet.

### A.18.3    Command Packet 0x8E-15 - Set/Request Datum

This packet allows the user to change the default datum from WGS-84 to one of 180 selected datums or a user-entered custom datum. The datum is a set of 5 parameters which describe an ellipsoid to convert the GPS receiver's internal coordinate system of XYZ ECEF into Latitude, Longitude and Altitude (LLA). This will affect all calculations of LLA in packets 0x4A and 0x84.

The user may wish to change the datum to match coordinates with some other system (usually a map). Most maps are marked with the datum used and in the US the most popular datum for maps is NAD-27. The user may also wish to use a datum which is more optimized for the local shape of the earth in that area. However, these optimized datum are truly "local" and will provide very different results when used outside of the area for which they were intended. WGS-84 is an excellent general ellipsoid valid around the world. See Table A.3 for information on saving the settings to non-volatile memory.

To request the current datum setting, one data byte is sent. Report Packet 0x8F-15 is returned.

**Table A-85    Command Packet 0x8E-15 Field Descriptions**

| Byte | Type | Value |
|------|------|-------|
| 0 | Superpacket ID | 0 x 15 |

To change to one of the internally held datums, the packet must contain exactly 2 bytes representing the integer value of the index of the datum desired:

**Table A-86    Command Packet 0x8E-15 Datum Index Field Descriptions**

| Byte | Type | Value |
|------|------|-------|
| 0 | Superpacket ID | 0 x 15 |
| 1-2 | INT16 | Datum index |

**Note 1. –** To request the current datum, send Packet 8E-15 with no data bytes.

**Note 2. –** The ACE III GPS does not support custom datums.

**Note –** Eccentricity Squared is related to flattening by the following equation:

$$e^2 = 2\rho - \rho^2$$

### A.18.4 Report Packet 0x8F-15 - Current Datum Values

This packet contains 43 data bytes with the values for the datum currently in use and is sent in response to Packet 0x8E 15. Both the datum index and the 5 double precision values for that index will be returned.

**Table A-87 Report Packet 0x8F-15 Data Formats**

| Byte | Type | Value |
|------|------|-------|
| 0 | UINT8 | Id for this sub-packet (always x15) |
| 1-2 | INT16 | Datum Index |
| 3-10 | Double | DX |
| 11-18 | Double | DY |
| 19-26 | Double | DZ |
| 27-34 | Double | A-axis |
| 35-42 | Double | Eccentricity Squared |

**Note –** A complete list of datums is provided at the end of this appendix. Eccentricity Squared is related to flattening by the following equation:

$e^2 = 2\rho - \rho^2$

### A.18.5    Report Packet 0x8F-17 - UTM Single Precision Output

This packet reports position in UTM (Universal Transverse Mercator) format. The UTM coordinate system is typically used for U.S. and international topographical maps.

The UTM coordinate system lays out a world-wide grid consisting of the following:

- 60 North/South zones in 6° increments extending eastward from the International Date Line

- 10 East/West zones divided in 8° increments extending above and below the Equator.

Coordinates within these boundaries cover all surface locations from 80° South to 84° North and encircle the earth. Locations are indicated by offset from the equator and in the zones east of the International Date Line. These offsets are known as Northing and Easting and are expressed in meters. UTM is not usable in polar regions.

**Table A-88    Report Packet 0x8F-17 Data Formats**

| Byte | Item | Type | Value |
|------|------|------|-------|
| 0 | Subcode | | 0x17 |
| 1 | Gridzone Designation | Char | |
| 2-3 | Gridzone | INT16 | |
| 4-7 | Northing | Single | Meters |
| 8-11 | Easting | Single | Meters |
| 12-15 | Altitude | Single | Meters |
| 16-19 | Clock Bias | Single | Meters |
| 20-23 | Time of Fix | Single | Seconds |

### A.18.6 Report Packet 0x8F-18 - UTM Double Precision Output

This packet reports position in UTM (Universal Transverse Mercator) format. The UTM coordinate system is typically used for U.S. and international topographical maps.

The UTM coordinate system lays out a world-wide grid consisting of the following:

- 60 North/South zones in 6° increments extending eastward from the International Date Line

- 10 East/West zones divided in 8° increments extending above and below the Equator.

Coordinates within these boundaries cover all surface locations from 80° South to 84° North and encircle the earth. Locations are indicated by offset from the equator and in the zones east of the International Date Line. These offsets are known as Northing and Easting and are expressed in meters. UTM is not usable in polar regions.

**Table A-89  Report Packet 0x8F-18 Field Descriptions**

| Byte | Description | Type | Value |
|------|-------------|------|-------|
| 0 | Subcode | | 0x18 |
| 1 | Gridzone Designation | Char | |
| 2-3 | Gridzone | INT16 | |
| 4-11 | Northing | Double | Meters |
| 12-19 | Easting | Double | Meters |
| 20-27 | Altitude | Double | Meters |
| 28-35 | Clock Bias | Double | Meters |
| 36-39 | Time of Fix | Single | Seconds |

### A.18.7    Command Packet 0x8E-19 - Enable / Disable UTM Output

This packet allows the user to enable or disable the position report, in UTM format. The UTM (Universal Transverse Mercator) coordinate system is typically used for U.S. and international topographical maps. It is a world -wide grid consisting of 60: 6(N/S zones extending eastward from the international Date Line, and 10:8 (E/W bands above and below the equator). This covers the surface location from 80 south to 84 north. Locations are indicated by offset of the equator and in the zones east of the International Date Line. These offsets are known as northing and easting and are express in meters. UTM is not usable in polar regions.

This packet allows the user to enable or disable the position report in UTM (Universal Transverse Mercator) format. If bit 4, byte 0 of Command Packet 0x35 is set to double precision, the 0x8F-18 packets will be enabled. If the bit set to single precision, the 0x8F-17 packets will be enabled.

**Table A-90    Command Packet 0x8E-19 Field Description**

| Byte | Description | Type | Value |
|------|-------------|------|-------|
| 0 | Subcode | | 0x19 |
| 1 | UTM Status | Char | 'E' = Enable,<br>'D' = Disable |

### A.18.8    Report Packet 0x8F-19 UTM Status

This packet reports whether the 0x8F-17 and 0x8F-18 packets are enabled.

**Table A-91    Command Packet 0x8F-19 Field Descriptions**

| Byte | Item | Type | Value |
|------|------|------|-------|
| 0 | Subcode | | 0x19 |
| 1 | UTM Status | Char | E = Enable<br>D = Disable |

### A.18.9 Command Packet 0x8E-20 - Request last fix with Extra Information

This packet requests Packet 0x8F-20 or marks it for automatic output. If only the first byte (20) is sent, an 0x8F-20 report containing the last available fix will be sent immediately. If two bytes are sent, the packet is marked/unmarked for auto report according to the value of the second byte as shown in Table A-92. 0x37 can also be used for requesting 0x8F-20 if the 0x8F-20 is scheduled for auto output.

**Table A-92    Command Packet 0x8E-20 Field Descriptions**

| Byte | Item | Type | Definition |
|------|------|------|------------|
| 0 | Sub-packet id | UINT8 | Id for this sub-packet (always 0x20) |
| 1 | Mark for Auto-report (See packet 35 byte 0 bit 5) | UINT8 | 0 = do not auto-report<br>1 = mark for auto-report |

**Note –** Auto-report requires that superpacket output is enabled. Refer to Command Packet 35.

### A.18.10 Report Packet 0x8F-20 - Last Fix with Extra Information (binary fixed point)

This packet provides complete information about the current position velocity fix in a compact, fixed-length 56-byte packet. The fields are fixed-point with precision matched to the receiver accuracy. It can be used for automatic position/velocity reports. The latest fix can also be requested by 0x8E-20 or 0x37 commands.The data format is shown in Table A-95:

**Table A-93      Report Packet 0x8F-20 Data Formats**

| Byte | Bit | Item | Type | Value | Definition |
|------|-----|------|------|-------|------------|
| 0 | | Sub-packet id | UINT8 | | Id for this sub-packet (always 0x20) |
| 1 | | KeyByte | UINT8 | | Reserved for Trimble DGPS Post-processing. |
| 2-3 | | east velocity | INT16 | | 0.005 m/s or 0.020 m/s See Note 1. |
| 4-5 | | north velocity | INT16 | | 0.005 m/s or 0.020 m/s See Note 1. |
| 6-7 | | up velocity | INT16 | | 0.005 m/s or 0.020 m/s See Note 1. |
| 8-11 | | Time Of Week | UINT32 | | GPS Time in milliseconds |
| 12-15 | | Latitude | INT32 | $-2^{30}$ to $2^{30}$ | WGS-84 latitude, $2^{-31}$ semicircle (-90° - 90°) |
| 16-19 | | Longitude | UINT32 | 0 to $2^{32}$ | WGS-84 latitude, $2^{-31}$ semicircle (0° - 360°) |
| 20-23 | | Altitude | UINT32 | | Altitude above WGS-84 ellipsoid, mm. |
| 24 | 0 | Velocity Scaling | | 0 1 | 0.005 m/s$^2$ 0.020 m/s$^2$ |
| | 1-7 | | | reserved | |
| 25 | | | | reserved | |
| 26 | | Datum | | | Datum index + 1 0=unknown |
| 27 | 0 | Fix Available | Bit | 0 1 | Yes No |
| | 1 | DGPS Corrected | Bit | 0 1 | No Yes |
| | 2 | Fix Dimension | Bit | 0 1 | 3D 2D |
| | 3 | Alt Hold | Bit | 0 1 | Last 3D Altitude User-entered altitude |
| | 4 | Filtered | Bit | 0 1 | Unfiltered Filtered |
| | 5-7 | | | reserved | |
| 28 | | NumSVs | UINT8 | | Number of satellites used for fix. Will be zero if no fix was available. |
| 29 | | UTC Offset | UINT8 | | Number of leap seconds between UTC time and GPS time. |
| 30-31 | | Week | INT16 | | GPS time of fix, weeks. |

**Table A-93    Report Packet 0x8F-20 Data Formats (Continued)**

| Byte | Bit | Item | Type | Value | Definition |
|---|---|---|---|---|---|
| 32 | 0-5 | PRN 1 | UINT8 | 1-32 | PRN of first satellite |
|  | 6-7 |  | reserved |  |  |
| 33 |  | IODE 1 | UINT8 |  | IODE of first satellite |
| 34 | 0-5 | PRN 2 | UINT8 | 1-32 | PRN of second satellite |
|  | 6-7 |  | reserved |  |  |
| 35 |  | IODE 2 | UINT8 |  | IODE of second satellite |
| 36 | 0-5 | PRN 3 | UINT8 | 1-32 | PRN of third satellite |
|  | 6-7 |  | reserved |  |  |
| 37 |  | IODE 3 | UINT8 |  | IODE of third satellite |
| 38 | 0-5 | PRN 4 | UINT8 | 1-32 | PRN of fourth satellite |
|  | 6-7 |  | reserved |  |  |
| 39 |  | IODE 4 | UINT8 |  | IODE of fourth satellite |
| 40 | 0-5 | PRN 5 | UINT8 | 1-32 | PRN of fifth satellite |
|  | 6-7 |  | reserved |  |  |
| 41 |  | IODE 5 | UINT8 |  | IODE of fifth satellite |
| 42 | 0-5 | PRN 6 | UINT8 | 1-32 | PRN of sixth satellite |
|  | 6-7 |  | reserved |  |  |
| 43 |  | IODE 6 | UINT8 |  | IODE of sixth satellite |
| 44 | 0-5 | PRN 7 | UINT8 | 1-32 | PRN of seventh satellite |
|  | 6-7 |  | reserved |  |  |
| 45 |  | IODE 7 | UINT8 |  | IODE of seventh satellite |
| 46 | 0-5 | PRN 8 | UINT8 | 1-32 | PRN of eighth satellite |
|  | 6-7 |  | reserved |  |  |
| 47 |  | IODE 8 | UINT8 |  | IODE of eighth satellite |
| 48-55 |  | Ionospheric Parameters |  |  |  |

**Note 1. –** Velocity scale controlled by byte 24, bit 1. Overflow = 0x8000.

**Note 2. –** See Section A-20, *Datums* for datum index tables.

### A.18.11   Command Packet 0x8E-23 - Compact Super Packet

This packet requests Packet 0x8F-23 or marks it for automatic output. If only the first byte (20) is sent, an 0x8F-23 report containing the last available fix will be sent immediately. If two bytes are sent, the packet is marked/unmarked for auto report according to the value of the second byte. 0x37 can also be used for requesting 0x8F-23 if the 0x8F-23 is scheduled for auto output.

The 8Ex23 command can be issued with no data to request a one time query of the super packet.

**Table A-94    Command Packet 0x8E-23 Field Descriptions**

| Byte | Item | Type | Value | Meaning |
|------|------|------|-------|---------|
| 0 | Sub-code | UINT8 | 0x23 | Request 8Fx23 |

The 8Ex23 command can be issued with one data byte to enable the superpacket.

**Table A-95    Command Packet 0x8E-23 Field Descriptions**

| Byte | Item | Type | Value | Meaning |
|------|------|------|-------|---------|
| 0 | Sub-code | UINT8 | 0x23 | |
| 1 | Packet control | UINT8 | | 0=off, 1=on |

### A.18.12 Report Packet 0x8F-23 - Compact Super Packet

This packet provides complete information about the current position velocity fix in a compact, fixed-length 29-byte packet. The fields are fixed-point with precision matched to the receiver accuracy. It can be used for automatic position/velocity reports. The latest fix can also be requested vy 0x8E-we or 0x37 commands. The Compact super packet will output with the following format.

**Table A-96    Report Packet 0x8F-23 Field Descriptions**

| Byte | Bit | Item | Type | Value | Meaning |
|------|-----|------|------|-------|---------|
| 0 | | Sub-packet ID | UINT8 | | ID for this sub-packet (always 0x23) |
| 1-4 | | Time of week | UINT32 | | GPS time of fix (milliseconds) |
| 5-6 | | Week | UINT16 | | GPS time of fix (weeks) |
| 7 | | UTC offset | UINT8 | | Number of leap seconds between UTC and GPS time |
| 8 | 0 | Fix Available | Bit | 0<br>1 | Yes<br>No |
| | 1 | DGPS Corrected | Bit | 0<br>1 | No<br>Yes |
| | 2 | Fix Dimension | Bit | 0<br>1 | 3D<br>2D |
| | 3 | Alt Hold | Bit | 0<br>1 | Last 3D Altitude<br>User-entered Altitude |
| | 4 | Filtered | Bit | 0<br>1 | Unfiltered<br>Position or Altitude filter on |
| | 5 | Velocity Scaling | Bit | 0<br>1 | No velocity scale<br>Velocity scaled by 4 (See bytes 21-28) |
| | 6 | Ephemeris | Bit | 0<br>1 | Old ephemeris<br>New ephemeris (reserved) |
| | 7 | Almanac | Bit | 0<br>1 | Almanac bad<br>Almanac good (reserved) |
| 9-12 | | Latitude | INT32 | | WGS-84 Latitude (units =$2^{(-31)}$ semicircle) |
| 13-16 | | Longitude | INT32 | | WGS-84 Longitude east of meridian (units =$2^{(-31)}$ semicircle) |
| 17-20 | | Altitude | INT32 | | Altitude above WGS-84 ellipsoid (millimeters) |
| 21-22 | | East Velocity | INT32 | | Units=0.005 m/s or 0.020 m/s (see byte #8, velocity scaling bit) |
| 23-24 | | North Velocity | INT32 | | Units=0.005 m/s or 0.020 m/s (see byte #8, velocity scaling bit) |
| 25-26 | | Up Velocity | INT32 | | Units=0.005 m/s or 0.020 m/s (see byte #8, velocity scaling bit) |
| 27-28 | | Flag Bytes | INT32 | | Reserved |

### A.18.13  Command Packet 0x8E-26 - SEEPROM Storage

The 0x8E-26 command is issued with no data to cause the current settings to be saved to non-volatile memory. See Table A.3 for information on saving the settings to non-volatile memory. The 0x8F-26 report is generated after the values have been saved.

**Table A-97    Command Packet 0x8E-26 Definitions**

| Byte # | Item | Type | Value | Definition |
|--------|------|------|-------|------------|
| 0 | Subcode | UINT8 | 0x26 | Save Settings |

### A.18.14  Report Packet 0x8F-26 - SEEPROM Storage Status

This report will be issued after an 0x8E-26 command.

**Table A-98    Report Packet 0x8F-26 Field Descriptions**

| Byte/ | Item | Type | Value | Definition |
|-------|------|------|-------|------------|
| 0 | Subcode | UINT8 | 0x26 | Save Settings |
| 1-4 | reserved | | | |

### A.18.15  Command Packet 0x8E-40 - TAIP Configuration

 The 0x8E-40 command can be issued with no data to request the current mask and internal settings. The 0x8F-40 report is sent in response to this command.

**Table A-99    TAIP Configuration Request**

| Byte | Item | Type | Value | Definition |
|------|------|------|-------|------------|
| 0 | Subcode | UINT8 | 40 | Request TAIP Configuration |

The 0x8E-40 command can be issued with 5 data bytes to set the TAIP configuration.

**Table A-100 TAIP Configuration Command Report Data Formats**

| Byte | Bit | Item | Type | Value | Definition | | Default |
|------|-----|------|------|-------|------------|---|---------|
| 0 | | Subcode | UINT8 | 0x40 | Set TAIP config | | 0x40 |
| 1 | | | | | TAIP sentence flags | | 0x0E |
| | 0 | ID Flag | Bit | 0<br>1 | off<br>on | | 0=off |
| | 1 | CS Flag | Bit | 0<br>1 | off<br>on | | 1=on |
| | 2 | EC Flag | Bit | 0<br>1 | off<br>on | | 1=on |
| | 3 | FR Flag | Bit | 0<br>1 | off<br>on | | 1=on |
| | 4 | CR Flag | Bit | 0<br>1 | off<br>on | | 0=off |
| | 5-7 | reserved | | | | | |
| 2 | | TAIP Auto Output Heartbeat Sentence | UINT8 | 0<br>2<br>6<br>8<br>11<br>14<br>15<br>16 | AL<br>CP<br>ID<br>LN<br>PV<br>ST<br>TM<br>VR | | 11 PV |
| 3-4 | | Toh Offset | INT16 | 0-3599 | Top of hour offset | | 0 |
| 5-6 | | HB rate | UINT16 | 0-3599 | Auto output interval (sec) | | 5 |
| 7-10 | | Veh ID | String | "See TAIP ID" | Vehicle ID | | "0000" |

## A.18.16 Report Packet 0x8F-40 - TAIP Configuration

The 8F:40 will be issued as a response to any valid 8E:40 command. See Appendix A-100, TAIP Configuration Command Report Data Formats for report format and definitions.

## A.19   Datums

Reference: DMA TR 8350.2 Second Edition, 1 Sept. 1991. DMA Technical Report, Department of Defense World Geodetic System 1984, Definition and Relationships with Local Geodetic Systems.

**Table A-101    International Datum**

| Trimble Datum | Local Geodetic Datum | |
|---|---|---|
| Index | Name | Code |
| 0 | **WGS-84** | |
| 6 | **WGS-72** | |
| 7 | **NAD-83** | |
| 8 | **NAD-02** | |
| 9 | **Mexican** | |
| 10 | **Hawaii** | |
| 11 | **Astronomic** | |
| 12 | **U.S. Navy** | |

**Table A-102    Africa**

| Trimble Datum | Local Geodetic Datum | |
|---|---|---|
| Index | Name | Code |
| 15 | **Adindan** Mean Solution (Ethiopia and Sudan) | ADI-M |
| 16 | **Adindan** Ethiopia | ADI-A |
| 17 | **Adindan** Mali | ADI-C |
| 18 | **Adindan** Senegal | ADI-D |
| 19 | **Adindan** Sudan | ADI-B |
| 20 | **Afgooye** Somalia | AFG |
| 23 | **ARC 1950** Mean Solution | ARF-M |
| 24 | **ARC 1950** Botswana | ARF-A |
| 25 | **ARC 1950** Lesotho | ARF-B |
| 26 | **ARC 1950** Malawi | ARF-C |
| 27 | **ARC 1950** Swaziland | ARF-D |
| 28 | **ARC 1950** Zaire | ARF-E |
| 29 | **ARC 1950** Zambia | ARF-F |
| 30 | **ARC 1950** Zimbabwe | ARF-G |
| 31 | **ARC 1960** Mean Solution | ARS |
| 32 | **ARC 1960** Kenya | ARS |
| 33 | **ARC 1960** Tanzania | ARS |
| 45 | **Cape** South Africa | CAP |

**Table A-102  Africa**

| Trimble Datum | Local Geodetic Datum | |
|---|---|---|
| 47 | **Carthage** Tunisia | CGE |
| 82 | **Liberia 1964** Liberia | LIB |
| 87 | **Massawa** Eritrea (Ethiopia) | MAS |
| 88 | **Merchich** Morocco | MER |
| 90 | **Minna** Nigeria | MIN-B |
| 94 | **Schwarzeck** Namibia | SCK |
| 118 | **Old Egyptian 1907** Egypt | OEG |

**Table A-103  Asia**

| Trimble Datum | Local Geodetic Datum | |
|---|---|---|
| 1 | **Tokyo** | |
| 21 | **Ain El Abd 1970** Bahrain Island | AIN-A |
| 51 | **Djakarta (Batavia)** Sumatra (Indonesia) | BAT |
| 71 | **Hong Kong 1963** Hong Kong | HKD |
| 72 | **Indian 1975** Thailand | INH -A |
| 73 | **Indian** India and Nepal | IND-I |
| 77 | **Kandawala** Sri Lanka | KAN |
| 79 | **Kertau 1948** West Malaysia and Singapore | KEA |
| 91 | **Nahrwan** Masirah Island (Oman) | NAH-A |
| 92 | **Nahrwan** United Arab Emirates | NAH-B |
| 93 | **Nahrwan** Saudi Arabia | NAH-C |
| 124 | **Oman** Oman | FAH |
| 143 | **Quatar National** Qatar | QAT |
| 161 | **South Asia** Singapore | SOA |
| 164 | **Timbalai 1948** Brunei and East Malaysia (Sarawak and Sabah) | TIL |
| 165 | **Tokyo** Mean Solution (Japan, Okinawa and South Korea) | TOY-M |
| 166 | **Tokyo** South Korea | TOY-B |
| 167 | **Tokyo** Okinawa | TOY-C |
| 176 | **Hu-Tzu-Shan** Taiwan | HTN |
| 179 | **Tokyo GIS Coordinates** | TOY-B |

**Table A-104    Australia**

| Trimble Datum | Local Geodetic Datum | |
|---|---|---|
| 5 | **Australian Geodetic 1966** Australia and Tasmania | AUA |
| 14 | **Australian Geodetic 1984** Australia and Tasmania | AUG |
| 39 | **Australian Geodetic 1966** Australia and Tasmania | AUA |

**Table A-105    Europe**

| Trimble Datum | Local Geodetic Datum | |
|---|---|---|
| 4 | **European 1950** Mean Solution | EUR-M |
| 13 | **European 1950** Mean Solution | EUR-M |
| 54 | **European 1950** Mean Solution | EUR-M |
| 55 | **European 1950** Cyprus | EUR-E |
| 56 | **European 1950** Egypt | EUR-F |
| 57 | **European 1950** England, Ireland, Scotland, Shetland Islands | EUR-G |
| 58 | **European 1950** England, Ireland, Scotland, Shetland Islands | EUR-K |
| 59 | **European 1950** Greece | EUR-B |
| 60 | **European 1950** Iran | EUR-H |
| 61 | **European 1950** Sardinia | EUR-I |
| 62 | **European 1950** Sicily | EUR-J |
| 63 | **European 1950** Norway and Finland | EUR-C |
| 64 | **European 1950** Portugal and Spain | EUR-D |
| 65 | **European 1979** Mean Solution | EUS |
| 74 | **Ireland 1965** Ireland | IRL |
| 125 | **Ordnance Survey of Great Britain** Mean Solution | OGB-M |
| 126 | **Ordnance Survey of Great Britain** England | OGB-M |
| 127 | **Ordnance Survey of Great Britain** Isle of Man | OGB-M |
| 128 | **Ordnance Survey of Great Britain** Scotland and Shetland Islands | OGB-M |
| 129 | **Ordnance Survey of Great Britain** Wales | OGB-M |
| 145 | **Rome 1940** Sardinia | MOD |

**Table A-106    North America**

| Trimble Datum | Local Geodetic Datum | |
|---|---|---|
| 0 | **WGS-84** | |
| 2 | **North American 1927** Mean Solution (CONUS) | NAS-C |
| 3 | **Alaska Canada** | |
| 46 | **Cape Canaveral** Mean Solution (Florida and Bahamas) | CAC |

**Table A-106    North America**

| Trimble Datum | Local Geodetic Datum | |
|---|---|---|
| 96 | **NAD 27** Western United States | NAS-B |
| 97 | **NAD 27** Eastern United States | NAS-A |
| 98 | **NAD 27** Alaska | NAS-D |
| 99 | **NAD 27** Bahamas | NAS-Q |
| 100 | **NAD 27** San Salvador | NAS-R |
| 101 | **NAD 27** Canada | NAS-E |
| 102 | **NAD 27** Alberta BC | NAS-F |
| 103 | **NAD 27** East Canada | NAS-G |
| 104 | **NAD 27** Manitoba Ontario | NAS-H |
| 105 | **NAD 27** Northwest Territories Saskatchewan | NAS-I |
| 106 | **NAD 27** Yukon | NAS-J |
| 107 | **NAD 27** Canal Zone | NAS-O |
| 108 | **NAD 27** Caribbean | NAS-P |
| 109 | **NAD 27** Central America | NAS-N |
| 110 | **NAD 27** Cuba | NAS-T |
| 111 | **NAD 27** Greenland | NAS-U |
| 112 | **NAD 27** Mexico | NAS-V |
| 113 | **NAD 83** Alaska | NAR-A |
| 114 | **NAD 83** Canada | NAR-B |
| 115 | **NAD 83** CONUS | NAR-C |
| 116 | **NAD 83** Mexico and Central America | NAR-D |

**Table A-107    South America**

| Trimble Datum | Local Geodetic Datum | |
|---|---|---|
| 42 | **Bogota Observatory** Columbia | BOO |
| 43 | **Compo Inchauspe 1969** Argentina | CAI |
| 49 | **Chua Astro** Paraguay | CHU |
| 50 | **Corrego Alegre** Brazil | COA |
| 132 | **Provisional South Chilean 1963** Southern Chile  (near 53ºS) | HIT |
| 133 | **Provisional South American 1956** Mean Solution  (Bolivia, Chile, Columbia, Ecuador, Guyana, Peru, Venezuela) | PRP-M |
| 134 | **Provisional South American 1956** Bolivia, Chile | PRP-A |
| 135 | **Provisional South American 1956** Northern Chile (near 19ºS) | PRP-B |
| 136 | **Provisional South American 1956** Southern Chile (near 43ºS) | PRP-C |
| 137 | **Provisional South American 1956** Columbia | PRP-D |

**Table A-107　South America**

| Trimble Datum | Local Geodetic Datum | |
|---|---|---|
| 138 | **Provisional South American 1956** Ecuador | PRP-E |
| 139 | **Provisional South American 1956** Guyana | PRP-F |
| 140 | **Provisional South American 1956** Peru | PRP-G |
| 141 | **Provisional South American 1956** Venezuela | PRP-H |
| 149 | **South American 1969** Mean Solution (Argentina, Bolivia, Brazil, Chile, Columbia, Ecuador, Guyana, Paraguay, Peru, Trinidad Tobago, Venezuela) | SAN-M |
| 150 | **South American 1969** Argentina | SAN-A |
| 151 | **South American 1969** Bolivia | SAN-B |
| 152 | **South American 1969** Brazil | SAN-C |
| 153 | **South American 1969** Chile | SAN-D |
| 154 | **South American 1969** Columbia, | SAN-E |
| 155 | **South American 1969** Ecuador (Excluding Galapagos Islands) | SAN-F |
| 156 | **South American 1969** Guyana | SAN-G |
| 157 | **South American 1969** Paraguay | SAN-H |
| 158 | **South American 1969** Peru | SAN-I |
| 159 | **South American 1969** Trinidad and Tobago | SAN-K |
| 160 | **South American 1969** Venezuela | SAN-L |
| 171 | **Zanderij** Surinam | ZAN |

**Table A-108　Atlantic Ocean**

| Trimble Datum | Local Geodetic Datum | |
|---|---|---|
| 34 | **Ascension Island 1958** Ascension Island | ASC |
| 37 | **Astro Dos 71 /4** St. Helena Island | SHB |
| 41 | **Bermuda 1957** Bermuda Islands | BER |
| 70 | **Hjorsey 1955** Iceland | HJO |
| 81 | **L.C.5 Astro 1961** Cayman Brac Island | LCF |
| 86 | **Selvagem Grande 1938** Salvage Islands | SGM |
| 95 | **Naparima, BWI** Trinidad and Tobago | NAP |
| 117 | **Observatorio Meteorologico 1939** Corvo and Flores Islands (Azores) | FLO |
| 130 | **Pico De Las Nieves** Canary Islands | PLN |
| 142 | **Puerto Rico** Puerto Rico and Virgin Islands | PUR |
| 144 | **Qornoq** South Greenland | QUO |
| 146 | **Santa Braz** Sao Miguel, Santa Maria Islands (Azores) | SAO |
| 148 | **Sapper Hill 1943** East Falkland Islands | SAP |

**Table A-108   Atlantic Ocean**

| Trimble Datum | Local Geodetic Datum | |
|---|---|---|
| 162 | **Porto Santo 1936** Porto Santo and Madera Islands | POS |
| 163 | **Graciosa Base Southwest 1948** Faial, Graciosa, Pico, San Jorg, and Terceira Islands (Azores) | GRA |
| 168 | **Tristan Astro 1968** Tristan Da Cunha | TDC |

**Table A-109   Indian Ocean**

| Trimble Datum | Local Geodetic Datum | |
|---|---|---|
| 22 | **Anna 1 Astro 1965** Cocos Islands | ANO |
| 66 | **Gan 1970** Republic of Maldives | GAA |
| 75 | **ISTS 073 Astro 1969** Diego Garcia | IST |
| 78 | **Kerguelen Island 1949** Kerguelen Island | KEG |
| 80 | **Reunion**  Mascarene Island | REU |
| 85 | **Mahe 1971** Mahe Island | MIK |

**Table A-110   Pacific Ocean**

| Trimble Datum | Local Geodetic Datum | |
|---|---|---|
| 35 | **Astro Beacon E 1945** Iwo Jima | ATF |
| 36 | **Astro Tern Island (FRIG) 1961** Tern Island | TRN |
| 38 | **Astronomical Station 1952** Marcus Island | TRN |
| 40 | **Bellevue (IGN)** Efate Erromango Island | IBE |
| 44 | **Canton Astro1966** Phoenix Island | CAO |
| 48 | **Chatham Island Astro 1971** Chatham Island (New Zealand) | CHI |
| 52 | **Dos 1968** Gizo Island (New Georgia Islands) | GIZ |
| 53 | **Easter Island 1967** Easter Island | EAS |
| 67 | **Geodetic Datum 1948** New Zealand | GEO |
| 68 | **Guam 1963** Guam | GUA |
| 69 | **Gux 1 Astro** Guadalcanal Islands | DOB |
| 76 | **Johnstone Island 1961** Johnstone Island | JOH |
| 83 | **Luzon** Philippines | LUZ-A |
| 84 | **Luzon** Mindanao Island | LUZ-B |
| 89 | **Midway Astro 1961** Midway Islands | MID |
| 119 | **Old Hawaiian** Mean Solution | OHA-M |
| 120 | **Old Hawaiian** Hawaii | OHA-A |
| 121 | **Old Hawaiian** Kauai | OHA-B |
| 122 | **Old Hawaiian** Maui | OHA-C |

**Table A-110    Pacific Ocean**

| Trimble Datum | Local Geodetic Datum | |
|---|---|---|
| 123 | **Old Hawaiian** Oahu | OHA-D |
| 131 | **Pitcairn Astro 1967**Pitcairn Island | PIT |
| 147 | **Santo (DOS) 1952** Espirito Santo Island | SAE |
| 169 | **Viti Levu 1916** Viti Levu Island (Fiji Islands) | MVS |
| 170 | **Wake Eniwetok 1960** Marshall Islands | ENW |

**Table A-111    Non-Satellite Derived Datums**

| Trimble Datum | Local Geodetic Datum | |
|---|---|---|
| 172 | **Bukit Rimpah**  Bangka and Belitung Islands (Indonesia) | BUR |
| 173 | **Camp Area Astro** Camp McMurdo Area, Antarctica | CAZ |
| 174 | **Gunung Segara** Kalimantan (Indonesia) | GSE |
| 175 | **Herat North** Afghanistan | HEN |

# B    TSIP Toolkit User's Guide

The GPS Tool Kit program disk includes several TSIP interface programs designed to help developer's evaluate and integrate the GPS module and create GPS and differential GPS applications. These programs run on a PC-Windows 95 or NT platform. They are intended as a base upon which to build application specific software, so the source code in ANSI C is included for many of these programs. The GPS Tool Kit program disk includes the following programs:

32 bit Windows Applications

TSIPMONITOR32:        is a 32 bit windows application which interfaces with a TSIP-speaking receiver through a serial port. The program accepts TSIP reports and displays them in a window with fields for position, velocity, time, receiver status and satellite track status. It allows the user to exercise some basic TSIP commands. TSIPMonitor32 can also log TSIP report in binary format for later translation.

DOS Programs and C Source Code

TSIPCHAT.EXE:        is a 16 bit DOS-based application which interfaces with a TSIP speaking receiver through a serial port. It allows the user to exercise all TSIP commands. TSIPCHAT can log a TSIP report in binary format. Source code is provided.

TSIPPRNT.EXE:        is a 16 bit DOS-based application which interprets a binary TSIP data stream, such as logged by TSIPCHAT or TSIPMonitor32, and prints it to a file. Source code is provided.

For further information on the above programs, see the README file on the Toolkit disk.

A 32-bit Windows application, TSIP Reader, is available from the ftp web site,

> ftp://ftp.trimble.com/pubs/8ct/embedded/bin

that interprets binary TSIP data streams.

## B.1    TSIPMonitor32

TSIPMonitor32 requires Win95 or WinNT. Once the program is started, it immediately prompts for the serial port connected to the GPS receiver.
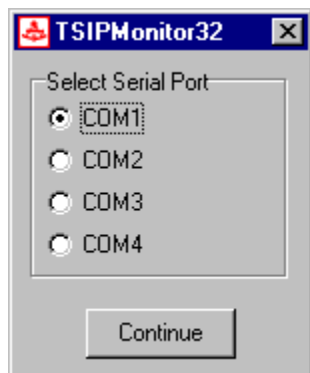


**Figure B-1      TSIPMonitor32 - Serial Port Selection**

The main window is displayed once the GPS receiver is communicating with the application. Fields with question marks "?" indicate that information is not yet available.
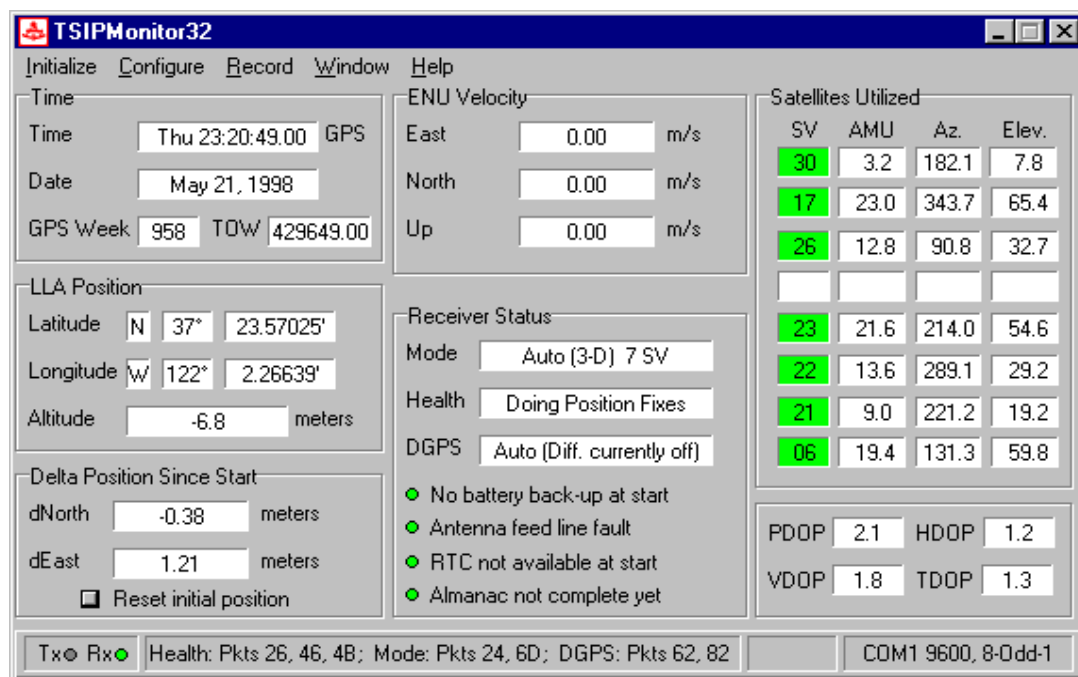


**Figure B-2      TSIPMonitor 32 - Main Window**

### B.1.1    Delta Position

TSIPMonitor32 displays delta position which is the difference between the current position and the initial position. The initial position can be reset at anytime by selecting [Reset Initial Position], (see Figure B-2).

### B.1.2    File Storage

TSIPMonitor32 provides for file storage of the raw binary TSIP stream directly from the serial port. To turn data collection on or off, use the record pull-down menu. The recorded binary data stream can be translated into an ASCII file with the program TSIPRNT.

# C   Trimble ASCII Interface Protocol (TAIP)

Trimble ASCII Interface Protocol (TAIP) is a Trimble-specified digital communication interface based on printable ASCII characters over a serial data link. TAIP was designed specifically for vehicle tracking applications but has become common in a number of other applications because of its ease of use. TAIP supports both scheduled and polled responses.

TAIP messages may be scheduled for output at a user specified rate starting on a given epoch from top of the hour. For communication robustness, the protocol optionally supports checksums on all messages. It also provides the user with the option of tagging all messages with the unit's user specified identification number (ID). This greatly enhances the functional capability of the unit in a network environment.

Additionally, given the printable ASCII format of all communication, TAIP is ideal for use with mobile data terminals, seven bit modems and portable computers. Although, sensors incorporating this protocol are shipped from the factory with a specific serial port setting, the port characteristics are fully programmable through TAIP messages.

This appendix is designed for easy reference to TAIP message formats and describes all the TAIP messages defined at the time of printing. Some of the defined TAIP messages are not supported by the ACE III GPS receiver. The ACE III GPS supports the following TAIP messages:

ACE III GPS supported TAIP messages include:

- AL Altitude/Up Velocity
- AP Auxiliary Port Characteristics
- CP Compact Position Solution
- DC Differential Corrections
- DD Delta Differential Corrections
- ID Identification Number
- IP Initial Position
- LN Long Navigation Message
- PR Protocol
- PT Port Characteristic
- PV Position/Velocity Solution
- RM Reporting Mode
- RT Reset Mode
- ST Status
- TM Time/Date
- VR Version Number

## C.1    Message Format

All TAIP communication uses printable, uppercase ASCII characters. The interface provides the means to configure the unit to output various sentences in response to queries or on a scheduled basis. Each sentence has the following general format:

```
ABB{C}[;ID=DDDD][;*FF]<
```

**Table C-1    Message Formats**

| ID | Meaning |
|---|---|
| > | Start of new message |
| A | Message qualifier |
| BB | a two character message identifier |
| C | data string |
| DDDD | Optional 4 character vehicle ID |
| FF | Optional 2 character checksum |
| < | delimiting character |
| {x} | signifies that x can occur any number of times. |
| [x] | signifies that x may optionally occur once. |

### C.1.1    Start of a New Message

The > character (ASCII code 62 decimal) is used to specify the start of a new sentence.

### C.1.2    Message Qualifier

A one character message qualifier is used to describe the action to be taken on the message. The following table lists the valid qualifiers.

**Table C-2    Message Format Qualifiers**

| Qualifier | Action |
|---|---|
| Q | Query for a single sentence (sent to GPS sensor). |
| R | Response to a query or a scheduled report (from the sensor) |
| F | Schedule reporting frequency interval in seconds |
| S | Enables equipment to be initialized, and sets various message types. |
| D | Specify a minimum distance traveled and a minimum and maximum time interval for the next report |

Details on the use of message qualifiers are given in Communication Using TAIP, page C-27.

**Note –** All TAIP message characters must be in uppercase.

### C.1.3        Message Identifier

A unique two character message identifier consisting of alphabetical characters is used to identify type messages. For example: PR for Protocol or VR for Version Number.

### C.1.4        Data String

The format and length of a data string is dictated by the message qualifier and the message identifier. The data string may contain any printable ASCII character with the exception of the >, <, and ; characters. Detailed descriptions of each message format are provided in the specific message sections of this Appendix. Most messages are length sensitive and unless otherwise specified, field separators, including spaces are not used.

### C.1.5        Vehicle ID

A vehicle identification(ID) may optionally be used in all the communications with the sensor. Each sensor in the fleet may be assigned a four character alpha-numeric ID and be forced to output that ID in all messages. The default is: ID set to 0000 and the ID Flag set to F (false).

The sensor will check all incoming messages for ID. If no ID is specified, the sensor will accept the message. If the ID is included in messages but does not compare with the ID previously set, the message will be ignored. This applies even when the ID Flag is turned off.

### C.1.6        Checksum

The checksum field provides for an optional two digit hex checksum value, which is computed as XOR of *all characters* from the beginning of the sentence up to and including the * character. If provided, the checksum is always the last element of the sentence before the message delimiter. The default mode of operation is to include checksum in sentences. The use of checksums can help in instances where the communication channel is noisy.

#### Example

The following message to set the vehicle ID flag on includes checksum.

```
>SRM;ID_FLAG=T;*6F<
```

The checksum (6F) was generated by XOR'ing the ASCII codes for > and S then XOR'ing that result with the ASCII code for R and so forth, up to and including the * character.

### C.1.7        Message Delimiter

The < character signifies end of a sentence and is used as the message delimiter.

## C.2     Sample PV Message

The Position/Velocity Solution (PV) message is one of the more commonly used TAIP messages and most sensors using TAIP are set by default to output the PV message once every 5 seconds.

The following analysis of a typical PV message is provided to further explain the TAIP message protocol.

```
>RPV15714+3739438-1220384601512612;ID=1234;*7F<
```

**Table C-3     Sample PV Message Fields**

| ID | Meaning |
|---|---|
| > | Start of Message Delimiter |
| R | Response Qualifier |
| PV | PV message Identifier |
| 15714 | GPS Time of Day |
| +3739438 | Latitude |
| -12203846 | Longitude |
| 015 | Speed |
| 126 | Heading |
| 1 | Source of Data |
| 2 | Age of Data |
| ;ID=1234 | Vehicle ID |
| ;*7F | Checksum |
| < | End of Message Delimiter |

**Note –** Refer to the discussion of the PV message data string for more detail on how this message is interpreted.

## C.3    Time and Distance Reporting

The 'D' message qualifier allows you to specify a minimum distance traveled as well as a minimum and maximum time interval for the next report. Units that are stationed at a fixed location can be programmed to report only when the unit moves "off station" or after a certain elapsed time since last report, but no more often than the specified minimum time interval.

The message format used with the 'D' qualifier is shown below:

```
>DAABBBBCCCCEEEEFFFF[;ID=GGGG][;*HH]<
```

**Table C-4       Time and Distance Reporting Message Format Qualifiers**

| ID | Meaning |
|------|---------|
| > | start of message delimiter |
| D | the Distance message qualifier |
| AA | message to report (i.e. PV means Position Velocity message) |
| BBBB | minimum time (seconds) interval between reports ($T_{interval}$) |
| CCCC | report epoch (number of seconds from top of the hour) |
| EEEE | delta distance (meters) from last reported distance |
| FFFF | maximum time (seconds) interval between reports ($T_{max}$) |
| GGGG | optional vehicle identification number (user selected) |
| HH | optional checksum |
| < | End of message delimiter |

**Note –** If BBBB = 0, then the message output is disabled. If FFFF = 0, maximum time feature is disabled (the unit will only report if current position is greater than or equal to the delta distance specified in EEEE).

## C.3.1    Example

When the message: >DPV0030000505000900;ID=0105< is sent to the GPS receiver, it specifies that vehicle number 105 (*GGGG* = 0105) is to report the Position Velocity message (*AA* = PV) whenever its current position differs from the previously reported position by at least 500 meters (*EEEE* = 0500), but no more often than every 30 seconds (*BBBB* = 0030) or less often than every 15 minutes (*FFFF* = 0900 seconds). The minimum and maximum time-out reports are to be issued with a 5 second offset (*CCCC* = 0005) from the top of the hour. The optional checksum was not used in this example. The square brackets, [...], shown in the format description above are used to indicate optional data. The brackets themselves are never included in the actual TAIP message string.

The 'D' message qualifier was designed by Trimble for use by Ambulance Companies to limit communication traffic between mobile units and the base when the ambulances are stationary on-station. When the ambulance has reached its stationary dispatch site, the operator signals the base by voice or by pushing a button on a Mobile Data Terminal (MDT) signifying that the unit is now on station. Once this communication is made, the base operator issues a 'D' qualifier and message so that the ambulance will only report either when it moves off-station or at specific reporting intervals.

## C.4     Latitude and Longitude Conversion

The TAIP protocol reports latitude as positive north decimal degrees and longitude as positive east decimal degrees, using the WGS-84 datum. For your application, you may wish to convert to degrees, minutes and seconds. The following example illustrates the conversion of decimal degrees to degrees, minutes and seconds.

### C.4.1     Example

Given latitude and longitude in decimal degrees,

Latitude:           +37.39438 degrees

Longitude:        -122.03846 degrees

Convert latitude by multiplying the decimal fraction of degrees by 60 to convert to minutes

0.39438 x 60 = 23.6628 minutes

Retain the integer (23) portion as the minutes then multiply the decimal fraction by 60 to convert to seconds,

0.6628 x 60 = 39.768 seconds

Since the sign of the latitude in this example is positive the result is:

Latitude: N 37$^{o}$ 23' 39.77"

The longitude is converted in the same fashion:

Longitude: W 122$^{o}$ 02' 18.46"

**Note –** At the earth's equator, one degree of latitude and longitude represents 68.7 miles; therefore, 0.00001 degrees represents approximately 3.6 feet or 1.1 meters. Each second represents approximately 100.76 ft. (30.7 m).

## C.5    Message Data Strings

The following table lists all the TAIP messages currently defined and comments regarding their application:

**Table C-5        Message Data String Descriptions**

| Identifier | Message Name | Frequency and Distance | Query | Response/ Report | Set |
|---|---|---|---|---|---|
| AL | Altitude/Vertical Velocity | X | X | X | X |
| AP | Auxiliary Port Characteristic | | X | X | X |
| CP | Compact Position Solution | X | X | X | X |
| DC | Differential Corrections | | | | X |
| DD | Delta Differential Corrections | | | | X |
| ID | Vehicle ID | X | X | X | X |
| IP | Initial Position | X | X | X | X |
| LN | Long Navigation Message | X | X | X | |
| PR | Protocol | | X | X | X |
| PT | Port Characteristic | X | X | X | X |
| PV | Position/Velocity Solution | X | X | X | X |
| RM | Reporting Mode | X | X | X | X |
| RT | Reset | | | | X |
| ST | Status | X | X | X | |
| TM | Time/Date | X | X | X | |
| VR | Version Number | X | X | X | X |

The data string format of each message is described in the following pages.



**Note 1. –** The Trimble GPS sensor may not support all the message types. Please refer to page 1 of this appendix for a list of the messages your sensor supports.



**Note 2. –** All TAIP message characters must be in uppercase.

## C.6    AL  Altitude/Up Velocity

**Note –** The first character of altitude or vertical velocity is "**+**" or "**-**".

Data String Format:

        AAAAABBBBBBCCCCDE

**Table C-6        Altitude/Up Velocity Data String Descriptions**

| Item | # of Char | Units | Format | Value |
|------|-----------|-------|--------|-------|
| GPS Time of day | 5 | Sec | AAAAA | |
| Altitude | 6 | Meter | BBBBBB | |
| Vertical Velocity | 4 | MPH | CCCC | |
| Source | 1 | n/a | D | 0 = 2D GPS<br>1 = 3D GPS<br>2 = 2D DGPS<br>3 = 3D DGPS<br>6 = DR<br>8 = Degraded DR<br>9 = Unknown |
| Age of Data Indicator | 1 | n/a | E | 2 = Fresh, <10 seconds<br>1 = Old, >10 seconds<br>0 = Not available |
| Total # of characters is 17 | | | | |

Altitude is above mean sea level in WGS-84. The GPS time of day is the time of fix rounded to the nearest second. This message contains data obtained from the last 3 dimensional fix and may not be current.

**Note –** The data in this message is to be considered invalid and should not be used, if the Age of Data Indicator is equal to 0 (signifying data not available).

## C.7    AM  Alarm

ACE III GPS does not support this TAIP message.

## C.8    AP  Auxiliary Port Characteristics

Data String Format:

    AAAA,B,C,D,E,F

**Table C-7        Auxiliary Port Characteristics Data String Descriptions**

| Item | # of Char | Units | Format | (Value) |
|---|---|---|---|---|
| Baud Rate | 4 | n/a | AAAA | 9600, 4800, 2400, 1200, or 0300 |
| # of data bits | 1 | n/a | B | 7 or 8 |
| # of stop bits | 1 | n/a | C | 1 or 2 |
| Parity | 1 | n/a | *D* | N = None<br>O = Odd<br>E = Even |
| Auxiliary Port Number | 1 | n/a | E | 1 |
| Reserved | 1 | n/a | F | 0 |
| Total number of characters is 9 (includes commas) | | | | |

This message defines the characteristics for the auxiliary port. The auxiliary port must be the RTCM input port on differential ready sensors.

The default settings of the auxiliary port are 4800 baud, 8 data bits, parity none, and 1 stop bit.

### C.8.1    Example

The following command will set the auxiliary port characteristics to 2400 baud, 8 data bits, 1 stop bit and no parity.

    >SAP2400,8,1,N,1,0<

**Note 1. –** See the inclusion of 0 in the reserved field.

**Note 2. –** The AP command applies only to receivers with dual serial ports.

**Note 3. –** The AP command requires commas between data fields.

## C.9    CP Compact Position Solution

**Note –** The first character of latitude or longitude is "**+**" or "**-**".

Data String Format:

    AAAAABBBCCCCDDDDEEEEFG

**Table C-8       Compact Position Solution Data String Descriptions**

| Item | # of Char | Units | Format | (Value) |
|---|---|---|---|---|
| GPS Time of day | 5 | Sec | AAAAA | |
| Latitude | 7 | Deg | BBBCCCC | |
| Longitude | 8 | Deg | DDDDEEEE | |
| Source | 1 | n/a | F | 0 = 2D GPS<br>1 = 3D GPS<br>2 = 2D DGPS<br>3 = 3D DGPS<br>6 = DR<br>8 = Degraded DR<br>9 = Unknown |
| Age of Data Indicator | 1 | n/a | G | 2 = Fresh, <10 sec<br>1 = Old, >10 sec<br>0 = Not available |
| Total number of characters is 22 | | | | |

Position is in latitude (positive north) and longitude (positive east) WGS-84. The GPS time of day is the time of fix rounded to the nearest second.

**Note –** The data in this message is to be considered invalid and should not be used, if the Age of Data Indicator is equal to 0 (signifying data not available).

## C.10   DC  Differential Corrections

The DC message provides the sensor with differential corrections from type-1 and type-9 RTCM-104 records. The numerical values are written out in hex format producing a two character hexadecimal number for each data byte.

Data String Format:

        AAAABBCC{DDEEEEFFGG}

**Table C-9      DC Delta Differential Corrections Data String Descriptions**

| Item | # of Char | Type | Units | Format |
|------|-----------|------|-------|--------|
| Modified Z-count | 4 | Word | .6 sec | AAAA |
| Station health | 2 | Byte | N/A | BB |
| Number of SVs | 2 | Byte | N/A | CC |
| The next five bytes (10 characters) are repeated for each SV. | | | | |
| SV PRN & scale factor | 2 | Byte | n/a | DD |
| Range correction | 4 | Word | RTCM-104 | EEEE |
| Range-rate correction | 2 | Byte | RTCM-104 | FF |
| IODE | 2 | Byte | n/a | GG |

Units and scale factors are defined by RTCM-104, version 2. The SV PRN and scale factor contains the SV PRN in the lower 5 bits and the scale factor in the higher 3 bits. The scale factor has only three acceptable values:

- 0 - Use with low scale factor
- 4 - Use with high scale factor
- 7 - Do not use

Range corrections are scaled by 0.02 meters for low scale factor and 0.32 m/sec for high scale factor.

**Note 1. –** DC and DD TAIP messages are used to enclose differential corrections within the TAIP format.

**Note 2. –** DC and DD messages used to input corrections require only one communications channel. When the auxiliary port is used to input RTCM 104 corrections, it assumes a separate communications channel is available for broadcast and receipt of differential corrections.

**Note 3. –** The TAIP Software Toolkit does not support DC and DD messages.

## C.11   DD  Delta Differential Corrections

This message provides the sensor with delta differential corrections from RTCM-104 record type 2. The values are numerical values written out in hex format, thus for each byte of data there is a two digit hex number.

The format of the data string is as follows:

    AAAABB{CCDDDD}

**Table C-10     DD Delta Differential Corrections Data String Descriptions**

| Item | # of Char | Type | Units | Format |
|------|-----------|------|-------|--------|
| Modified Z-count | 4 | Word | .6 sec | AAAA |
| Number of SVs | 2 | Byte | n/a | BB |
| The next 3 bytes (6 characters) are repeated for each SV | | | | |
| SV PRN | 2 | Byte | n/a | CC |
| Delta Range Correction | 4 | Word | RTCM-104 | DDDD |

**Note 1. –**  The units and scale factors are as defined by RTCM-104 version 1. The health/UDRE/scale factor given for the specific SV in the most recent message DC is used. Delta range corrections are scaled by 0.02 meters times 2 raised to the health power.

The DC and DD TAIP messages described herein apply only to differential ready sensors and are provided to enclose differential corrections within the TAIP format.

Use of DC and DD messages to input corrections requires only one communications channel. Use of the auxiliary port to input RTCM-104 corrections assumes a separate communications channel is available for broadcast and receipt of differential corrections.

**Note 2. –** The TAIP software toolkit, GPSSK, does not support DC and DD messages.

## C.12   ID   Identification Number

Data String Format:

    `AAAA`

**Table C-11     Identification Number Data String Descriptions**

| Item | # of Char | Units | Format |
|------|-----------|-------|--------|
| Vehicle ID | 4 | n/a | AAAA |
| Total number of characters is 4 | | | |

This message is used to report or set the vehicle's (or sensor's) unique, four character, alpha-numeric, user assigned ID. The default at cold start is 0000.

### C.12.1   Example

The following message will set the vehicle ID to 101.

    `>SID0101<`

The following is simply a response to a query for vehicle ID.

    `>RID0101<`

**Note –** The sensor will always check incoming messages for ID and compare with the vehicle ID set in the sensor's memory. If no ID is included in the message, the sensor will assume a match and accept the message. If the message sent to the sensor does contain a vehicle ID but that ID does not match the ID previously set in the sensor, the message will be ignored. This process is followed even when the ID_Flag is turned off (refer to the message RM).

## C.13    IP    Initial Position

Data String Format:

    AAABBBBCCCCC

**Table C-12    Initial Position Data String Descriptions**

| Item | # of Char | Units | Format |
|------|-----------|-------|--------|
| Initial Latitude | 3 | Deg | AAA |
| Initial Longitude | 4 | Deg | BBBB |
| Initial Altitude | 5 | 10 Meters | CCCCC |
| Total number of characters is 12 | | | |

This is a very coarse initial position that the user can provide to aid the sensor in obtaining its first fix. This is particularly useful with sensors that do not have non-volatile (Battery Backed-up) memory. In such cases, every time the unit is powered up, it goes through a complete cold-start and it has absolutely no knowledge of where it is. Providing this message improves performance by decreasing the time to first fix and enhances the accuracy of the initial two dimensional navigation solutions by providing a reference altitude. In case of units with non-volatile memory, sending this message is only helpful if the unit has moved more than 1,000 miles since its previous fix. In either case, the sensor can initialize itself appropriately without any data from the user; it merely requires more time.

**Note –** For all the above values, the first character specifies the sign (+/-).

## C.13.1    Example

The following message will set the initial position to 37$^o$ North, 122$^o$ West, altitude 10 meters.

    >SIP+37-122+0001<

## C.14   LN  Long Navigation Message

**Note –** The first character of latitude, longitude, altitude or vertical speed is "**+**" or "**-**".

Data String Format:

```
AAAAA.BBBCCCDDDDDDDEEEEFFFFFFFFGGGGGGGGHHIIIJKKKKLMMMNOOP
PQQPPQQ...PPQQRRRRRRRRRRST
```

**Table C-13    Long Navigation Message Data String Descriptions**

| Item | # of Char | Units | Format | Value |
|------|-----------|-------|--------|-------|
| GPS Time of day | 8 | Sec | AAAAA.BBB | |
| Latitude | 10 | Deg | CCC.DDDDDDD | |
| Longitude | 11 | Deg | EEEE.FFFFFFF | |
| Altitude above MSL | 9 | Ft | GGGGGGG.HH | |
| Horizontal Speed | 4 | MPH | III.J | |
| Vertical Speed | 5 | MPH | KKKK.L | |
| Heading | 4 | Deg | MMM.N | |
| Number of SVs used | 2 | n/a | OO | |
| SV Id (see note) | 2 | n/a | PP | |
| IODE (see note) | 2 | n/a | QQ | |
| Reserved | 10 | n/a | RRRRRRRRRR | |
| Source | 1 | n/a | S | 0 = 2D GPS<br>1 = 3D GPS<br>2 = 2D DGPS<br>3 = 3D DGPS<br>6 = DR<br>8 = Degraded DR<br>9 = Unknown |
| Age of Data Indicator | 1 | n/a | T | 2 = Fresh, <10 sec<br>1 = Old, >10 sec<br>0 = Not available |
| Total number of characters is 65+4x(number of SV's used) | | | | |

**Note 1. –** At least 2 satellites are required to get the LN Message.

Position is in Degrees, minutes, decimal minutes. And latitude is (positive north) and longitude (positive east) WGS-84. Heading is in degrees from True North increasing eastwardly. The GPS time of day is the time of fix rounded to the nearest second.

**Note 2. –** The data in this message is to be considered invalid and should not be used, if the Age of Data Indicator is equal to 0 (signifying data not available).

## C.15   PR Protocol

The protocol message (PR) is the method used to control which I/O protocols are active on each of the two ACE III GPS ports. Each protocol can be set to:

- Off

- Input Only

- Output Only

- Both Input and Output

The PR data string format is:

    [;TAIP=xy] [;TSIP=xy] [;NMEA=xy] [;RTCM=xy]

**Table C-14     PR Data String Descriptions**

| Item | # of Char | Units | Format | (Value) |
|------|-----------|-------|--------|---------|
| Port 1 Protocol | 1 | n/a | x | T = Both in and out<br>I = Input only<br>O= Output only<br>F = Off<br>N = Not available |
| Port 2 Protocol | 1 | n/a | y | T = Both in and out<br>I = Input only<br>O= Output only<br>F = Off<br>N = Not available |

Sending the following message will set the receiver to TAIP in and out on PORT 1, and RTCM in, NMEA out on PORT 2.

    >SPR;TAIP=TF;TSIP=FF;NMEA=FO;RTCM=FI<

**Note 1. –** There are two restrictions to setting protocols: RTCM is input only, and TAIP cannot be running on both ports at the same time.

**Note 2. –** If a protocol is not implemented within the application, x and/or y will have the value N, and any set message for that protocol is ignored.

It is possible to turn off all input processing on a port. If this is done, neither TAIP nor TSIP can be used to change the active protocols. The break sequence must used.

If you do not use battery back-up, all port characteristics will reset to the default after power is removed.

## C.16   PT  Port Characteristic

This message defines the characteristics for the <u>primary</u> TAIP port.

Data String Format:

    AAAA,B,C,D

**Table C-15     Port Characteristic Data String Descriptions**

| Item | # of Char | Units | Format | (Value) |
|------|-----------|-------|--------|---------|
| Baud Rate | 4 | n/a | *AAAA* | 9600, 4800, 2400, 1200, or 0300 |
| # of data bits | 1 | n/a | B | (7 or 8) |
| # of stop bits | 1 | n/a | C | (1 or 2) |
| Parity | 1 | n/a | D | ("N" = None)<br>("O" = Odd)<br>("E" = Even) |
| Total number of characters is10 (includes commas) | | | | |

Most TAIP using sensors use the following default port characteristics

- 4800 baud

- 8 data bits

- 1 stop bit

- No parity

**Note 1. –** The characteristics set by this message will be stored in the sensor's battery backed ram. The ACE III GPS family of sensors do not include an internal battery but provide a battery back-up input line that may be used to retain memory when main power is removed.

**Note 2. –** If you do not use battery back-up, all port characteristics will reset to the default after power is removed.

**Note 3. –** The PT command uses commas between data fields.

## C.17  PV  Position/Velocity Solution

**Note –** The first character of latitude or longitude is "**+**" or "**-**".

Data String Format:

        AAAAABBBCCCCCDDDDEEEEEFFFGGGHI

**Table C-16     Position/Velocity Solution Data String Descriptions**

| Item | # of Char | Units | Format | Value |
|------|-----------|-------|--------|-------|
| GPS Time of day | 5 | Sec | AAAAA | |
| Latitude | 8 | Deg | BBB.CCCCC | |
| Longitude | 9 | Deg | DDDD.EEEEE | |
| Speed | 3 | MPH | FFF | |
| Heading | 3 | Deg | GGG | |
| Source | 1 | n/a | H | 0 = 2D GPS<br>1 = 3D GPS<br>2 = 2D DGPS<br>3 = 3D DGPS<br>6 = DR<br>8 = Degraded DR<br>9 = Unknown |
| Age of Data Indicator | 1 | n/a | I | 2 = Fresh, <10 sec<br>1 = Old, >10 sec<br>0 = Not available |
| Total | 30 | | | |

Position is in latitude (positive north) and longitude (positive east) WGS-84. Heading is in degrees from True North increasing eastwardly. The GPS time of day is the time of fix rounded to the nearest second.

**Note –** The data in this message is to be considered invalid and should not be used, if the Age of Data Indicator is equal to 0 (signifying data not available).

## C.18   RM Reporting Mode

Data String Format:

```
[;ID_FLAG=A][;CS_FLAG=B][;EC_FLAG=C] [;FR_FLAG=D]
[;CR_FLAG=E]
```

**Table C-17     Reporting Mode Data String Descriptions**

| Item | # of Char | Units | Format | Value |
|------|-----------|-------|--------|-------|
| ID Flag | 1 | n/a | A | T = True<br>F = False |
| CS Flag | 1 | n/a | B | T = True<br>F = False |
| EC Flag | 1 | n/a | C | T = True<br>F = False |
| FR Flag | 1 | n/a | D | T = True<br>F = False |
| CR Flag | 1 | n/a | E | T = True<br>F = False |

ID Flag determines whether the unit is to include the vehicles ID with each report.

CS Flag determines whether the unit is to include a checksum as part of each message.

EC Flag, when set, will cause the unit to echo back all complete and properly formatted set commands, except for DC and DD, with a "Response qualifier". This provides an easy way to verify that the unit did in fact receive the intended data.

FR Flag indicates whether the unit is to report messages automatically per their individually scheduled frequency. When set to false, the unit will only respond when queried for a specific message.

CR Flag, when set to True, will cause the sensor to append a carriage return and line feed [CR] [LF] to the end of each message output. This is useful when viewing the unencoded sensor responses on a terminal or a PC.

The default value at start-up for ID flag and the CR flag is false; the default for CS, EC and FR flags is true.

### C.18.1   Example

The following command will turn checksums off and carriage return on:

```
>SRM;CS_FLAG=F;CR_FLAG=T<
```

**Note –** Note the use of semicolon before the flag name.

## C.19   RT  Reset Mode

Data String Format:

Any one of the following data strings can be set. Upper case characters are required.

[ ]

[COLD]

[FACTORY]

[SAVE_CONFIG]

**Table C-18     Reset Mode Data String Descriptions**

| Message | Description |
|---|---|
| >SRT< | Warm start |
| >SRTCOLD< | Cold start |
| >SRTFACTORY< | Factory reset |
| >SRTSAVE_CONFIG< | Save serial EEPROM user values |

The SAVE_CONFIG data string will save parameters entered in TSIP to SEEPROM (see Command Packet 0x8E-26 - SEEPROM Storage, page A-85).

To save parameters to a TAIP-speaking receiver, follow these steps:

1.     Change the protocol to TSIP using the TAIP PR command.

2.     Enter the parameters via TSIP commands (see section 3.7).

3.     Change the protocol to TAIP using TSIP command 0xBC.

4.     Save to SEEPROM using the TAIP command >SRTSAVE_CONFIG<.

## C.20   ST  Status

Data String Format:

      AABCDDEFGG

**Note –** This message provides information about the satellite tracking status and the operational health of the sensor. This information is contained in five status bytes which are output as five 2 digit hexadecimal values. The data format and the meanings of the hex characters are given in the following tables.

**Table C-19    Data String Hex Characters**

| Item | # of Char | Units | Format | Definition |
|------|-----------|-------|--------|------------|
| Tracking Status Code | 2 | n/a | AA | (see table below) |
| Status Codes - Nibble 1 | 1 | n/a | B | (see table below) |
| Status Codes - Nibble 2 | 1 | n/a | C | (see table below) |
| Machine ID | 2 | n/a | DD | |
| Status Codes - Nibble 3 | 1 | n/a | E | (not currently used) |
| Status Codes - Nibble 4 | 1 | n/a | F | (see table below) |
| Reserved | 2 | n/a | GG | (not currently used) |

**Table C-20    Tracking Status Codes**

| Value | AA Meaning |
|-------|------------|
| 00 | Doing position fixes |
| 01 | Don't have GPS time yet |
| 02 | Not used |
| 03 | PDOP is too high |
| 08 | No usable satellites |
| 09 | Only 1 usable satellite |
| 0A | Only 2 usable satellites |
| 0B | Only 3 usable satellites |
| 0C | Chosen satellite is unusable |

**Table C-21    Error Codes: Nibble 1**

| Value of B | Meaning |
|------------|---------|
| 0 | No problems reported |
| 2 | Antenna open |
| 6 | Antenna sport |

**Table C-22      Error codes: Nibble 2**

| Value of B | Meaning |
|---|---|
| 0 | No problems reported |
| 1 | Battery-backup failed; RAM not available at power-up (see Note) |

**Table C-23      Error Codes: Nibble 4**

| Value of B | Meaning |
|---|---|
| 0 | No problems reported |
| 2 | RTC not available at power-up (see Note) |
| 8 | Stored almanac not complete and current |
| A | RTC not available; stored almanac not complete and current |

**Note –** After the status is detected, this bit remains set until the sensor is reset.

## C.21   TM  Time/Date

Data String Format:

```
AABBCCDDDEEFFGGGGHHIJJKLLLLL
```

**Table C-24     TM Time/Data Data String Descriptions**

| Item | # of Char | Units | Format | (Value) |
|------|-----------|-------|--------|---------|
| Hours | 2 | Hour | AA | |
| Minutes | 2 | Min | BB | |
| Seconds | 5 | Sec | CC.DDD | |
| Date; Day | 2 | Day | EE | |
| Date; Month | 2 | Month | FF | |
| Date; Year | 4 | Year | GGGG | |
| GPS UTC Time Offset | 2 | Sec | HH | |
| Current Fix Source | 1 | n/a | I | 0 = 2D GPS<br>1 = 3D GPS<br>2 = 2D DGPS<br>3 = 3D DGPS<br>6 = DR<br>8 = Degraded DR<br>9 = Unknown |
| Number of Usable SVs | 2 | n/a | JJ | |
| GPS UTC Offset Flag | 1 | n/a | K | (1 = Valid)<br>(0 = Invalid) |
| Reserved | 5 | n/a | LLLLL | |
| Total | 28 | | | |

This message outputs the time and date as computed by the GPS sensor. The time is most accurate when the unit is doing fixes. It is less accurate but still usable when the unit is not doing fixes but the Number of Usable SVs is one or more. If the GPS UTC offset is available, the time will be in UTC. If not, the time will be in GPS.

**Note 1. –** GPS UTC Time Offset is the difference between GPS and UTC time standards in seconds. The UTC time of Day is only valid if the GPS UTC Offset Valid Flag is indicating valid.

**Note 2. –** The TM message is not supported under the Set qualifier.

## C.22   VR  Version Number

Data String Format:

```
XXXXXXX;VERSION A.AA(BB/BB/BB); CORE VERSION C.CC (DD/
DD/DD); E
```

**Table C-25     Version Number Data String Descriptions**

| Item | # of Char | Units | Format |
|------|-----------|-------|--------|
| Product Name | n/a | n/a | n/a |
| Major Version number | 4 | n/a | A.AA |
| Major Release Date | 8 | n/a | BB/BB/BB |

## C.23   X1  Extended Status

The ACE III GPS does not support this message.

## C.24   Communication Using TAIP

Communication with the unit takes place in four different ways. Message qualifiers are used to differentiate between these.

### C.24.1   Query for Single Sentence

The query (Q) message qualifier is used to query the GPS sensor to respond immediately with a specific message. The format is:

>QAA[;ID=BBBB][;*CC]<

where AA is the requested message identifier. Messages supported by this qualifier are AL, AP, CP, ID, IP, LN, PT, PV, RM, ST, TM, and VR.

### C.24.2   Scheduled Reporting Frequency Interval

The scheduled reporting frequency interval(F) message qualifier is used to tell the unit how often and when to report a specific message. The format is:

>FAABBBBCCCC[;ID=DDDD][;*FF]<

where sending this sentence tells the unit to report message specified by the two digit identifier AA at the time interval of BBBB seconds with time epoch at CCCC seconds from top of the hour. Specifying time interval of 0000 stops scheduled reporting of the message. The default is 0000 time interval for all messages except PV. The output frequency for PV at cold-start is set at once every five seconds, zero seconds from top of the hour. Messages supported by this qualifier are AL, AP, CP, ID, IP, LN, PT, PV, RM, ST, TM, and VR.

**Note –** The data specified by this qualifier is the timing of the message output and may be different from the time tag of the data in the message.

### C.24.3   The Response to Query or Scheduled Report

The response (R) qualifier carry various types of data between the unit and the user equipment. The format is:

>RAA[{B}][;ID=CCCC][;*DD]<

where AA is the two character message identifier and {B} specifies the data string within the message. For the format of {B}, please refer to the message definitions in the previous section. Messages supported by the response qualifier are AL, AP, CP, ID, IP, LN, PT, PV, RM, ST, TM, and VR.

### C.24.4  The Set Qualifier

The set (S) qualifier enables the user equipment to initialize/set-up various types of data in the GPS unit. The format is:

```
>SAA[{B}][;ID=CCCC][;*DD]<
```

where AA is the two character message identifier and {B} specifies the data string within the message. For the format of {B}, please refer to the message definitions in the previous section. Note that all the messages have very specific formats and are length dependent. Messages normally supported by the set qualifier are AL, AP, CP, DC, DD, ID, IP, LN, PT, PV, and RM.

The set qualifier may be used with the AL, CP, LN, or PV message to set more precise initial position data into the GPS sensor than can be set with the IP message.

### C.24.5    Sample Communication Session

The following is a sample communication session to illustrate how message qualifiers are used. Query the sensor for version number for the TAIP firmware:

>QVR<

The sensor responds with a message in the following form:

>RVR OEM SK8 OEM STTP APP; VERSION 7.52 (05/23/97);*38<

**Note** – The sensor identified its product name, firmware version number, core signal processing version number, and release dates, then included the checksum for the message (the default for the CS Flag is TRUE). Also notice that the sensor did respond to our query even though we did not send a checksum.

Query the sensor for its ID number:

>QID<

The sensor will respond (assuming factory default settings):

>RID0000;*70<

Set the ID to match the number for a vehicle in your fleet and then tell the sensor to include the Vehicle ID in its responses:

>SID1234<

>SRM;ID_FLAG=T<

The ACE III GPS sensor is set by default to report the PV message once every 5 seconds. To schedule the PV message from vehicle 1234 to respond once every 10 seconds, starting at 5 seconds after the top of the hour, use the following command:

>FPV00100005;ID=1234<

The sensor will check the ID included in the message for a match with its own and then reschedule the PV message. At the next scheduled time, the sensor will respond with:

>RPV15714+3739438-1220384601512612;ID=1234;*7F<

**Note** – The time given in the message is the time of the last GPS fix (04:21:54 GPS), not necessarily the time of the message response. If the time of last fix is 10 or more seconds old, the age flag will be set to 1.

# D   GPSSK User's Guide (TAIP)

The TAIP Tool Kit, known as GPSSK is a software package available from Trimble Navigation to assist users of the Trimble ASCII Interface Protocol (TAIP). GPSSK supports all Trimble sensors that use TAIP.

GPSSK can be used to setup, diagnose, and monitor your sensor and provides the following capabilities:

- Program the GPS sensor for automatic message reporting and verify the success of the programming.

- Quickly program Vehicle ID numbers into a fleet of sensors.

- Log the GPSSK session with the GPS sensor to disk and replay the data.

- On-screen plotting of GPS positions from the sensor.

- Poll for and view combinations of TAIP messages.

- Set different polling intervals for each message type.

- Conduct an interactive terminal session with the GPS sensor.

**Note –** The information about GPSSK in this document is presented as a general overview. The GPSSK distribution diskette includes a READ.ME file that details the most current information about GPSSK functions and on loading and using GPSSK.

The GPSSK program does not support the TAIP messages DC and DD. These messages are used to input differential corrections to the receiver and are defined as special TAIP format versions of RTCM SC-104 Type 1 and Type 2 messages.

The GPSSK program requires well over 500K RAM. It may not run in a DOS window, and may require removal of TSRs.

## D.1     The GPSSK Files

GPSSK is included on the 3.5 inch DOS formatted GPS Toolkit diskette. The diskette contains the following GPSSK related files:

- GPSSK.EXE       The executable GPSSK program

- GPSSK.HLP       The on-line, context-sensitive help file

- READ.ME          Current information about GPSSK

- TAIP.C              Sample source code for encoding and decoding TAIP

## D.2    TAIP.C Source File

The sample source code for encoding and decoding TAIP messages is provided as a guide for the system integrator who is developing a communications controller that handles TAIP. There is no warranty of any kind on this software. Use it at your own risk.

The distribution diskette is not copy protected. Before using GPSSK or installing on your hard disk, make a working copy and put the original diskette in a safe place. During normal use, GPSSK will save configuration information to the diskette or current directory. Storing the original diskette away will allow you to restore the original configuration should you encounter problems.

Copy the files GPSSK.EXE and GPSSK.HLP to a hard disk directory.

## D.3    GPSSK Start-up

At the DOS prompt in the directory containing GPSSK, enter the command:

```
GPSSK
```

When the program is finished loading into memory, the GPSSK title page will be displayed. The program will then wait for 10 seconds to begin normal execution; you may bypass the 10 second wait by pressing any key after the title page is displayed.

The function key menu will be displayed on the bottom of the screen. GPSSK is structured as a hierarchy of menus. The function keys control access to the menus.

To terminate GPSSK, simply back out of the menu structure by pressing F9 until GPSSK prompts you to confirm your desire to exit the program.

At start-up, GPSSK will attempt to initialize itself by querying the sensor for some basic information. If you wish to abort the sensor initialization process and use GPSSK to replay stored data, enter Ctrl + X (hold down the control key and press x). If initialization has been aborted, you must restart GPSSK when you wish to communicate with the sensor.

## D.4    On-line Help

Once GPSSK is running, on-line help is available to assist in performing all the GPSSK operations. Help is context sensitive and will display information regarding the current display or menu. A brief overview of GPSSK is available in the main menu's help screen.

There are several command line options available. For help with command line options, run GPSSK with the /HELP argument:

```
GPSSK /HELP
```

The help available on the GPSSK main menu will explain menu operation and the menu hierarchy.

## D.5    Connecting the GPS Sensor

Consult the *Installation and Operator's Manual* for information on installation, power requirements and cables specific to your ACE III GPS sensor.

Connect the serial port of the sensor to the computer's COM1 or COM2 port. The default serial port settings for GPSSK are:

- 4800 baud

- 8 data bits

- 1 stop bit

- no parity

These default settings match the default settings for the ACE III GPS sensor. Consult the *Installation and Operator's Manual* for the actual default settings and type of serial port on your sensor.

If the sensor is connected to COM2, start GPSSK by entering the command:

```
GPSSK /2
```

**Note –** A null modem may be required when connecting the sensor to a personal computer. The serial port on your computer is a DTE port (data terminal equipment) designed to connect to a DCE port (data communications equipment). If your sensor's serial port is DTE, you must use a null modem adapter.

# E  NMEA 0183

NMEA 0183 is an interface protocol created by the National Marine Electronics Association. The latest release of NMEA 0183 is Version 2.1 (October 15, 1995). This protocol was originally established to allow marine navigation equipment to share information. NMEA 0183 is a simple, yet comprehensive ASCII protocol which defines both the communication interface and the data format. Since it is a well established industry standard, NMEA 0183 has also gained popularity for use in applications other than marine electronics.

For those applications requiring output only from the GPS receiver, NMEA 0183 is a popular choice since, in many cases, an NMEA 0183 software application code already exists. The ACE III GPS receiver is available with firmware that supports a subset of the NMEA 0183 messages: GGA and VTG. For a nominal fee, Trimble can offer custom firmware with a different selection of messages to meet your application requirements.

This appendix provides a brief overview of the NMEA protocol and describes both the standard and optional messages offered by the ACE III GPS.

For a complete copy of the NMEA 0183 standard, contact:

NMEA National Office
PO Box 3435
New Bern, NC 28564-3435
U.S.A.
Telephone: +1-919-638-2626
Fax: +1-919-638-4885

## E.1    The NMEA 0183 Communication Interface

NMEA 0183 allows a single source (talker) to transmit serial data over a single twisted wire pair to one or more receivers (listeners). The table below lists the characteristics of the NMEA 0183 data transmissions.

**Table E-1      NMEA 0183 Characteristics**

| Signal Characteristic | NMEA Standard |
|---|---|
| Baud Rate | 4800 |
| Data Bits | 8 |
| Parity | None (Disabled) |
| Stop Bits | 1 |

## E.2    NMEA 0183 Message Format

The NMEA 0183 protocol covers a broad array of navigation data. This broad array of information is separated into discrete messages which convey a specific set of information. The entire protocol encompasses over 50 messages, but only a sub-set of these messages apply to a GPS receiver like the ACE III GPS. The NMEA message structure is described below.

```
$IDMSG,D1,D2,D3,D4,.......,Dn*CS[CR][LF]
```

| | |
|---|---|
| "$" | The "$" signifies the start of a message. |
| ID | The talker identification is a two letter mnemonic which describes the source of the navigation information. The GP identification signifies a GPS source. |
| MSG | The message identification is a three letter mnemonic which describes the message content and the number and order of the data fields. |
| "," | Commas serve as delimiters for the data fields. |
| Dn | Each message contains multiple data fields (Dn) which are delimited by commas. |
| "*" | The asterisk serves as a checksum delimiter. |
| CS | The checksum field contains two ASCII characters which indicate the hexadecimal value of the checksum. |
| [CR][LF] | The carriage return [CR] and line feed [LF] combination terminate the message. |

NMEA 0183 messages vary in length, but each message is limited to 79 characters or less. This length limitation excludes the "$" and the [CR][LF]. The data field block, including delimiters, is limited to 74 characters or less.

## E.3    NMEA 0183 Message Options

The ACE III GPS can output any or all of the messages listed in Table E-2. In its default configuration (as shipped from the factory), the ACE III GPS outputs two messages: GGA (NMEA Version 2.1) and VTG. These messages are output at a 1 second interval with the "GP" talker ID and checksums.

**Note –** The user can configure a custom mix of the messages listed in Appendix E-2, ACE III GPS NMEA Messages. See Configuring the ACE III GPS Receiver Protocols, page 3-7 in Chapter 3, and TSIP command packets 0xBC, 0x7A, and 8E-26 in Appendix A for details on configuring NMEA output.

**Warning –** If too many messages are specified for output, you may need to increase the unit's baud rate.

**Table E-2        ACE III GPS NMEA Messages**

| Setting | Message | Description |
|---------|---------|-------------|
| Default | GGA | GPS fix data (NMEA Version 2.1) |
|         | GLL | Geographic position - Latitude/Longitude |
|         | GSA | GPS DOP and active satellites |
|         | GSV | GPS satellites in view |
|         | RMC | Recommended minimum specific GPS/Transit data |
| Default | VTG | Track made good and ground speed |
|         | ZDA | Time & Date |

The format for each message in Appendix E-2, ACE III GPS NMEA Messages is described in more detail in the next section.

## E.4     NMEA 0183 Message Formats

### E.4.1     GGA - GPS Fix Data

The GGA message includes time, position and fix related data for the GPS receiver.

```
$GP GGA,hhmmss,llll.lll,a,nnnnn.nnn,b,t,uu,v.v,w.w,M,
x.x,M,y.y,zzzz*hh <CR><LF>
```

**Table E-3     GGA - GPS Fix Data Message Parameters**

| Field | Description |
|---|---|
| 1 | UTC of Position |
| 2,3 | Latitude, N (North) or S (South) |
| 4,5 | Longitude, E (East) or W (West) |
| 6 | GPS Quality Indicator: 0 = No GPS, 1 = GPS, 2 = DGPS |
| 7 | Number of Satellites in Use |
| 8 | Horizontal Dilution of Precision (HDOP) |
| 9, 10 | Antenna Altitude in Meters, M = Meters |
| 11, 12 | Geoidal Separation in Meters, M=Meters. Geoidal separation is the difference between the WGS-84 earth ellipsoid and mean-sea-level. |
| 13 | Age of Differential GPS Data. Time in seconds since the last Type 1 or 9 Update |
| 14 | Differential Reference Station ID (0000 to 1023) |
| hh | Checksum |

### E.4.2     GLL - Geographic Position - Latitude/Longitude

The GLL message contains the latitude and longitude of the present vessel position, the time of the position fix and the status.

```
$GP GLL,llll.lll,a,yyyyy.yyy,a,hhmmss.s,A*hh<CR><LF>
```

**Table E-4     GLL - Geographic Position - Latitude / Longitude Message Parameters**

| Field # | Description |
|---|---|
| 1,2 | Latitude, N (North) or S (South) |
| 3,4 | Longitude, E (East) or W (West) |
| 5 | UTC of position |
| 6 | Status: A = Valid, V= Invalid |
| hh | Checksum |

### E.4.3        GSA - GPS DOP and Active Satellites

The GSA messages indicates the GPS receiver's operating mode and lists the satellites used for navigation and the DOP values of the position solution.

```
$GP GSA,a,x,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,x.x,
x.x,x.x*hh<CR><LF>
```

**Table E-5        GSA - GPS DOP and Active Satellites Message Parameters**

| Field # | Description |
|---------|-------------|
| 1 | Mode: M = Manual, A = Automatic. In manual mode, the receiver is forced to operate in either 2D or 3D mode. In automatic mode, the receiver is allowed to switch between 2D and 3D modes subject to the PDOP and satellite masks. |
| 2 | Current Mode: 1 = fix not available, 2 = 2D, 3 = 3D |
| 3 to 14 | PRN numbers of the satellites used in the position solution. When less than 12 satellites are used, the unused fields are null |
| 15 | Position dilution of precision (PDOP) |
| 16 | Horizontal dilution of precision (HDOP) |
| 17 | Vertical dilution of precision (VDOP) |
| hh | Checksum |

### E.4.4    GSV - GPS Satellites in View

The GSV message identifies the GPS satellites in view, including their PRN number, elevation, azimuth and SNR value. Each message contains data for four satellites. Second and third messages are sent when more than 4 satellites are in view. Fields #1 and #2 indicate the total number of messages being sent and the number of each message respectively.

```
$GP GSV,x,x,xx,xx,xx,xxx,xx,xx,xx,xxx,xx,xx,xx,xxx,
xx,xx,xx,xxx,xx*hh<CR><LF>
```

**Table E-6    GSV - GPS Satellites in View Message Parameters**

| Field #       | Description                                             |
|---------------|---------------------------------------------------------|
| 1             | Total number of GSV messages                            |
| 2             | Message number: 1 to 3                                  |
| 3             | Total number of satellites in view                      |
| 4             | Satellite PRN number                                    |
| 5             | Satellite elevation in degrees (90° Maximum)            |
| 6             | Satellite azimuth in degrees true (000 to 359)          |
| 7             | Satellite SNR (C/No), null when not tracking            |
| 8,9,10,11     | PRN, elevation, azimuth and SNR for second satellite    |
| 12,13,14,15   | PRN, elevation, azimuth and SNR for third satellite     |
| 16,17,18,19   | PRN, elevation, azimuth and SNR for fourth satellite    |
| hh            | Checksum                                                |

### E.4.5    RMC - Recommended Minimum Specific GPS/Transit Data

The RMC message contains the time, date, position, course, and speed data provided by the GPS navigation receiver. A checksum is mandatory for this message and the transmission interval may not exceed 2 seconds. All data fields must be provided unless the data is temporarily unavailable. Null fields may be used when data is temporarily unavailable.

```
$GP RMC,hhmmss.s,A,llll.lll,a,yyyyy.yyy,a,x.x,x.x,
xxxxxx,x.x,a*hh<CR><LF>
```

**Table E-7      RMC - Recommended Minimum Specific GPS / Transit Data Message Parameters**

| Field # | Description |
|---------|-------------|
| 1 | UTC of Position Fix. |
| 2 | Status: A = Valid, V = navigation receiver warning |
| 3,4 | Latitude, N (North) or S (South). |
| 5,6 | Longitude, E (East) or W (West). |
| 7 | Speed over the ground (SOG) in knots |
| 8 | Track made good in degrees true. |
| 9 | Date: dd/mm/yy |
| 10,11 | Magnetic variation in degrees, E = East / W= West |
| hh | Checksum (Mandatory for RMC) |

### E.4.6    VTG - Track Made Good and Ground Speed

The VTG message conveys the actual track made good (COG) and the speed relative to the ground (SOG).

```
$GP VTG,x.x,T,x.x,M,x.x,N,x.x,K*hh<CR><LF>
```

**Table E-8      VTG - Track Made Good and Ground Speed Message Parameters**

| Field # | Description |
|---------|-------------|
| 1 | Track made good in degrees true. |
| 2 | Track made good in degrees magnetic. |
| 3,4 | Speed over the ground (SOG) in knots. |
| 5,6 | Speed over the ground (SOG) in kilometer per hour. |
| hh | Checksum |

### E.4.7    ZDA - Time & Date

The ZDA message contains UTC, the day, the month, the year and the local time zone.

```
$GP ZDA,hhmmss.s,xx,xx,xxxx,,*hh<CR><LF>
```

**Table E-9      ZDA - Time & Date Message Parameters**

| Field # | Description |
|---------|-------------|
| 1 | UTC |
| 2 | Day (01 to 31) |
| 3 | Month (01 to 12) |
| 4 | Year |
| 5 | unused |
| 6 | unused |
| hh | Checksum |

**Note –** Fields #5 and #6 are null fields in the ACE III GPS output. A GPS receiver cannot independently identify the local time zone offsets.

**Caution –** If UTC offset is not available, time output will be in GPS time.

**Note –** GPS time can be used as a timetag for the 1PPS. The ZDA message comes out 100-500 msec after the PPS.

# F   ACE III GPS Specifications and Mechanical Drawings

The ACE III GPS module is designed for embedded industrial computing or control, mobile computing or data collection, precision timing, and vehicle tracking applications. This appendix includes the system specifications and mechanical drawings for the ACE III GPS receiver module and the miniature magnetic mount GPS antenna.

**Table F-1     Environmental Specifications**

| | |
|---|---|
| **Operational Temperature** | -40°C to +85°C |
| **Storage Temperature** | -55°C to +105°C |
| **SMDevice Reflow** | ± 0.5 ppm max change after 240°C for 20 seconds |
| **Shock** | ± 0.5 ppm max change after 5000G 6 msec .5 sine |
| **G Sensitivity** | ± 0.100 5 ppm max per G |
| **Vibration** | ± 0.5 ppm max change — $0.008g^2$/Hz to 20Hz<br>±0.5 ppm max change — $0.05g^2$/Hz to 100Hz<br>-3 dB/octave — 100Hz to 900 Hz<br>Specifications comply with SAE J1211 requirements |
| **Altitude** | -400 to +18,000 meters MSL |
| **Humidity** | 95% R.H. non-condensing @ +60°C |
| **Velocity** | 515 m/sec. (maximum) |
| **Acceleration** | 4g (39.2 m/sec.$^2$) |
| **Jerk** | 20 m/sec.$^3$ |

**Table F-2     Mechanical Specifications**

| | |
|---|---|
| **Size** | Receiver board: 82.6 mm x 46.5 mm x 14.9 mm (3.25" x 1.83" x 0.587") |
| **Weight** | Receiver board: 28.3 g (1.0 oz) without optional shield |
| **Prime Power** | +5 volts DC (±5%); 95 mA without antenna |
| **RAM Backup** | optional +3.2 - +5.25 volts DC input via 8-pin header J4; 4 micro amp |
| **Electrodes** | Gold |
| **Markings on Top** | 5-digit Crystal Frequency, Manufacturer Name or Logo, Date Code or Lot Number |

**Table F-3    Electrical Specifications**

| Operating Frequency | 12.504 MHz |
|---|---|
| Crystal Frequency | 12.504 MHz, Fundamental Mode |
| Tolerance | ±1 ppm @ room temp |
| Temperature Stability | 2.5 ppm /°C |

**Table F-4    GPS Receiver**

| General | L1 frequency (1575.42 MHz), C/A code (Standard Positioning Service), 8-channel, continuous tracking receiver, 32 correlator |
|---|---|
| Datum | WGS-84 (standard DMA datum set) |

**Table F-5    GPS Accuracy**

| Accuracy | Position | 25 meters CEP (Circular Error Probability) (50%) without SA (Selective Availability) |
|---|---|---|
| | Velocity | 0.1 m/sec. (1 Sigma) steady state conditions (without SA) |
| | Time | UTC to nearest microsecond with 1 pulse per second available |
| DGPS Accuracy | Position | 2 meters CEP (50%) |
| | Velocity | 0.05 m/sec. (1 Sigma) steady state conditions |
| | Time | ±500 nanosecond (nominal) |
| Acquisition Rate | Cold Start | <3 minutes (90%) |
| | Warm Start | <45 seconds (90%) |
| | Hot Start | <20 seconds (90%) |

**Table F-6    Input/Output Specifications**

| Interface | Two TTL level, bi-directional, serial I/O ports on J3 8-pin header |
|---|---|
| Protocols Available | Trimble Standard Interface Protocol (TSIP); binary data I/O provides maximum bi-directional control over all GPS board functions. Sample C source code interface routines are available. |
| | Trimble ASCII Interface Protocol (TAIP); ASCII message data for I/O control over a serial communication link. Controls scheduled and polled responses from the GPS receiver. Sample C source code interface routines are available. |
| | NMEA 0183: Industry standard ASCII protocol for marine electronics applications. Supports NMEA sentences GGA, VTG, GLL, ZDA, and GSV, GSA, RMC. Note: GGA and VTG are factory default messages. |

**Table F-7      Pulse Per Second Specifications**

| | |
|---|---|
| **Timing** | Under nor al conditions, in the middle latitudes, the rising edge of the pulse is synchronized to UTC within 100 ns, one Sigma. |
| **Pulse Width** | 10 microsecond wide pulse; rising edge is 20 nanoseconds or less, depending upon distributed capacitance in cable |
| **Output** | TTL level signal |

**Figure F-1     ACE III GPS Circuit Board**
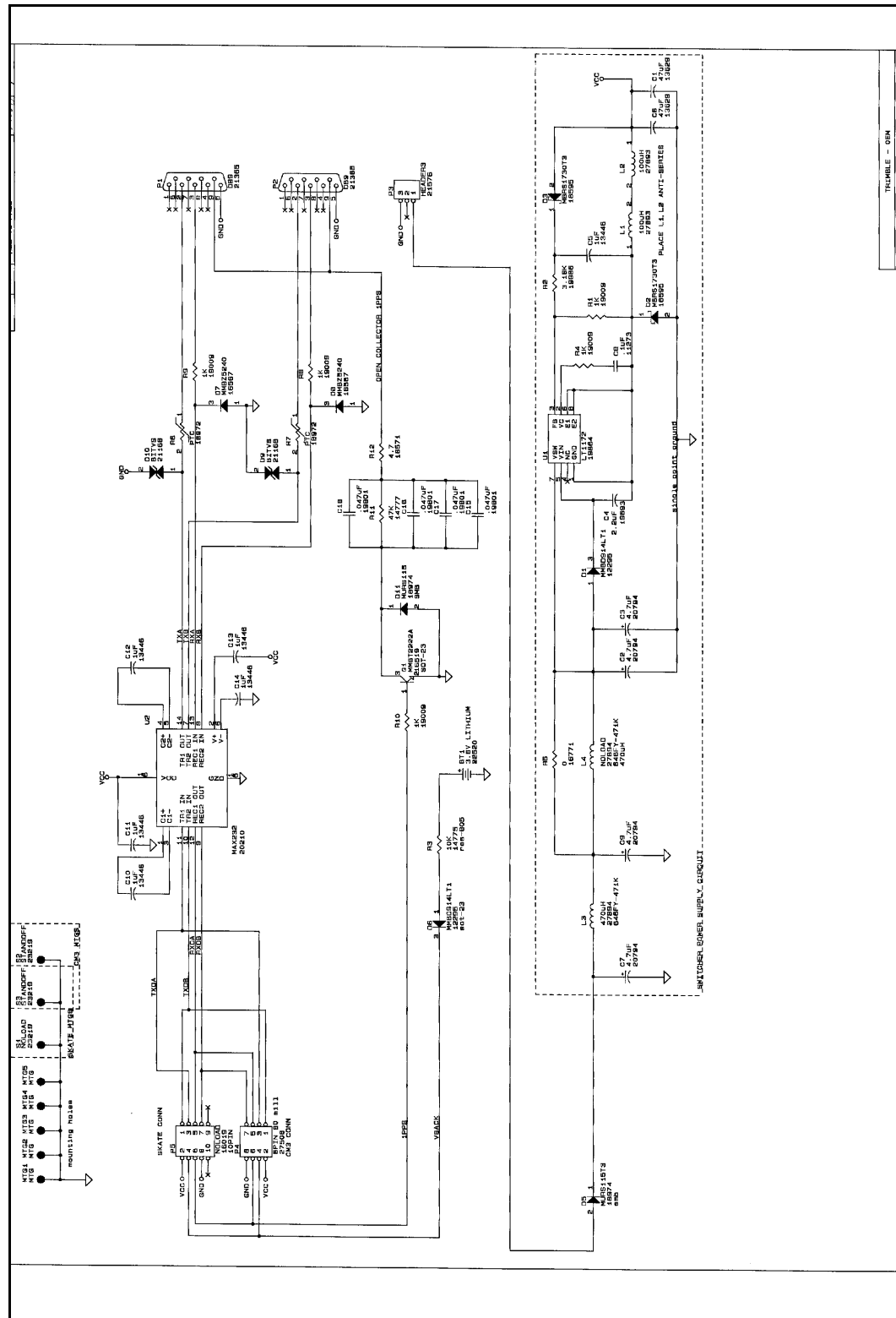
**Figure F-2     ACE III GPS Starter Kit Motherboard**
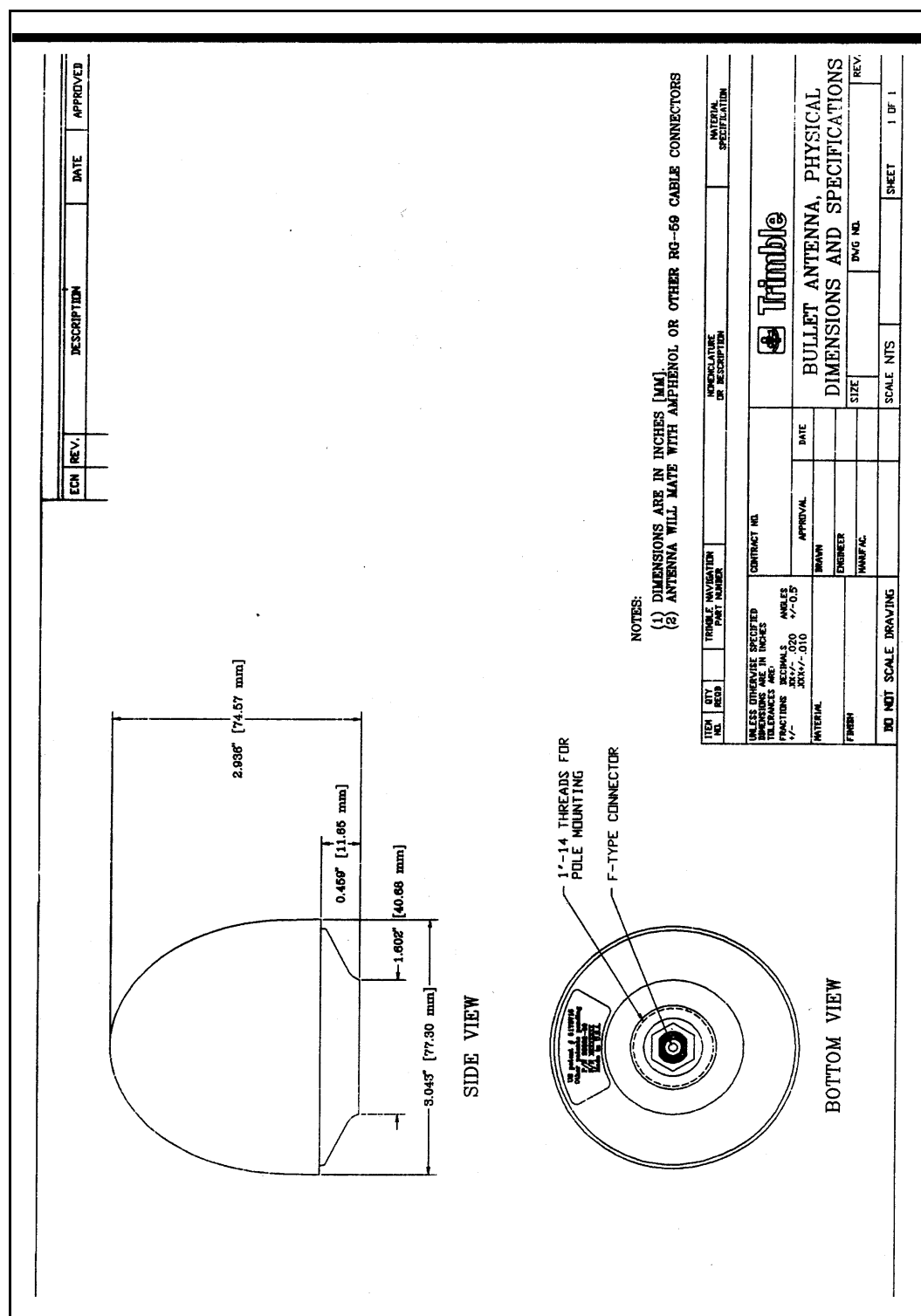
**Figure F-3     Bullet II Antenna**
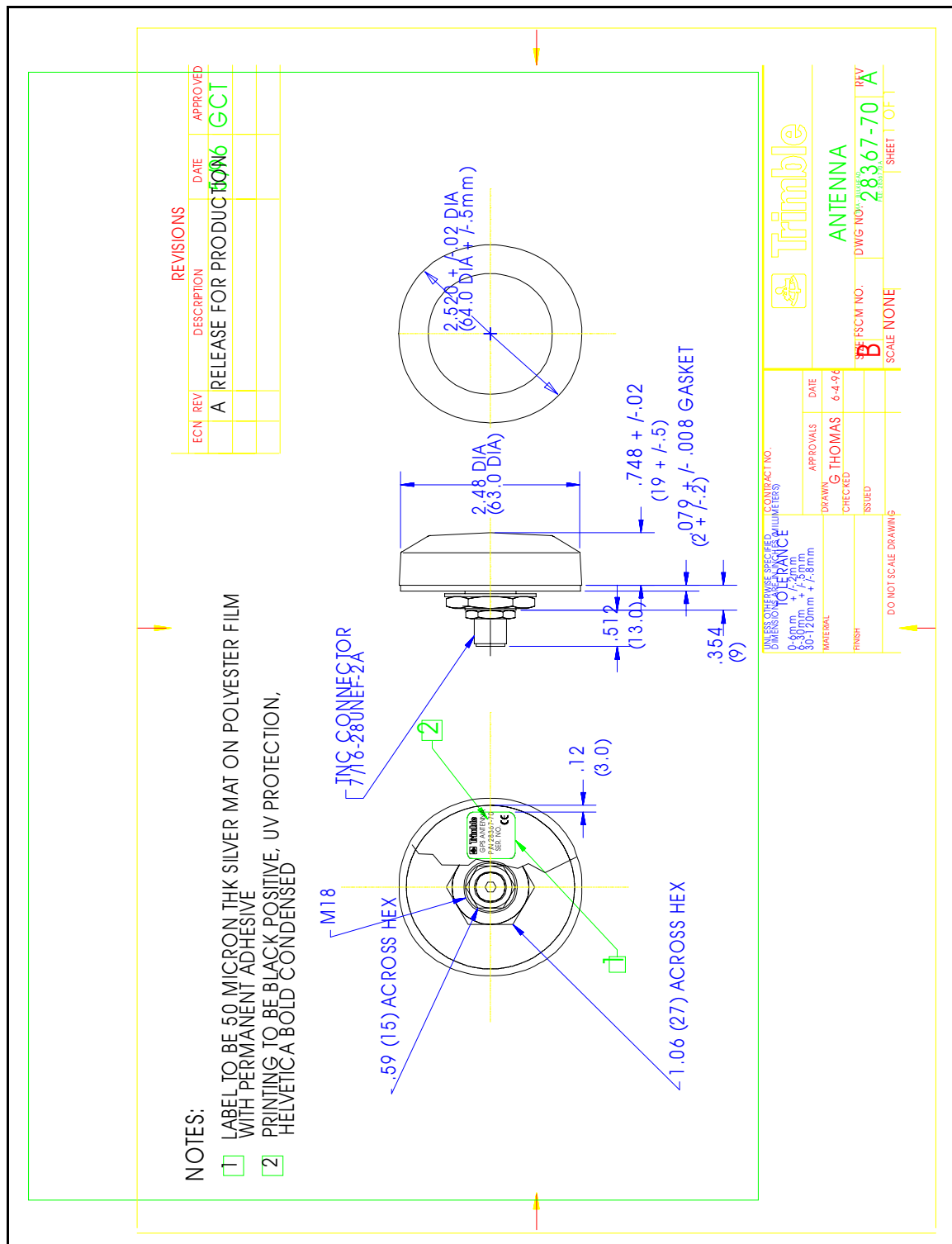
**Figure F-4     Bulkhead Antenna**
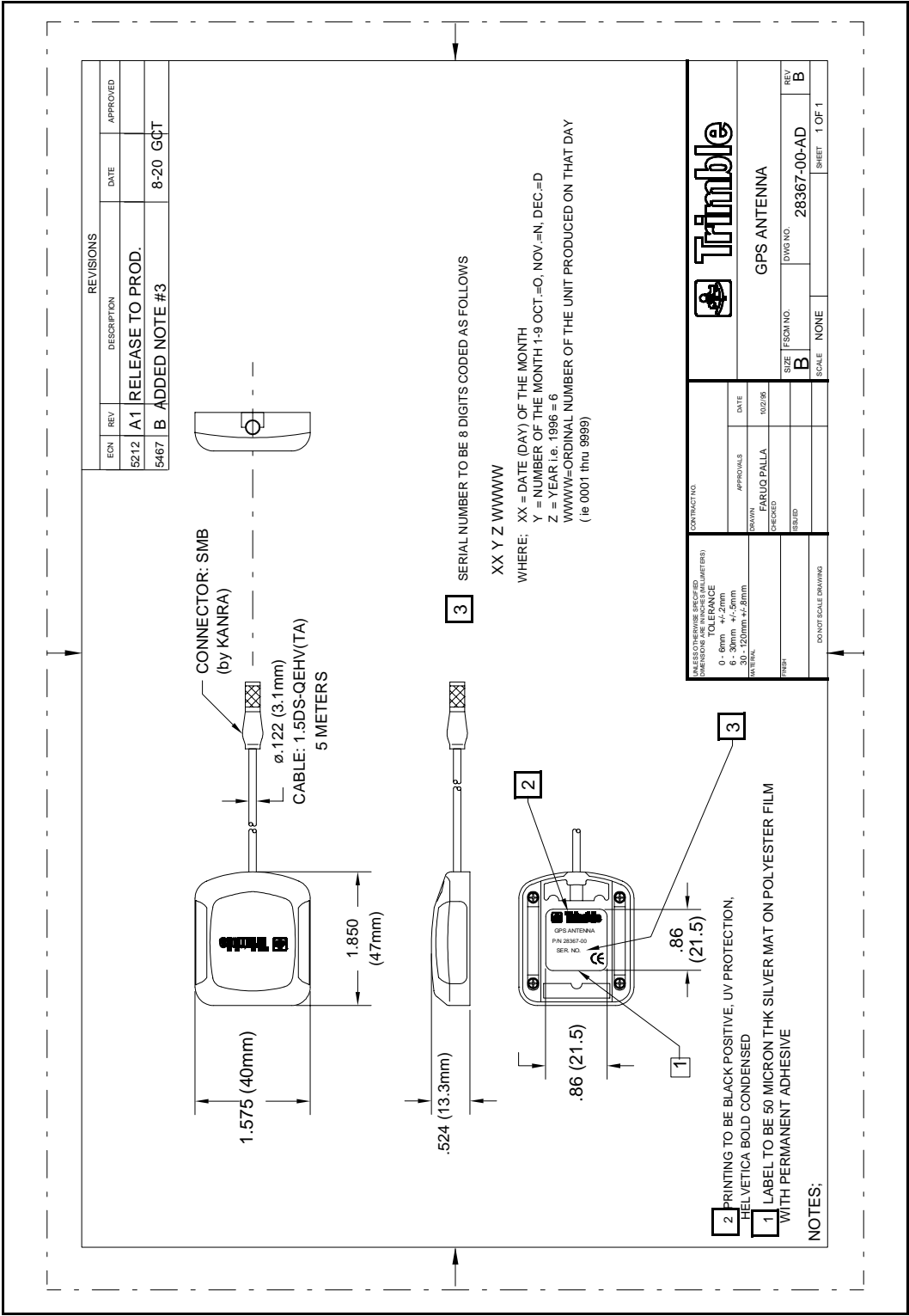
**Figure F-5    GPS Miniature Antenna**

# Glossary

This section defines technical terms and abbreviations used in this manual. It includes terms from the field of GPS technology.

**2D GPS mode**
A procedure of determining a 2D position using signals received from the best (or only) three available GPS satellites. Altitude is assumed to be known and constant. A 2D position solution will only be determined if signals from three or more satellites are available.

**2 dRMS**
Twice the distance root mean squared. The error distance within which 95% of the position solutions will fall.

**3D**
Three Dimensional. A 3D position is defined as latitude, longitude, and altitude.

**2D**
Two Dimensional. A 2D position is defined as latitude, longitude, and altitude.

**3D GPS mode**
A procedure of determining a 3D position using signals received from the best (or only) four available GPS satellites. A 3D position solution will only be determined if signals from four or more satellites are available.

**almanac**
A reduced-precision subset of the ephemeris parameters. Used by the receiver to compute the elevation angle, azimuth angle, and estimated Doppler of the satellites. Each satellite broadcasts the almanac for all the satellites in the system.

**ASCII**
American Standard Code for Information Interchange. A standard set of 128 characters, symbols and control codes used for computer communications. ASCII characters require 7 bits of data to send, but are often sent 8 bits at a time with the extra bit being a zero.

**asynchronous communication**
A method of sending data in which the bits can be sent at random times. Data transmission is not synchronized to a clock. With asynchronous transmission, each character is transmitted one at a time with a "start" bit at the beginning and one or more "stop" bits at the end. Any amount of time can elapse before the next character is sent. \

**auto GPS mode**
A procedure of automatically determining either a 2D or 3D position using signals received from GPS satellites. The solution automatically transitions between 2D and 3D depending on the number of satellites available, the PDOP of the available satellites, and the defined PDOP switch value. (See PDOP and PDOP constellation switch).

**azimuth angle**
The angle of the line-of-site vector, projected on the horizontal plane, measured clockwise from true North.

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| **bandwidth** | The range of frequencies occupied by a signal. Also, the information carrying capability of a communication channel or line. |
| **baud** | A measure of the speed of data transmission. Baud and bit rate are the same for direct equipment interconnections (e.g., via RS-232). Baud and bit rate are not the same for modulated data links, whether wire or radio. |
| **bit** | Binary digit. The smallest unit of information into which digital data can be subdivided and which a computer can hold. Each bit has only two values (e.g., on/off, one/zero, true/false). |
| **bit rate** | The rate at which bits are transmitted over a communication path. Normally expressed in bits per second (bps). |
| **byte** | A set of contiguous bits that make up a discrete item of information. A byte usually consists of a series of 8 bits, and represents one character. |
| **C/A code** | The Coarse/Acquisition code. This is the civilian code made available by the Department of Defense. It is subject to selective availability (SA). Users can reduce the effects of SA by using differential GPS. |
| **carrier** | The radio signal on which information is carried. The carrier can be sensed to determine the presence of a signal. |
| **channel** | Either a single frequency or a pair of radio frequencies used as a communication path. |
| **chip** | The length of time to transmit either a zero or a one in a binary pulse code. |
| **chip rate** | Number of chips per second (e.g., C/A code = 1.023 MHz). |
| **configuration** | A set of conditions or parameters that define the structure of an item. A configuration defines the GPS processing and characteristics of the RS-232 interface ports. The term configuration can also define the hardware components that comprise a subsystem or system. |
| **data bits** | The bits in a byte of data which carry the actual information. |
| **datum** | Refers to a mathematical model of the earth. Many local datums model the earth for a small region: e.g., Tokyo datum, Alaska, NAD-27 (North America). Others, WGS-84, for example, model the whole earth. |
| **DCE** | Data Communications Equipment. The equipment that provides the functions required to establish, maintain, and terminate a communication connection. Any equipment that connects to DTE using an RS-232 or CCITT V.24 standard interface. |
| **default setting** | A preset or initial value that is assumed to be the preferred or appropriate selection for most situations. The ACE GPS sensor is shipped with factory default configuration settings; the settings were determined by Trimble Navigation. |
| **DGPS** | see *differential GPS* |
| **DGPS reference station** | A device that tracks all GPS satellites in view, periodically performs inter-channel calibrations, and calculates and transmits differential corrections. |

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| **differential capable** | A term used to describe a GPS receiver that is capable of receiving and applying differential GPS corrections. |
| **differential GPS** | A procedure of correcting GPS solutions to achieve improved position accuracy. Differential GPS provides 2 to 5 meter position accuracy. Differential accuracy is obtained by applying corrections determined by the stationary Differential GPS Reference Station to the GPS data collected by the RPU unit on-board the vehicle. |
| **differential processing** | GPS measurements can be differenced between receivers, satellites, and epochs. Although many combinations are possible, the present convention for differential processing of GPS phase measurements is to take differences between receivers (single difference), then between satellites (double difference), then between measurement epochs (triple difference). |
| **differential relative positioning** | Determination of relative coordinates of two or more receivers which are simultaneously tracking the same satellites. Static differential GPS involves determining baseline vectors between pairs of receivers. Also see *differential GPS* |
| **dilution of precision** | A description of the purely geometrical contribution to the uncertainty in a position fix, given by the expression DOP = SQRT TRACE (AA) where AA is the design matrix for the instantaneous position solution (dependent on satellite-receiver geometry). The DOP factor depends on the parameters of the position-fix solution. Standard terms for the GPS application are: |
| | GDOP: Geometric (three position coordinates plus clock offset in the solution) |
| | PDOP: Position (three coordinates) |
| | HDOP: Horizontal (two horizontal coordinates) |
| | VDOP: Vertical (height only) |
| | TDOP: Time (clock offset only) |
| **DOP** | see *dilution of precision*. |
| **Doppler aiding** | The use of Doppler carrier-phase measurements to smooth code-phase position measurements. |
| **Doppler shift** | The apparent change in frequency of a received signal due to the rate of change of the range between the transmitter and receiver. |
| **earth-centered earth-fixed** | Cartesian coordinate system where the X direction is the intersection of the prime meridian (Greenwich) with the equator. The vectors rotate with the earth. Z is the direction of the spin axis. |
| **elevation angle** | The angle between the line of sight vector and the horizontal plane. |

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| **elevation mask angle** | A measure of the minimum elevation angle, above the horizon, above which a GPS satellite must be located before the signals from the satellite will be used to compute a GPS location solution. Satellites below the elevation angle are considered unusable. The elevation mask angle is used to prevent the GPS receiver from computing position solutions using satellites which are likely to be obscured by buildings or mountains. |
| **ellipsoid** | In geodesy, unless otherwise specified, a mathematical figure formed by revolving an ellipse about its minor axis. It is often used interchangeably with spheroid. Two quantities define an ellipsoid; these are usually given as the length of the semimajor axis, a, and the flattening, $f = (a - b)/a$, where b is the length of the semiminor axis. |
| **ephemeris** | A set of parameters that describe the satellite orbit very accurately. It is used by the receiver to compute the position of the satellite. This information is broadcast by the satellites. |
| **epoch** | Measurement interval or data frequency, as in making observations every 15 seconds. Loading data using 30-second epochs means loading every other measurement. |
| **firmware** | A set of software computer/processor instructions that are permanently or semi-permanently resident in read-only memory. |
| **frequency** | The number of vibrations per second of an audio or radio signal. Measured in hertz (Hz), kilohertz (kHz), or megahertz (MHz). GPS frequencies are: L1 = 1575.42 MHz L2 = 1227.60 MHz |
| **GDOP** | Geometric Dilution of Precision. GDOP describes how much an uncertainty in pseudo-range and time affects the uncertainty in a position solution. GDOP depends on where the satellites are relative to the GPS receiver and on GPS clock offsets. |
| **geodetic datum** | A mathematical model designed to best fit part or all of the geoid. It is defined by an ellipsoid and the relationship between the ellipsoid and a point on the topographic surface established as the origin of datum. This relationship can be defined by six quantities, generally (but not necessarily) the geodetic latitude, longitude, and the height of the origin, the two components of the deflection of the vertical at the origin, and the geodetic azimuth of a line from the origin to some other point. The GPS uses WGS-84. |
| **geoid** | The actual physical shape of the earth which is hard to describe mathematically because of the local surface irregularities and sea-land variations. In geodetic terms it is the particular equipotential surface which coincides with mean sea level, and which may be imagined to extend through the continents. This surface is everywhere perpendicular to the force of gravity. |
| **GPD** | GPS with differential corrections applied. |

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| **GPS** | Global Positioning System. A constellation of 24 radio navigation (not communication) satellites which transmit signals used (by GPS receivers) to determine precise location (position, velocity, and time) solutions. GPS signals are available world-wide, 24 hours a day, in all weather conditions. This system also includes 5 monitor ground stations, 1 master control ground station, and 3 upload ground stations. |
| **GPS antenna** | An antenna designed to receive GPS radio navigation signals. |
| **GPS processor** | An electronic device that interprets the GPS radio navigation signals (received by a GPS antenna) and determines a location solution. The GPS processor may also be able to apply (and determine) differential GPS corrections. |
| **GPS receiver** | The combination of a GPS antenna and a GPS processor. |
| **GPS time** | The length of the second is fixed and is determined by primary atomic frequency standards. Leap-seconds are not used, as they are in UTC. Therefore, GPS time and UTC differ by a variable whole number of seconds. |
| **HDOP** | Horizontal Dilution of Precision. |
| **HOW** | Handover word. The word in the GPS message that contains time synchronization information for the transfer from C/A to P-code. |
| **interface cable (serial)** | The interface cable allows data to flow between the ACE GPS and the communication equipment. One end of the cable has a 9-pin female RS-232 connector and the other end of this cable has a 9-pin male RS-232 connectors. |
| **interference** | Refers to the unwanted occurrences on communication channels that are a result of natural or man-made noises and signals, not properly a part of the signals being transmitted or received. |
| **integrated Doppler** | A measurement of Doppler shift frequency or phase over time. |
| **IODE** | Issue Of Data, Ephemeris. Part of the navigation data. It is the issue number of the ephemeris information. A new ephemeris is available usually on the hour. Especially important for Differential GPS operation that the IODE change is tracked at both the reference station and mobile stations. |
| **jamming** | Interference (in either transmitting or receiving signals) caused by other radio signals at exactly or approximately the same frequency |
| **Kalman filter** | A numerical method used to track a time-varying signal in the presence of noise. If the signal can be characterized by some number of parameters that vary slowly with time, then Kalman filtering can be used to tell how incoming raw measurements should be processed to best estimate those parameters as a function of time. |
| **masks** | See *satellite masks*. |
| **maximum PDOP** | A measure of the maximum Position Dilution of Precision (PDOP) that is acceptable in order for the GPS processor to determine a location solution (see PDOP). |

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| **NAVSTAR** | The name given to the GPS satellites, built by Rockwell International, which is an acronym formed from NAVigation System with Time And Ranging. |
| **NMEA** | National Marine Electronics Association. An association that defines marine electronic interface standards for the purpose of serving the public interest. |
| **NMEA 0183 message** | NMEA 0183 is a standard for interfacing marine electronics navigational devices. The standard specifies the message format used to communicate with marine devices/components. |
| **packet** | An "envelope" for data, which contains addresses and error checking information as well as the data itself. |
| **parity** | A scheme for detecting certain errors in data transmission. Parity defines the condition (i.e., even or odd) of the number of items in a set (e.g., bits in a byte). |
| **PDOP** | Position Dilution of Precision. PDOP is a unitless figure of merit that describes how an uncertainty in pseudo-range affects position solutions. |
| **PDOP constellation switch** | A value, based on PDOP, that defines when the GPS receiver/processor should switch between 2D and 3D GPS modes. The PDOP constellation switch is only active when the GPS mode of operation is set to Auto. |
| **PRN** | Pseudo-random noise. Each GPS satellite generates its own distinctive PRN code, which is modulated onto each carrier. The PRN code serves as identification of the satellite, as a timing signal, and as a subcarrier for the navigation data. |
| **protocol** | A formal set of rules that describe a method of communication. The protocol governs the format and control of inputs and outputs. |
| **pseudo-range** | A measure of the range from the GPS antenna to a GPS satellite. Pseudo-range is obtained by multiplying the speed of light by the apparent transit time of the signal from the GPS satellite. Pseudo-range differs from actual range because the satellite and user clocks are offset from GPS time and because of propagation delays and other errors. |
| **RAM** | Random-Access Memory. |
| **random-access memory** | Memory in which information can be referred to in an arbitrary or random order. The contents of RAM are lost when the System Unit is turned off. |
| **range** | A term used to refer to the distance radio signals can travel before they must be received or repeated due to loss of signal strength, the curvature of the earth and the noise introduced because of moisture in the air surrounding the earth's surface. |
| **range rate** | The rate of change of range between the satellite and receiver. The range to a satellite changes due to satellite and observer motions. Range rate is determined by measuring the Doppler shift of the satellite beacon carrier. |

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| **read-only memory** | Memory whose contents can be read, but not changed. Information is placed into ROM only once. The contents of ROM are not erased when the system unit's power is turned off. |
| **real time clock** | An electronic clock, usually battery powered, that keeps current time. Used by a GPS receiver during a warm or hot start to determine where to search for GPS satellite signals. |
| **relative positioning** | The process of determining the vector distance between two points and the coordinates of one spot relative to another. This technique yields GPS positions with greater precision than a single point positioning mode can. |
| **rise/set time** | Refers to the period during which a satellite is visible; i.e., has an elevation angle that is above the elevation mask. A satellite is said to "rise" when its elevation angle exceeds the mask and "set" when the elevation drops below the mask. |
| **ROM** | Read-Only Memory. |
| **RS-232** | A communication standard for digital data. Specifies a number of signal and control lines. RS-232 is often associated with a 25 pin connector called a DB-25. |
| **RTCM** | Radio Technical Commission for Maritime Services. Commission that recommends standards for differential GPS services. "RTCM Recommended Standards For Differential GPS Service," prepared by RTCM Special Committee No. 104 (RTCM SC-104), defines a communication protocol for sending GPS differential corrections from a differential reference station to remote GPS receivers. |
| **satellite masks** | As satellites approach the horizon, their signals can become weak and distorted, preventing the receiver from gathering accurate data. Satellite masks enable you to establish criteria for using satellite data in a position solution. There are three types of satellite masks: Elevation, SNR, and PDOP. |
| **SA** | Selective Availability. This is the name of the policy and the implementation scheme by which unauthorized users of GPS will have their accuracy limited to 100 meters 2D RMS horizontal and 156 meters 2D RMS vertical. |
| **SEP** | Spherical Error Probability. The radius of a sphere such that 50% of the position estimates will fall within the surface of the sphere. |
| **serial communication** | A system of sending bits of data on a single channel one after the other, rather than simultaneously. |
| **serial port** | A port in which each bit of information is brought in/out on a single channel. Serial ports are designed for devices that receive data one bit at a time. |
| **signal to noise level** | GPS signals with SNRs that do not meet the mask criteria are considered unusable. |
| **signal to noise ratio** | A measure of the relative power levels of a communication signal and noise on a data line. SNR is expressed in decibels (dB). |

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| **SNR** | Signal to Noise Ratio. |
| **spread spectrum** | The received GPS signal is a wide bandwidth, low-power signal (-160dBW). This property results from modulating the L-band signal with a PRN code in order to spread the signal energy over a bandwidth which is much greater than the signal information bandwidth. This is done to provide the ability to receive all satellites unambiguously and to provide some resistance to noise and multipath. |
| **SPS** | Standard Positioning Service. Refers to the GPS as available to the authorized user. |
| **start bit** | In asynchronous transmission, the start bit is appended to the beginning of a character so that the bit sync and character sync can occur at the receiver equipment. |
| **stop bit** | In asynchronous transmission, the stop bit is appended to the end of each character. It sets the receiving hardware to a condition where it looks for the start bit of a new character. |
| **SV** | Space Vehicle (GPS satellite). |
| **synchronous communication** | A method of sending digital data in which the bits come at fixed, rather than random, times and are synchronized to a clock. |
| **TAIP** | Trimble ASCII Interface Protocol. Designed originally for vehicle tracking applications, TAIP uses printable uppercase ASCII characters in 16 message types for easy integration with mobile data modems, terminals, and personal computers. The TAIP protocol is defined in full in Appendix C. |
| **TANS** | Trimble Advanced Navigation Sensor. Also refers to a Trimble-specified interface protocol for digital packet communication to/from the GPS receiver. Data output includes time-tagged position and velocity, satellite status, dilution of precision factors and diagnostics of GPS receiver operational status.<br><br>Also see *TSIP* |
| **TNL 4000RL** | Trimble Navigation, Ltd. Reference Locator (4000RL). Product name for the Differential GPS Reference Station. |
| **TSIP** | Trimble Standard Interface Protocol. A binary/hex packet bi-directional protocol, also known as the TANS protocol. Used by a large number of Trimble sensors. TSIP is the subset of TANS which is recognized by all Trimble sensors except the 4000 series. The TSIP protocol is defined in full in Appendix A. |

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| **URA** | Satellite user range accuracy. The URA is sent by the satellite and is computed by the GPS operators. It is a statistical indicatory of the contribution of the apparent clock and ephemeris prediction accuracies to the ranging accuracies obtainable with a specific satellite based on historical data. |
| **UTC** | Universal Time Coordinated. Uniform atomic time system/standard that is maintained by the US Naval Observatory. UTC defines the local solar mean time at the Greenwich Meridian. |
| **UTC offset** | The difference between local time and UTC (Example: UTC - EST = 5 hours). |

# Index

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