

SVeeSix-CM3™
Embedded GPS Core Module
System Designer
Reference Manual




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Part Number 34150-01

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Part Number 34150-01

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Table of Contents

Preface

Introduction	P-1
Conventions Used in This Manual.....	P-2
The Global Positioning System.....	P-3

Chapter 1: Introduction

Introduction	1-1
SVEeSix-CM3 Configurations	1-3
Starter Kit.....	1-3
Core Modules.....	1-3
Accessories	1-4
The SVEeSix-CM3 GPS Receiver Module	1-4
Antennas.....	1-5

Chapter 2: The SVEeSix-CM3 Starter Kit

Introduction	2-1
Starter Kit Interface Unit & Receiver Module	2-2
Hardware Setup.....	2-4
Power	2-6
Removing the SVEeSix-CM3 Receiver Module from Interface Unit.....	2-8
Run the TSIP Interface Program.....	2-10
TSIPCHAT Command Window and Report Window	2-11

Chapter 3: Configuring the Message Protocol on the SVEeSix-CM3 Starter Kit

Introduction	3-1
About the Configuration Program	3-2
Setup the System Hardware	3-3
Load the Configuration Program	3-4

Chapter 4: Hardware Integration

Introduction	4-1
Interface Connectors.....	4-2
I/O Connector Signals.....	4-3
2mm Mating I/O Connectors	4-4
Power Requirement.....	4-5
CM3 Power Requirement.....	4-6
+5 VD6 Ripple Specification	4-6
Serial Interface.....	4-7
One Pulse Per Second.....	4-7
Mounting.....	4-7

Chapter 5: Software Interface

Introduction	5-1
Startup	5-2
Software Tool Kits	5-2
Communicating with the SVEE6-CM3 Module	5-3
Protocol Summary	5-4
TSIP Data Output	5-4
TAIP Data Output.....	5-5
NMEA 0183 Data Output.....	5-5
Time Operation.....	5-6
Effect of GPS Week Number Roll-over on Trimble OEM Receivers	5-7
Differential GPS	5-9

Chapter 6: Operating Characteristics

Introduction	6-1
GPS Satellite Message.....	6-2
Satellite Acquisition and Time to First Fix.....	6-3
Cold Start.....	6-3
Warm Start	6-3
Garage Search Strategy.....	6-4
Hot Start	6-4
Satellite Mask Settings.....	6-5
Standard Operating Modes.....	6-6
Over-Determined Mode	6-6
Fix Modes	6-8
2D Manual	6-8
3D Manual	6-8
Automatic 3D/ 2D/ 2D CH.....	6-9
One Satellite Timing	6-9
Differential GPS Operating Modes.....	6-10
DGPS On.....	6-10
DGPS Off	6-10
DGPS Automatic.....	6-10
Differential GPS Operation	6-11
Position Accuracy	6-11
Selective Availability (SA).....	6-11
Differential GPS (DGPS).....	6-12
Coordinate Systems.....	6-12
TSIP	6-13
TAIP	6-13
NMEA 0183	6-13
Performance Characteristics	6-14
Update Rate.....	6-14
Dynamic Limits.....	6-14
Re-Acquisition.....	6-15

Chapter 6: Operating Characteristics (continued)

GPS Timing	6-16
Serial Time Output.....	6-17
Timing Pulse Output (1PPS)	6-17
Determining the Time Tag of the PPS Timing Pulse.....	6-18
Time Tagging.....	6-19

Appendix A: Trimble Standard Interface Protocol (TSIP)

Appendix B: TSIP User's Guide

Appendix C: Trimble ASCII Interface Protocol (TAIP)

Appendix D: GPSSK User's Guide

Appendix E: NMEA 0183

Appendix F: Specifications and Mechanical Drawings

Glossary

Preface

Congratulations on your selection of the SVeeSix-CM3. The SVeeSix-CM3 is a compact GPS receiver module that provides accurate, world-wide position, velocity and time capability to your system.

This manual provides all the information required to integrate and operate the SVeeSix-CM3:

Chapter 1:	Introduction
Chapter 2:	The SVeeSix-CM3 Starter Kit
Chapter 3:	Configuring the SVeeSix-CM3 Receiver Protocol
Chapter 4:	Hardware Interface
Chapter 5:	Software Interface
Chapter 6:	Operating Characteristics
Appendix A:	Trimble Standard Interface Protocol (TSIP)
Appendix B:	TSIP User's Guide
Appendix C:	Trimble ASCII Interface Protocol (TAIP)
Appendix D:	GPSSK User's Guide
Appendix E:	NMEA 0183
Appendix F:	Specifications and Mechanical Drawings
	Glossary

You will discover that the SVeeSix-CM3 is easy to integrate and simple to use. Before proceeding with Chapter 1, please review this preface for an overview of the Global Positioning System.

Conventions Used in This Manual

Annotations

Annotations, preceded by bullets, are used in this manual to highlight important information.

- ◆ NOTE
Special notes and tips are prefaced with the ◆ symbol. This information is provided to assist you in installing and using the SVeeSix starter kit.
- Items that should be accounted for or reviewed are prefaced with the □ symbol.

Abbreviations

The generic terms *module*, *receiver* and *CM3* are sometimes used to refer to the SVeeSix-CM3 receiver.

The SVeeSix-CM3 Developer's Starter Kit is abbreviated to starter kit.

Differential GPS is abbreviated to DGPS.

The Trimble Standard Interface Protocol is abbreviated to TSIP.

The Trimble ASCII Interface Protocol is abbreviated to TAIP.

The Global Positioning System

The Global Positioning System (GPS) is a satellite based navigation system operated and maintained by the U.S. Department of Defense. GPS consists of a constellation of 24 satellites providing world-wide, 24 hour, three dimensional (3-D) 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. There is now virtually 24 hour, world-wide, three dimensional (3-D) GPS coverage which makes GPS fully functional for navigation and timing applications.

As a satellite based system, GPS is immune from 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 2-D position calculation requires three satellite ranges. A 3-D 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 with other receivers in the same locale. Differential GPS eliminates virtually all the measurement error in the satellite ranges and enables a highly accurate position calculation.

Chapter 1

Introduction

The SVeeSix-CM3 *core module* is a miniature 6-channel GPS receiver designed for easy integration. Its compact size and low power consumption make it ideal for applications ranging from hand-held navigation units to complex GIS instrumentation systems. The SVeeSix-CM3 receiver features the same high-performance architecture common to Trimble's standard SVeeSix series receivers; the SVeeSix architecture uses six channels for tracking up to eight GPS satellites, automatically selecting the satellites to optimize position and velocity data accuracy. The CM3 is also differential-ready for high-accuracy applications.

The CM3 is the third generation of Trimble's popular core modules first introduced in 1993. The CM3 features Trimble's latest signal processing code, a high-gain RF preamplifier for compatibility with the standard GPS antennas, and a CMOS TTL level one-pulse-per-second output for timing applications.

The SVeeSix-CM3 contains one firmware ROM. The firmware ROM contains the core signal processing code and the I/O protocol. Trimble offers three protocols for use with the SVeeSix series of GPS receivers. The SVeeSix-CM3 Starter Kit module provides a software toolkit diskette and the software to configure the receiver for either TSIP, NMEA, and TAIP protocols.

The system designer can experiment with the different protocols to determine which best suits their application. As delivered from the factory, the CM3 modules are configured with the TSIP protocol and can be changed via software to output TAIP or NMEA protocols.

Introduction (con't.)

The Trimble Standard Interface Protocol (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. TSIP includes commands to upload time, initial position, and almanac data to shorten acquisition time.

NMEA 0183 is an industry-standard protocol common to marine applications. NMEA provides direct compatibility with other NMEA capable devices such as chart plotters, etc. The standard CM3 NMEA protocol supports the GGA and VTG messages. Trimble can provide a custom configuration program for CM3's to output other NMEA messages as required. Contact a Trimble representative for further information.

The Trimble ASCII Interface Protocol (TAIP) uses printable ASCII characters in a set of 16 message types. TAIP is designed for easy integration and can provide position, speed, heading, and time in a single 35 byte message. TAIP allows the user to schedule automatic message reports or poll for information.

CM3 Starter Kit Components

The SVeeSix-CM3 is available in a developer's Starter Kit or as individual modules. The Starter Kit includes all the components necessary to quickly test and integrate the module.

The Starter Kit components are listed in Table 1. Table 2 lists the CM3 Standard and Extended temperature receivers with protocol configuration disk and part number. Table 3 lists the individual accessories and part numbers.

Table 1-1
CM3 Starter Kit

SVeeSix-CM3 Starter Kit (PN 21589-50)	Part Number
6-channel SVeeSix-CM3 Receiver module with socketed ROM (Differential Ready)	34055-99-D
Magnetic Mount GPS Antenna with Cable	28367-00
GPS Toolkit Disk	34173-01
System Designer Reference Manual	34150-01

Table 1-2
CM3 Modules

SVeeSix-CM3 Core Modules	Part Number
SVeeSix-CM3 Standard Temp (-10°C to 60°C)	34055-61
SVeeSix-CM3 Extended Temp (-40°C to 85°C)	34057-61
Configuration Disk for CM3	34151-01

Table 1-3
Accessories

Core Module Accessories	Part Number
Hard Mount GPS Antenna	28367-70
Magnetic Mount	28367-00
Rooftop Antenna Kit with 75 foot cable	23726-00

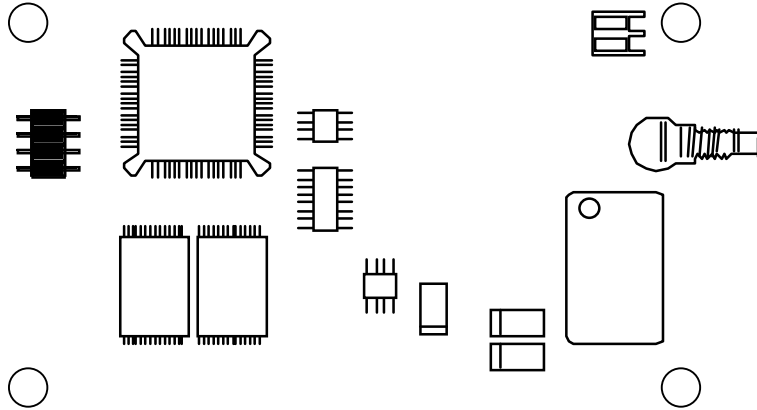
◆ **NOTE:** *Part numbers are subject to change. Confirm part numbers with your Trimble representative when placing your order.*

SVeeSix-CM3 Starter Kit GPS Receiver Module

The receiver consists of a single 3.25" x 1.83" x 0.7" module. A miniature SMB male connector (J1) is provided for the GPS antenna cable. J1 also supplies +5 VDC through the antenna cable to power the antenna preamplifier. An 8-pin, two millimeter header connector (J3) is provided for the CMOS TTL level serial I/O, the one-pulse-per-second signal, and input power (+5 VDC) interface. Four 0.095" holes are provided for mounting. U71 is the signal processing /protocol ROM and is socketed on starter kit versions of the module.

Figure 1-1
SVeeSix-CM3 Starter Kit Module





Antennas

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 SVeeSix-CM3 requires an *active* antenna. The received GPS signals are very low power (approximately -140 dB). 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 SVeeSix-CM3. The compact Magnetic Mount GPS Antenna and integral cable supplied with the starter kit is ideal for portable and mobile applications. The Hard Mount GPS Antenna is a bulkhead mount antenna with a hex nut to secure to a bulkhead. It is used for permanent mobile applications. Also available is the Bullet II Antenna, a compact, pole-mount rooftop antenna for fixed-site installations. Refer to Appendix F for mechanical outline drawings for the GPS antennas.

Figure 1-2
Magnetic Mount GPS Antenna

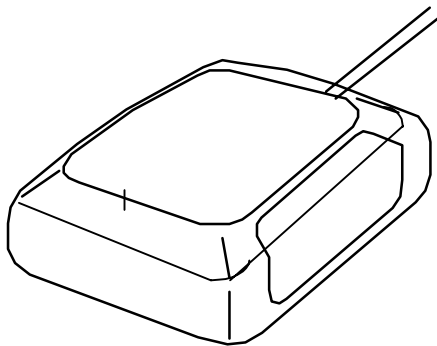


Figure 1-3
Hard Mount GPS Antenna

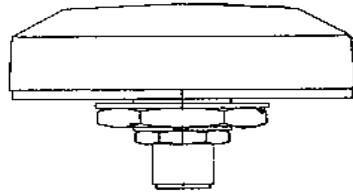
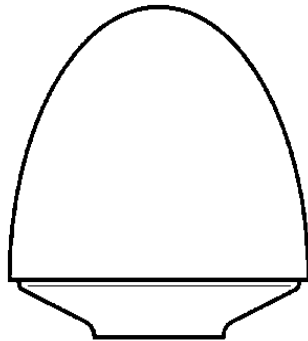


Figure 1-4
Bullet II GPS Antenna



Chapter 2

The SVEESix-CM3 Starter Kit

Trimble's OEM Starter Kits are differential-ready and contain all the necessary items to easily evaluate the receiver's features and to begin integration into a users' specific application. The CM3 Starter Kit includes:

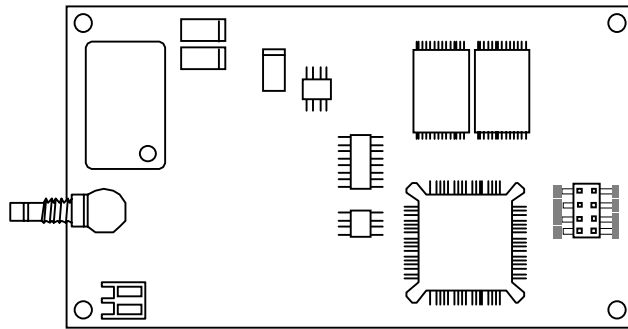
- Differential-ready CM3 module
- Software toolkits for the TSIP and TAIP protocols
- Software to configure the module for TSIP, TAIP or NMEA protocols
- Metal enclosure that allows the CM3 to be connected to the RS-232 serial port of a personal computer
- Magnetic mount antenna with cable
- Manual

Please take a moment to review the following sections before proceeding with any testing or evaluation of the CM3 Starter Kit.

Starter Kit Interface Unit & Receiver Module

The SVeeSix-CM3 receiver module (see Figure 2-1) consists of a single 3.25" x 1.83" x 0.58" 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, 0.2 mm header (J3) supports the serial interface (CMOS TTL level), the pulse-per-second (PPS) signal (CMOS TTL level), and the input power (+5 VDC).

Figure 2-1
SVeeSix-CM3 Receiver Module

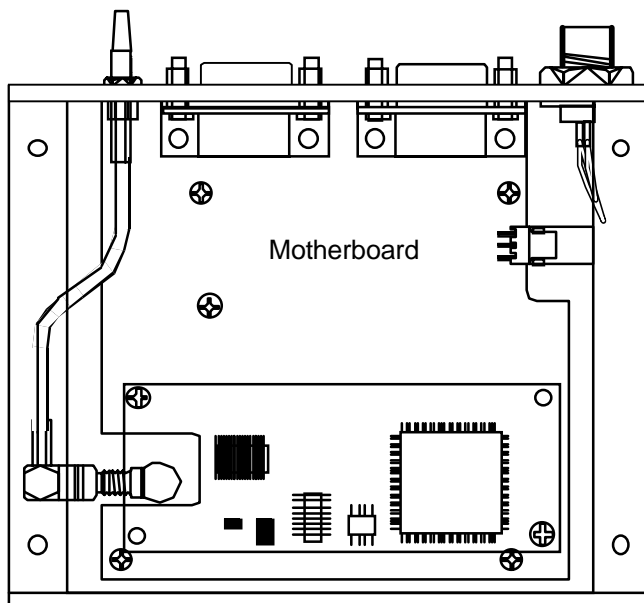


- ◆ **NOTE:** *The SVeeSix-CM3 receiver included in the starter kit contains a socket for the firmware ROM. This socketed module may be used to evaluate future releases of firmware. The SVeeSix-CM3 module for standard OEM applications does not have a socket.*

In the starter kit, the SVeeSix-CM3 is installed on an interface motherboard which is housed in a metal enclosure (see Figure 2-2). This packaging simplifies testing and evaluation of the SVeeSix-CM3 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 volts DC 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.

This module connects to the motherboard via the 8-pin header and is secured by two standoffs. An RF-interface cable connects the SVeeSix-CM3 antenna port to an SMB connector on the enclosure panel.

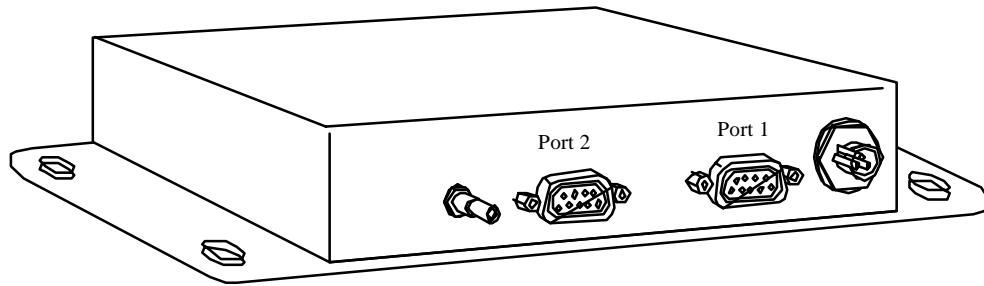
Figure 2-2
The SVeeSix-CM3 Module Installed Inside the Interface Unit



The SVeeSix-CM3 interface motherboard includes a 9 to 32 VDC switching power supply which provides a regulated +5 VDC to the SVeeSix-CM3 receiver. It also converts the SVeeSix-CM3 TTL-level I/O to RS-232 for a direct interface to the computer. The motherboard provides an open-collector interface for the PPS and also includes a 3.6V lithium backup battery enabling fast hot starts. The starter kit includes an AC/DC converter for powering the module from an AC wall socket. The metal enclosure (see Figure 2-3) provides two 9 pin interface port connectors, an antenna connector and a power connector. The mounting plate is secured to the metal enclosure with four screws.

- ◆ **NOTE:** Due to the open-collector interface, through the 9 pin RS-232 port the polarity of the PPS signal is inverted. The pulse is a 10 μ s negative-going pulse with the falling edge synchronized to UTC. When removed from the motherboard, the receiver provides a positive going TTL level pulse, with the rising edge synchronized to UTC.

Figure 2-3
Starter Kit Interface Unit



Hardware Setup

The SVEE6-CM3 has one input/output serial port (port 1) and one input port (port 2). Port 1 is used for normal communication with the receiver; port 2 is available for input of RTCM SC-104 differential corrections. Figure 2-4 illustrates the basic hardware setup.

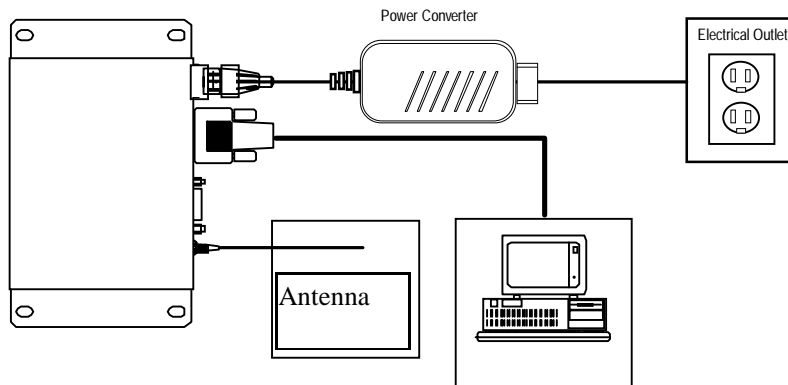
Table 2-1
Port Characteristics

	TSIP Default	TAIP Default	NMEA Default
Primary Port			
Input	TSIP (note 1)	TAIP	TSIP (note 1)
Output	TSIP	TAIP	NMEA
Stop Bits	9600	4800	4800
Data Bits	8	8	8
Stop Bits	1	1	1
Parity	Odd	None	None

Table 2-1 (con't.)
Port Characteristics

TSIP Default	TAIP Default	NMEA Default	
Secondary Port			
Input	RTCM SC-104	RTCMSC-104	RTCM SC-104
Output	None (off)	None (off)	None (off)
Stop Bits	4800	4800	4800
Data Bits	8	8	8
Stop Bits	1	1	1
Parity	None	None	None

Figure 2-4
Interconnect Diagram



◆ *Note: The port assignment on CM3 interface unit is different from the SVeeSix Plus.*

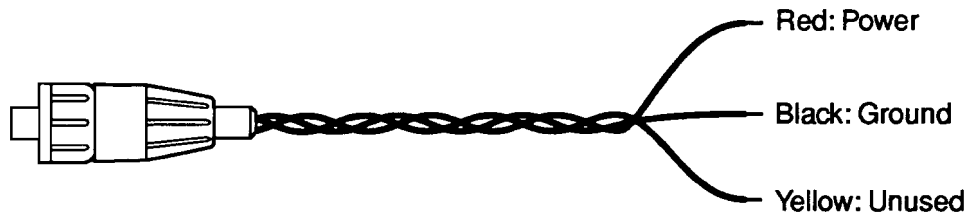
1. Connect one end of the 9-pin serial interface cable to port 1. Connect the other end of the cable to COM1 or COM2 of the PC. A 9-pin to 25-pin adapter may be needed on the cable to adapt the serial interface connection to the PC's 25-pin communication port if so equipped.
2. Connect the antenna cable to the interface unit. This connection is made by pushing the antenna cable connector straight onto the SMB connector on the unit (to remove the antenna cable, simply pull the antenna connector straight off of the SMB connector). The SMB connector on the antenna has a positive locking jaw built in, this is to insure a solid connection to the GPS receiver.
3. Place the antenna so that it has a clear view of the sky.

Power

The SVEE6ix-CM3 receiver module is designed for embedded applications and requires a regulated +5.0 VDC input (+4.85 to +5.25 VDC). See *Power Requirements* in Chapter 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 SVEE6ix-CM3. Power can be applied to the starter kit module using one of two options: the DC power cable (see Figure 2-5) or the AC/DC power converter (see Figure 2-6).

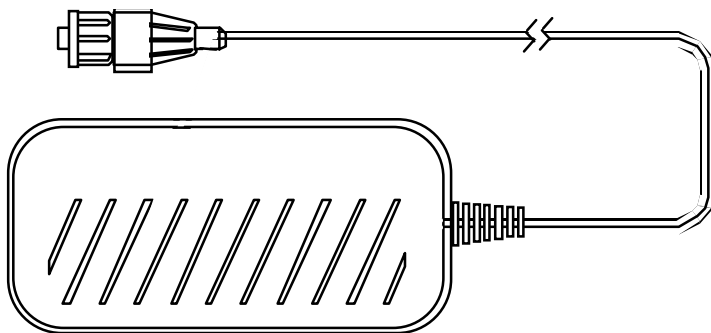
The DC power cable is ideal for bench-top or automotive testing environments. The power cable is terminated at one end with a 3-pin plastic connector which mates with the power connector on the metal enclosure. The unterminated end of the cable provides for easy connection to a DC power supply. Connect 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 interface unit, the SVEE6ix-CM3 and the antenna is approximately 2 watts. (The yellow wire is not used; battery back-up is provided by a factory installed lithium battery on the motherboard.)

Figure 2-5
DC Power Cable



Alternatively, the AC/DC power converter can provide power to the starter kit module. The AC/DC power converter converts 110 or 220 VAC to a regulated 12 VDC. This is compatible with the CM3 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 2-6
AC/DC Power Converter

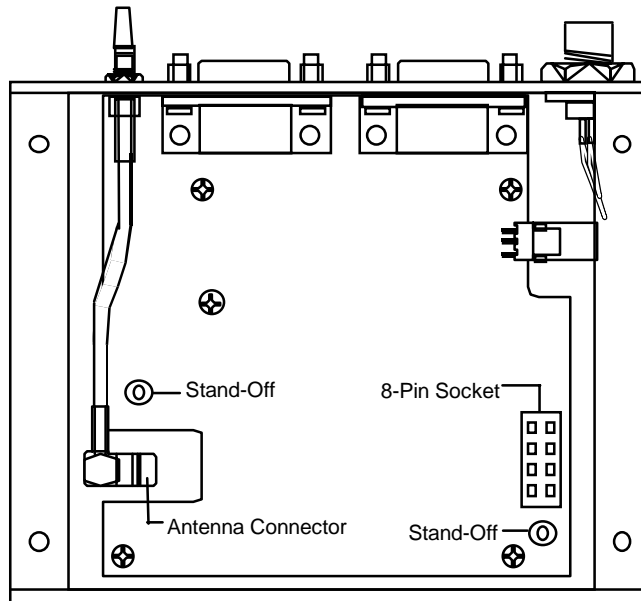


Removing the SVeeSix-CM3 Receiver Module from the Interface Unit

In the starter kit, the SVeeSix-CM3 receiver module is installed on the interface motherboard to facilitate testing and evaluation. The receiver module can be detached from the motherboard for specific device installations.

The receiver module is connected to the motherboard at four points: the antenna connector, the interface connector, and two standoffs (see Figure 2-7). Follow the steps below to remove the receiver module from the motherboard.

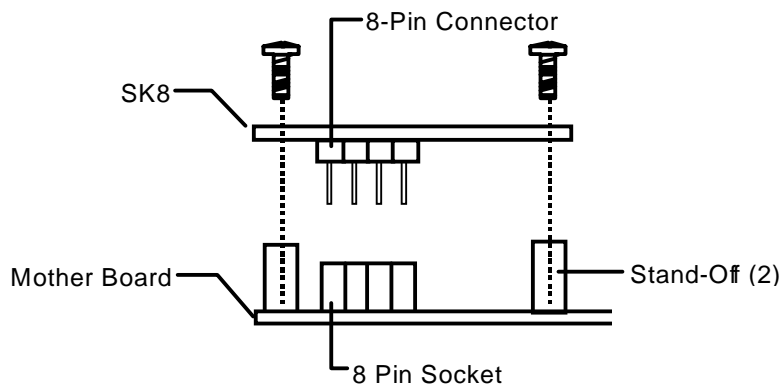
Figure 2-7
Motherboard Connection Points



▲ **CAUTION:** Prior to disassembling the interface unit, disconnect the unit from any external power source and confirm that both you and the work surface are properly grounded for ESD protection.

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 SVeeSix-CM3 module to the standoffs on the motherboard. These screws are located at opposite ends of the receiver module (see Figure 2-8)

Figure 2-8
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 2-8). Do not rotate or flex the module while disengaging the header, since this could damage the connector or the module components. Pull straight up, keeping the SVeeSix-CM3 parallel to the motherboard.
4. Disconnect the RF cable connecting the SVeeSix-CM3 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 SVeeSix-CM3 module in the motherboard, follow steps 1 - 4 in reverse order.

◆ **NOTE:** *The SVeeSix-CM3 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.*

Run the TSIP Interface Program

The SVeeSix-CM3 Starter Kit includes a disk containing TSIP interface programs which run on a PC-DOS platform. These programs aid system integrators in developing the software interface for the GPS module. The TSIP programs are described in detail in Appendix B, *TSIP User's Guide*. This section assumes that the SVeeSix-CM3 is configured with the TSIP interface protocol and that the TSIPCHAT program is installed in a directory on the computer hard disk (see Chapter 3, *Configuring the Message Protocol on the SVeeSix-CM3 Starter Kit*).

To monitor the TSIP output and communicate with the GPS module:

1. Turn on the DC power supply.
2. Turn on the PC.
3. Insert the GPS Tool Kit disk in the disk drive.
4. Go to the directory where the GPS toolkit will be installed. In most cases, this will be the root directory on the C: drive.

◆ **NOTE:** *For detailed installation guidelines, read A:\INSTALL.TXT and A:\README.TXT.*

5. At the DOS prompt, type A:\INSTALL to create a sub directory called TOOLKIT and to install the tool kit files.
6. Type the appropriate path name to execute the TSIPCHAT program (e.g. C:\TOOLKIT\TSIPCHAT). TSIPCHAT provides full access to the TSIP protocol. It converts binary TSIP packets into printable ASCII characters and vice versa.
7. After the TSIPCHAT title screen appears, type "?", and the primary TSIPCHAT screen shown in Figure 2-9 is displayed.

When there is no GPS antenna connected to the receiver, the TSIPCHAT.EXE program will display a report window which lists satellite health, machine ID, software version, and initial position information. When a GPS antenna is connected and the receiver has achieved a position fix, the transmitted position reports scroll through the report window. These reports include position, velocity, almanac, ephemeris status and almanac health. A receiver health report is sent approximately every 30 seconds, even when no satellites are being tracked.

Figure 2-9
TSIPCHAT Command Window and Report Window

```

10:21 AM tsipchat 3/04/96
Keystroke Command List <Key Pkt-ID Description>:
f 0x1D clear osc offset a 0x29 almanac health > 0x3C show track status
F 0x1D set osc offset ^n 0x2A altitude for 2-D U 0x3D show Ch A format
^M 0x1E clear battery RAM I 0x2B input LLA pos ^U 0x3D set Ch A format
u 0x1F show $M version p 0x2C show mask parms Z 0x3E show aux fix parms
A 0x20 almanac data P 0x2C set mask parms D 0x62 set DGPS mode
t 0x21 show time o 0x2D show osc offset / 0x65 show DGPS info
z 0x21 sync PC to UTC I 0x2E set time from PC c 0x6E show cph options
n 0x22 set manual 2-D u 0x2F show UTC info C 0x6E set cph options
N 0x22 set manual 3-D b 0x31 set acc ECEP pos I 0x71 show pos fit pms
^N 0x22 set auto 2-D/3-D B 0x32 set acc LLA pos L 0x71 set pos fit parms
^T 0x22 Time Only Mode S 0x34 set SU Time Mode H 0x73 height filter
y 0x22 auto 3d->2d->2dch O 0x35 show I/O options j 0x75 show track mode
Y 0x22 auto 2d->2dch ^O 0x35 set I/O options J 0x75 set track mode
i 0x23 input XYZ pos ^U 0x36 velocity input G 0x77 set DGPS max age
H 0x24 show 2-D/3-D mode w 0x37 show last fix g 0x77 show DGPS max age
^R 0x25 reset receiver $ 0x38 set/recv SU data - 0x79 clock/fix integ
h 0x26 receiver health d 0x39 disable/ign hlth = 0x8E extended cmds
s 0x27 show sig levels < 0x3A show raw meas z 0x13 generic cmds
m 0x28 GPS sys message e 0x3B ephemeris info
^M=Rpt Cmd; <Esc>=Exit; ^F,^L=log TSIP,TAIP; !,e=down,upload alm; ^I=RS232
Enter Keystroke:

```

The upper (shaded) portion of the screen is the command window and the lower portion of the screen is the automatic report window (auto window). The auto window displays a running account of the messages which are automatically output by the GPS module in the lower half of the screen. The most frequent automatic reports are the position and velocity reports. Other automatic reports include the almanac, ephemeris status and almanac health reports.

If the auto window is not displaying messages, then the GPS module may not be connected properly to the computer. To test the connection, type "v". This message requests the firmware version numbers from the GPS module. If connected and operating properly, the module should respond with a software version report within one second. This report will be displayed in the command window.

If "waiting for reply" appears continuously in the command window, then the GPS module is not 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, then call the Trimble Technical Assistance Center (TAC) for assistance.

Chapter 3

Configuring the Message Protocol on the SVeeSix-CM3 Starter Kit

This chapter provides step-by-step instructions for using the Basic operating mode to change the SVeeSix-CM3 receiver protocol. Additional program features beyond the contents of this manual may be available. Updates are documented in the READ.ME file on the program disk.

The SVeeSix-CM3 receiver supports three message protocols: TSIP, TAIP and NMEA. The firmware for all three protocols and the navigation processor firmware are contained in PROM (read only memory). When purchased in a starter kit, the SVeeSix-CM3 receiver is configured for the TSIP protocol. The unit can be re-configured for either TAIP or NMEA protocols by using one of the configuration programs stored on the GPS Software Tool Kit program disk, provided in the starter kit.

TSIP - The Trimble Standard Interface Protocol is a powerful binary packet protocol which provides bi-directional communication for optimal performance.

TAIP - The Trimble ASCII Interface Protocol which is a bi-directional ASCII protocol designed for easy integration. This protocol can provide position, speed, heading, and time in a single 35 byte ASCII message.

NMEA 0183 is a National Marine Electronic Association standard which is a uni-directional ASCII protocol designed for information transfer between marine navigation equipment.

See Chapter 5, *Software Interface*, for a brief overview of the message protocols. For a more in-depth descriptions of the protocols and software tools. See appendices A through E.

About the Configuration Programs

The protocol configuration programs run under DOS, and are in executable form. These three files are on the GPS Software Tool Kit diskette which comes with the CM3 Starter Kit. (*For use with the standard temperature modules only.*)

- | | |
|----------------------|--|
| 34055-61.EXE: | Will program the CM3 module with the TSIP protocol in/out on Port 1. |
| 34055-63.EXE | Will program the CM3 module with the TAIP protocol in/out on Port 1. |
| 34055-62.EXE | Will program the CM3 module with the TSIP protocol in and NMEA protocol out on Port 1. |

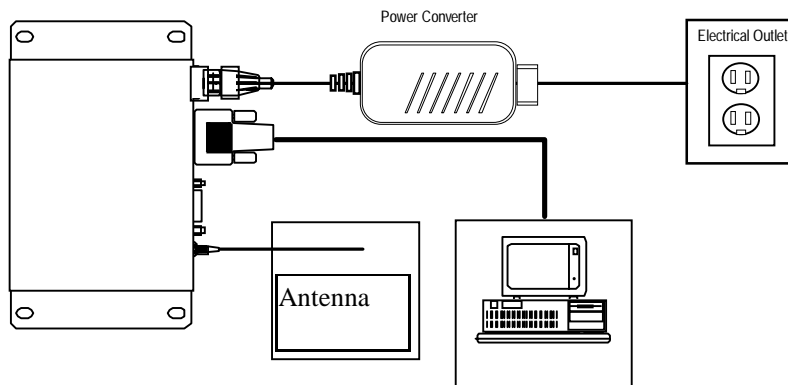
◆ **NOTE:** *Port 2 is RTCM SC-104 in only. No setup is required to use RTCM SC-104 differential corrections, however, the secondary serial port characteristics (baud rate, data bits, stop bits and parity) may be reconfigured to match the characteristics of the RTCM SC-104 data source by using the 8E-03 packet in TSIP or the AP command in TAIP. Refer to Appendix A or Appendix C for more information on these messages. Table 5-2 summarizes the default characteristics for both the primary and secondary serial ports. The CM3 units are configured for NMEA 0183 protocol and will accept TSIP command packet request on Port 1.*

Setup the System Hardware

If you have not already done so, connect the equipment.

1. Connect the 9-pin serial cable to port 1 of the CM3 Starter Kit.
2. Connect the other end of the 9-pin RS-232 cable to the host computer. A 25-pin to 9-pin adapter may be required for proper connection.
3. Connect the antenna cable to the SMB connector J1 and place the antenna so that it has a clear view of the sky.
4. Connect the power supply which is included with the CM3 Starter Kit. A computer power cable which is not supplied in the CM3 Starter Kit is required to provide power to the power supply.

Figure 3-1
Interconnect Diagram



Load the Configuration Program

The SVEE6ix-CM3 Starter Kit includes the OEM GPS Tool Kit diskette. This diskette contains the protocol configuration programs. If you have not already done so, load these programs onto your hard disk. Then execute the proper configuration file for the particular protocol desired.

1. Power cycle the receiver to reset the unit.
2. Go to the TK510A directory.
3. Type 34055-XX.EXE. -cY where XX = 61 TSIP, 62 for NMEA and 63 for TAIP protocols, and the Y denotes the host COM port. *i.e., 34055-61.exe -c2 This will program the GPS receiver to TSIP in / out via the hosts COM 2 port.*

◆NOTE: *The SVEE6ix-CM3 receiver has a 5 minute time-out feature to prevent accidental reconfiguration in the field. Power cycle the receiver prior to accessing the Configuration program. This will ensure that program's time-out feature is not activated before you have completed your selections.*

◆NOTE: *If you have selected the NMEA or TAIP protocol, you may use ProComm™, Windows Terminal, Win 95 Hyperterm™, or the terminal mode in GPSSK to view this data.*

Chapter 4

Hardware Integration

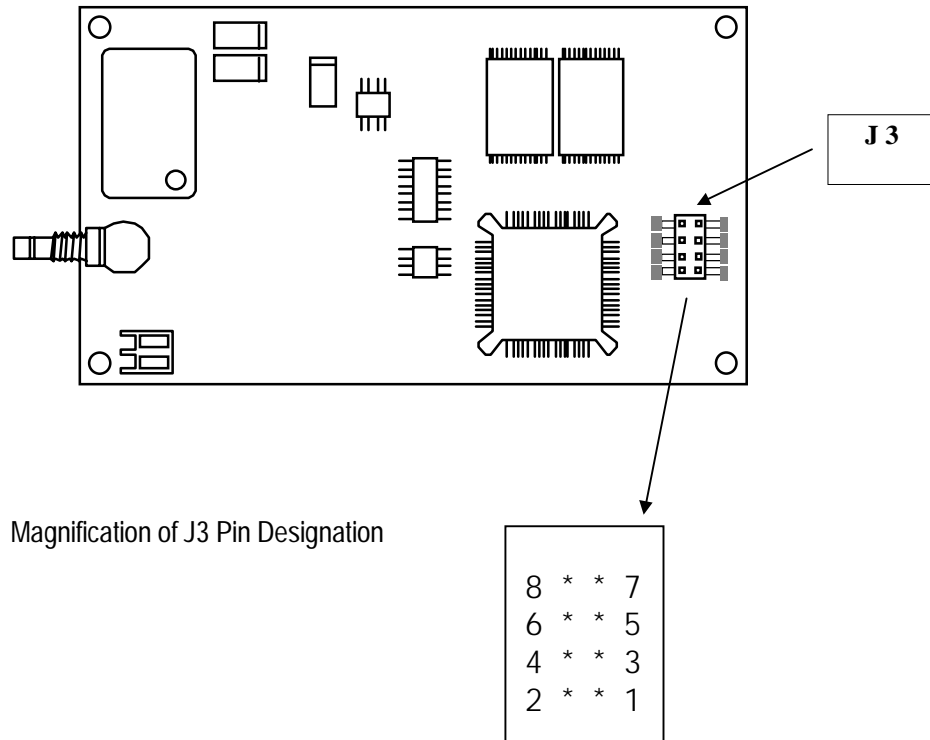
Integration of the SVeeSix-CM3 can be divided into two categories: hardware and software. Hardware integration includes mounting the GPS module and physically connecting the module to the antenna, the host processor, and the power source. Software integration involves configuring the GPS module to communicate with the host processor. The magnitude of the software integration varies with the selected protocol.

This chapter provides information on hardware integration. For information on software integration, refer to Chapter 5, *Software Interface*.

Interface Connectors

The SVeeSix-CM3 uses a single 8-pin header connector, J3, for power and data I/O. The J3 connector uses 0.150 inch (3.8 mm) pins on 0.0787 inch (2 mm) spacing (refer to the mechanical outline drawing in Appendix F).

Figure 4-1
SVeeSix-CM3 Interface Connector



Interface Connectors (con't.)

Table 4-1
I/O Connector Signals

PIN	J3 I/O Connector Signal
1	No connection
2	VCC (+5VDC)
3	TXD1 (TTL level Serial Out)
4	Battery Backup (+3 to +5 VDC)
5	RXD1 (TTL level Serial In)
6	One Pulse-Per-Second (TTL level)
7	RXD2 (TTL level Serial In)
8	DC ground

Pins 3 and 5 on J3 are referred to as the primary serial port. Pin 7 is the secondary serial port. The secondary serial port, also referred to as the receive-only port, is used with differential-ready CM3 modules for input of RTCM SC-104 differential corrections.

Mating connectors for J3 are available in ribbon cable, discrete wire (crimp), surface-mount PCB, and through-hole PCB varieties. Consult Table 4-2 for a partial list of 2 mm, 8 position mating connectors. Each of the three vendors listed have extensive distribution networks, including Europe. Contact a Trimble representative for a list of distributors in your area.

Interface Connectors (con't.)

Table 4-2
2 mm Mating I/O Connectors

Source	Ribbon Cable	Discrete Wire	Surface Mount	Through Hole
3M Electronic Products Div. 6801 River Place Blvd. Austin, TX 78726-9000 call 800-225-5373	Contact 3M to specify cable length and 8-position connector	n/a	150208-2000-TH Series 15, 2mm, Board Mount Socket, 8 position surf. mount	150208-6002-TH Series 15, 2mm, Board Mount Socket, 8 Position vertical
Hirose Electric (U.S.A), Inc. 2685-C Park Center Drive Simi Valley, CA 93065 call (805) 522-7958 FAX (805) 522-3217	n/a	DF-8 DS-2C (8 pos. housing) DF11-2428SC (female contacts)	n/a	n/a
Samtec, Inc. P O Box 1147 New Albany, IN 47151-1147 call (812) 944-6733 FAX (812) 948-5047	Contact Samtec to specify cable length and 8-position connector	n/a	SMM-104-02-S-D	n/a

n/a = information not available at time of printing

- ◆ **NOTE:** 2mm connectors are commonly used on PC disc drivers. Mating connectors and cables may be available through local computer suppliers.

Power Requirement

The SVeeSix-CM3 module requires +5 volts DC (-3%, +5%) at 240 ma, nominal excluding antenna. The CM3 does not require any special power up or down sequencing. The receiver power is supplied through pin 2 of the J3 I/O connector. Refer to Table 4-3 and to Figure 4-1 for the +5 VDC power specifications.

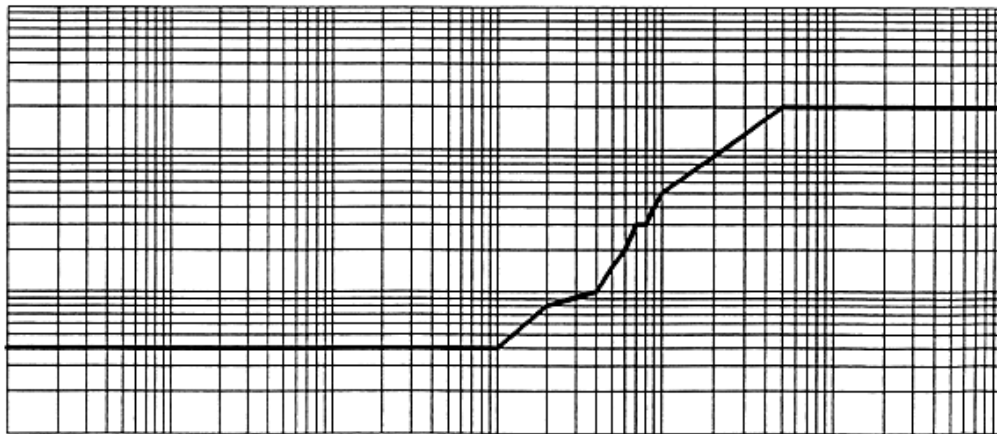
The CM3 module provides an input for battery back-up (BBU) power to keep the module's RAM memory alive and power the real-time clock when the receiver's main power is turned off. RAM memory is used to store the GPS almanac, ephemeris, and user configuration data. Though not required, providing BBU power can reduce the time required at power-on for the SVeeSix-CM3 to acquire GPS satellite signals and compute position to less than 50 seconds (typical). A 3.5 volt lithium battery will typically supply back-up power for up to five years.

Power Requirement (con't.)

Table 4-3
CM3 Power Requirements

Signal	Voltage	Current	J3 Connector Pin
VCC	+4.85 to +5.25	240 ma	2
Battery Backup	+3.2 to +5	1 micro amp @ 5V, 25°C	4
Ground	0	-	8

Figure 4-1
+5 VDC Ripple Specification



Serial Interface

As an embedded design, the CM3 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 CM3. Interfacing these signals directly to a DUART provides a direct serial interface without the expense of RS-232 or RS-422 line drivers.

◆NOTE: *The CM3 module serial I/O signals on J3 are at TTL level (0 to +5VDC); They are not inverted or driven to RS-232 levels. Use the starter kit motherboard supplied with the CM3 starter kit to connect to a RS-232 serial port.*

One Pulse Per Second

A one 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 nanoseconds wide. The falling edge should not be used.

The timing accuracy is ± 600 nanoseconds typical (5 microseconds worst case) and is valid only when computing position fixes, or in a static, one-satellite, time-only mode. 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 S/A).

Mounting

The CM3 provides four 0.095 inch mounting holes that will accept 3/16 inch round or hex standoffs and #2-56 or M2 mounting screws. Refer to the mechanical outline drawing in Appendix F for dimensions and clearances.

Chapter 5

Software Interface

This chapter describes the SVeeSix-CM3 software interface and start-up characteristics for each of the interface protocols. In addition, a description of the receiver operating modes is provided along with a brief discussion of the interface protocols.

When connected to an external GPS antenna, the SVeeSix-CM3 receiver contains all the circuitry necessary to automatically acquire GPS satellite signals, track up to 8 GPS satellites and compute and output location, speed, heading, and time.

The SVeeSix-CM3 receiver will automatically begin to search for and track GPS satellite signals at power-up. The time to first fix from a complete cold start is normally 2 to 4 minutes, varying with time required to acquire satellite almanac and ephemeris data. The receiver will respond to commands almost immediately after power-up.

Startup

The SVEE6ix-CM3 is a complete 6-channel GPS receiver for embedded applications. The receiver will automatically begin to search for and track GPS satellite signals at power-up. The SVEE6ix-CM3 time to first fix from a complete cold start is normally 2 to 4 minutes, varying with time required to acquire satellite almanac and ephemeris data. This time to first fix can typically be shortened to less than 50 seconds if back-up power is used to power the real-time clock and maintain RAM. The receiver will respond to commands almost immediately after power-up.

Software Tool Kits

Trimble provides two software developer tool kits to support the two I/O protocols supplied with the SVEE6ix-CM3 Starter Kit. These tool kits contain user-friendly programs to communicate with the receiver and include sample source code or reusable routines to aid system integrators in developing their own applications.

If unfamiliar with Trimble's SVEE6ix family of GPS receivers and the I/O protocols available, please take a moment to review *Appendix B, TSIP User's Guide* or *Appendix D, GPSSK User's Guide for TAIP*. If a copy of the software tool kit for the I/O protocol chosen was not included, please contact the nearest Trimble representative or call the Technical Assistance number listed on the front cover of this manual.

Communicating with the SVeeSix-CM3 Module

The SVeeSix-CM3 supports three I/O message protocols. The developer's starter kit includes configuration software to program the unit for TSIP (Trimble Standard Interface Protocol), TAIP (Trimble ASCII Interface Protocol), and NMEA (National Marine Electronics Association). The protocols are discussed at the end of this chapter, and are explained in greater detail in Appendices A through E.

The SVeeSix-CM3 modules are delivered with the TSIP protocol installed. A separate configuration disk can be purchased or downloaded from the Trimble FTP: site at

FTP://FTP.trimble.com/pub/sct/embedded/bin/

These files can change the CM3 module to output TSIP, TAIP or NMEA protocols.

◆ *NOTE: The standard temperature configuration disk only works with the standard temperature module. Similarly, the extended temperature configuration works with the extended temperature board. The extended temperature software configuration will give unpredictable results on the Standard temperature module or vice-versa.*

Communication with the SVeeSix-CM3 module is through a CMOS compatible, TTL level serial port. This approach makes the SVeeSix-CM3 module software compatible with other members of the SVeeSix family of GPS receivers and simplifies system integration. If connecting the CM3 to a RS-232 serial port on a PC, use either the starter kit motherboard or a TTL to RS 232 converter along with the proper interface cables.

The SVeeSix-CM3 serial port default characteristics are under firmware control and are different for the TSIP, TAIP and NMEA protocols. When running TSIP or TAIP, the port characteristics may be changed by the user. Refer to Table 5-1 for the default port settings. On differential-ready modules, the secondary serial port factory settings for RTCM SC-104 input are: 4800, 8, 1, None.

Communicating with the SVeeSix-CM3 Module (con't.)

Table 5-1
Default Serial Port Characteristics (Primary Port)

Characteristic	TSIP Default	TAIP	NMEA Default
Baud Rate	9600	4800	4800
Data Bits	8	8	8
Stop Bits	1	1	1
Parity	Odd	None	None

Any standard DOS serial communications program such as PROCOMM or Windows terminal program can be used with TAIP or NMEA, however TSIP is a binary protocol and will not display standard text. Trimble encourages the use of the DOS compatible software tool kit when using the TSIP and TAIP protocols included in the CM3 Starter Kit.

Protocol Summary

TSIP Data Output

The Trimble Standard Interface Protocol (TSIP) is the base level protocol for the CM3. TSIP is a Trimble proprietary bit level protocol using hexadecimal request packets and hexadecimal response packets. The user can select the data output by the CM3 by sending request packets to the GPS receiver. Bit settings within the bytes of the request packets determine what data is output by the CM3. The format of these request and response packets are described in Appendix A. The TSIPCHAT program in the CM3 Starter Kit allows the system developer to use a computer keyboard to send the request packets to the GPS receiver and have the responses to these requests displayed on a DOS computer screen in ASCII format. Also provided in the Starter Kit are the C source code routines for the TSIPCHAT program. This C source can be used as a software design guide by programmers who need to communicate with the CM3 for system integration.

Protocol Summary (con't.)

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 SVeeSix-CM3 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.

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. Although the Trimble CM3 supports seven NMEA sentences that contain GPS information, the standard CM3 only outputs the GGA and VTG data strings. (Note: Contact your Trimble sales representative if you need access to all or a subset of the other five NMEA sentences). 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 CM3, NMEA is an output only protocol. The NMEA protocol is described in detail in Appendix E.

Time Operation

The SVeeSix-CM3 is an excellent source of accurate time for a system such as environmental data acquisition or communications networks. The timing functions of the receiver are supported by both the TSIP and TAIP I/O protocols. Please refer to Report Packet 41 in Appendix A or the TM message in Appendix C for a description of the time function reports for the TSIP and TAIP protocols.

GPS time differs from UTC (Universal Coordinated Time) by a variable number of seconds. This GPS/UTC offset has two parts: an integer number of seconds called "leap seconds", and a small sub-microsecond part that tracks the differences between the GPS clock run by "DOD" and the world wide UTC standard.

$$\text{UTC} = (\text{GPS time}) - (\text{GPS}\backslash\text{UTC offset})$$

As of June 30, 1997, the GPS\UTC offset was 12 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 SVeeSix-CM3 must have a complete almanac before the offset data is valid.

Effect of GPS Week Number Roll-over (21/22 August 1999) on Trimble OEM Receivers

At midnight GMT, on 21/22 August 1999, the GPS week number will "roll-over" from 1023 back to 0. There is no GPS Week Number higher than 1023, and such Week Number Roll-Overs (WNROs) occur every 1024 weeks, or about 19 years 8 months. August 1999 is the first roll-over ever for the GPS system. Trimble receivers have numerous protections to prevent this from being a catastrophic event. However, they may benefit from extra care with the first power-up after WNRO. Tests of a representative sample of Trimble OEM receivers revealed only two issues:

1. On previous receivers, an almanac recorded pre-WNRO is not correct after WNRO. This is only a problem if the receiver has main power off and battery-back power on at the moment of WNRO. After a post-WNRO almanac has been collected (via a cold start), the receiver's behavior returns to normal.
2. On previous receivers, the TAIP (TM) and NMEA (ZDA) messages, which report day-month-year (E.g.: August 23, 1999), will be incorrect after WNRO. Time of day and day of week information will not be affected.

TSIP users will not see any impact on position or time information. However, the reported GPS week number will reset to zero and users of this information may need to make a software modification to accommodate this change. Below is information regarding specific Trimble OEM GPS receivers.

Effect of GPS Week Number Roll-over (con't)

No Effect, Firmware Version 5.06 and Later Versions

No problems with dates or the first fix after WNRO through the year 2015.

One-time Long TTFF, Firmware Version 4.0 through Version 5.04

In these receivers, a pre-WNRO almanac cannot be used post-WNRO. The GPS receiver is constantly decoding and collecting new almanacs, so the old almanac will be promptly replaced during normal operation. The difficulty occurs when the receiver is powered on for the first time after WNRO. If battery-backed, the receiver wakes up with a pre-WNRO (incorrect) almanac and the receiver will have difficulty finding satellites for a fix. Fortunately, the Trimble OEM receiver is designed to generate a fix even with an incorrect almanac; however, the process requires more time, perhaps more than ten minutes. Longer-than-normal TTFFs will continue until a full post-WNRO almanac is collected, after which the receiver will have normal behavior. To prevent long TTFFs again, allow the receiver to track satellites long enough to replace the almanac (about 15 minutes after first fix). After a full almanac is collected, TTFF performance will return to normal.

Incorrect Date Message, Firmware Version 4.0 through 5.02

These receivers have the initial long TTFF described in the above paragraph. In addition, dates (day-month-year) will be misreported permanently after WNRO. The only standard date messages put out by Trimble OEM receivers are the NMEA-ZDA NMEA-RMC, and TAIP-TM messages. Therefore, only users of these specific messages will be affected. All other standard time messages are day-of-week or time-of-day, which will not be in error. Any custom date messages could also be permanently incorrect starting on 22 August 1999.

- ◆ *NOTE: The CM3 supplied with the starter kit as described in this manual contains version 5.0 or later firmware and will not be affected by week number roll-over.*

Differential GPS

The differential-ready SVeeSix-CM3 module can use differential corrections to compute a Differential GPS position (DGPS). DGPS can provide position accuracy of 2 to 5 meters (1 sigma). The SVeeSix-CM3 supplied with the Starter Kit is differential-ready.

RTCM SC-104 is an industry standard format for differential corrections available from most DGPS reference stations, Coast Guard beacon transmissions, and commercial DGPS subscription services. The SVeeSix-CM3 is fully compatible with RTCM SC-104 versions 1 and 2. A differential-ready SVeeSix-CM3 is configured to accept RTCM SC-104 correction data over the secondary serial port (J3, 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 SVeeSix-CM3 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, reconfigure the secondary serial port characteristics (baud rate, data bits, stop bits and parity) to match the characteristics of the RTCM SC-104 data source using the 8E-03 packet in TSIP or the AP command in TAIP. Refer to Appendix A or Appendix C for more information on these messages. Table 5-2 summarizes the default characteristics for both the primary and secondary serial ports on differential-ready modules. Notice that units using the NMEA 0183 protocol will accept TSIP command packet 8E-03.

Alternatively, use Trimble's TSIP packets 60 and 61, or TAIP messages DC and DD to apply differential corrections through the CM3's primary serial port (J3, pin 5). These messages may be useful in applications which require the use of a single communications channel between the SVeeSix-CM3 and the system. Note that using these messages requires reformatting the RTCM SC-104 differential correction data into the 60/61 or DC/DD message formats. See Appendix A and Appendix C for more information on these messages.

Differential GPS (con't.)

Table 5-2
Port Characteristics

TSIP Default	TAIP Default	NMEA Default
Primary Port		
Input	TSIP (note 1)	TAIP
Output	TSIP	TAIP
Stop Bits	9600	4800
Data Bits	8	8
Stop Bits	1	1
Parity	Odd	None
Secondary Port		
Input	RTCM SC-104	RTCMSC-104
Output	None (off)	None (off)
Stop Bits	4800	4800
Data Bits	8	8
Stop Bits	1	1
Parity	None	None

◆ **NOTE 1:** *TSIP and NMEA users who wish to input RTCM SC-104 data through the primary port must first use the TSIP 8E-03 command to reconfigure the secondary port input language to packets. Then, use the TSIP 3D command to reconfigure the primary port input language to RTCM SC-104. Only one port may be set to RTCM SC-104 at a time, not both.*

Chapter 6

Operating Characteristics

This chapter describes the SVeeSix-CM3 receiver's satellite acquisition and tracking processes, performance characteristics and system architecture. This discussion assumes the reader is familiar with a basic theory of operation for 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 SVeeSix-CM3 receiver's 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 SVeeSix-CM3 automatically acquires new satellites and includes them in the solution set as required.

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 C/A code is a unique pseudo-random number for each satellite. 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 time required to transmit the complete system almanac is 12.5 minutes and the time to transmit the satellite ephemeris is 30 seconds.

The system almanac contains information about each of the satellites in the constellation, ionospheric data, and special system messages. The ephemeris contains detailed orbital information for a specific satellite. The GPS system almanac is updated weekly and is typically valid for months. 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 SVEE6ix-CM3 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.

Satellite Acquisition and Time to First Fix

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 an SVeeSix-CM3 which 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 six satellites and dedicates an individual tracking channel to search the Doppler range frequency for each satellite in the set. If none of the six selected satellites are acquired after a pre-determined period of time (time-out), the receiver will select a new search set of six 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 SVeeSix-CM3 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, during a cold start, is less than 5 minutes.

A complete system almanac is not required to achieve a first position fix. The almanac is used in subsequent warm starts, and to aid in acquiring GPS satellites that come into view.

Warm Start

In a warm start condition, the receiver has been powered down for a period of time but has a current almanac, and an initial position (within 3,000 km) stored in memory.

When connected to an external backup battery and power is disconnected, the SVeeSix-CM3 retains the almanac, initial position and time. This aids in satellite acquisition and reduces the time to first fix. When an external back-up battery is not used, the TSIP protocol allows the almanac, initial position, and time to be uploaded to the receiver to initiate a warm start.

Satellite Acquisition and Time to First Fix (con't.)

During a warm start, the SVEE6ix-CM3 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 six tracking channels in a parallel search for these satellites. If the internal oscillator error is known, the SVEE6ix-CM3 compensates for the offset to optimize the search. If the offset is not known, the search algorithms will be set wide enough to allow for oscillator tolerance, aging, and temperature errors.

The warm start time to first fix, when the receiver has been powered down for more than four hours (i.e. the ephemeris data is old) is usually less than 50 seconds (40 seconds typical).

Garage Search Strategy

During a warm start search, the SVEE6ix-CM3 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.

In this mode, half of the tracking capability of the receiver is dedicated to warm start search mode while the other half of the receivers tracking capability is directed to cold start search mode (receiver off for more than 36 hours). 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.

Hot Start

A hot start strategy applies when the SVEE6ix-CM3 has been powered down for less than four hours, and the almanac, position and ephemeris 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 30 seconds.

Satellite Mask Settings

Once the SVeeSix-CM3 has acquired and locked onto a set of satellites, which pass the mask criteria listed below, 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 SVeeSix-CM3 are listed in Table 6-1. 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 SVeeSix-CM3 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 the SVeeSix-CM3 by using the TSIP protocol. (See the section titled *Key Setup Parameters*, located in Appendix A.)

Table 6-1
Default Satellite Mask Settings - Packet 2C of App. A

Mask	Setting
Elevation	4°
Signal Level Mask (SNR)	2.2
DOP Mask	12
DOP Switch	5

Standard Operating Modes

The allocation of signal-processing channels and output of GPS data are controlled by three operating modes:

- Over-Determined Mode (On or Off)
- Fix Modes (2D, 3D, or Automatic 3D / 2D / 2D CH).
- 0-D Timing Mode (Stationary timing application)
- Over-Determined Mode (On or Off)

Each of these operating modes are described below.

Over-Determined Mode

An over-determined solution employs more than the minimum number of satellites required for the position solution. For a 2D position, an over-determined solution requires four or more satellites. An over-determined 3D solution requires 6 to 8 satellites. By reducing the relative contribution of each individual satellite to the overall solution, an over-determined solution moderates the effects of Selective Availability, smoothes the position output and minimizes the jumps caused by constellation changes.

The best over-determined solution requires a continuous-tracking, 6-channel receiver architecture. For 6-channel modules, the default setting for over-determined mode is set to ON. The SVEE6-CM3 will use up to eight satellites in the position solution as long as all mask criteria are satisfied. The over-determined solution can be turned off for TSIP-compatible receivers by issuing the appropriate TSIP command. See Appendix A for more information about the TSIP protocol.

Over-Determined Mode (con't.)

High 8 mode: (also known as Smart Sequencing) The receiver outputs an all-in-view, over-determined solution. It provides six continuous tracking channels which are allocated based on SNR age of latest measurement. A satellite will receive a continuous tracking channel if it has a low SNR or is much fresher than a satellite which has its own channel. The channel swapping logic responds quickly to changing conditions, such as every few seconds, so if a weak signal is reacquired from a sequencing satellite then it will quickly receive its own channel. Safeguards are applied to prevent the receiver from over-allocating system resources when satellites are quickly obscured, and then reacquired. Prior to first fix, five channels are used to acquire data, with the constraint of two satellites per channel. After the first fix, only three channels are allowed to acquire data if eight satellites are being tracked. If less than eight satellites are in the tracked list, then up to four channels are allowed to collect data.

The main advantage of an over-determined solution is the increase in accuracy which is generally about a factor of two.

High 6 mode: This mode offers the fastest satellite reacquisition since no channel sequencing is required. Both the High 6 and Best 4 modes have the advantage that when there are no obstructions, measurements can be taken from all satellites in the fix at the same time, and thus, there are no latency induced errors due to vehicle dynamics or receiver clock non linearity's. The penalty of High 6 mode is the degradation of DOP's and satellite visibility due to tracking only six satellites. The drawback of Best 4 is that there is no averaging of measurement errors with this solution.

Best 4 tracking mode: A non over-determined solution. The continuous tracking channels are allocated based on the Best 4 satellite selection. The selected satellites are continuously tracked and satellites not in the selected fix set are moved to the sequencing channels. All sequencing is done on channel 6 which means that there will be three SV's on channel 6 when there are eight satellites being tracked.

Standard Operating Modes (con't)

Fix Modes

The SVeeSix-CM3 offers three positioning modes (in order of appearance): 3D Manual, 2D Manual, Automatic 3D / 2D / 2D CH. However, Automatic 3D/2D/2D CH is the default mode for the SVeeSix-CM3. The positioning mode can be modified in receivers accepting TSIP commands. See Appendix A for more information on the TSIP protocol.

◆ **NOTE:** *One Satellite Timing Mode is only used for stationary timing applications.*

2D Manual

In 2D Manual mode, the SVeeSix-CM3 will only generate 2-dimensional (2D) position solutions (latitude and longitude only), regardless of the number of visible satellites. For 2D solutions, the receiver uses mean sea level 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 #2A (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. For DGPS applications, 3D Manual is the recommended positioning mode for the highest level of accuracy.*

3D Manual

In 3D Manual mode, the SVeeSix-CM3 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 SVeeSix-CM3 will suspend position data outputs. 3D Manual mode is recommended for differential GPS applications requiring the highest level of accuracy.

Automatic 3D/ 2D/ 2D CH

The default operating mode for the SVeeSix-CM3 is Automatic 3D/2D /2D CH. In this mode, the SVeeSix-CM3 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 SVeeSix-CM3 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. If the DOP is above the DOP mask, or when only two satellites are visible the receiver will switch to 2D Clock Hold mode. This mode will model the trajectory of the receiver clock and use it to predict the behavior of the same clock for a short time in the future (default is 10 seconds). This will allow a 2D fix with only two satellites, or 3D fix when three satellites are visible. In 3D/2D 2D CH Automatic mode, the PDOP switch is active.

One Satellite Timing

One Satellite Timing mode is only used in stationary timing applications. In this mode, the SVeeSix-CM3 maintains the one pulse-per-second output quality by tracking a single satellite. A TSIP compatible receiver can be switched to One Satellite Timing mode, after it has achieved its first fix, by issuing the appropriate TSIP command (see Appendix A). This last calculated position fix is assumed to be current and accurate, or a manual position may be entered.

Differential GPS Operating Modes

Differential GPS (DGPS) operation is available on versions of SVeeSix-CM3 with the DGPS option (a differential-ready version of the CM3 module us supplied in the Starter Kit). The default mode for this version of the SVeeSix-CM3 is DGPS Automatic. The TSIP version of the SVeeSix-CM3 DGPS 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 NMEA and TAIP version of the SVeeSix-CM3 DGPS supports only the DGPS Automatic mode. The three DGPS operating modes are described on the next page.

DGPS On

When DGPS On is selected, the SVeeSix-CM3 will only provide differential GPS solutions. If the source of correction data is interrupted or becomes invalid, the SVeeSix-CM3 will suspend all output of position, course and speed data. When a valid source of correction data is restored, the SVeeSix-CM3 will resume outputting corrected data.

DGPS Off

When DGPS Off is selected, the SVeeSix-CM3 will not differentially correct the GPS solutions, even if a valid source of correction data is supplied. In this mode, the receiver will only supply standard GPS data.

DGPS Automatic

DGPS Automatic is the default operating mode for the SVeeSix-CM3. In this mode, the SVeeSix-CM3 will provide differential GPS solutions when valid correction data is available. If correction data is either unavailable or invalid, the SVeeSix-CM3 will output standard GPS solutions. The SVeeSix-CM3 automatically switches between DGPS and standard GPS based on the availability of valid correction data.

Differential GPS Operating Modes (con't)

Differential GPS Operation

The TSIP, NMEA and TAIP versions of the SVeeSix-CM3 are capable of accepting and decoding RTCM SC-104 data. RTCM SC-104 is an industry standard protocol for differential correction data.

The SVeeSix-CM3 receiver provided in the starter kit is configured to accept RTCM SC-104 correction data over the second serial port (J3, pin 7). Alternatively, you can use the TSIP packets 60 and 61 or the TAIP DC and DD messages to input differential corrections through the primary serial port (J3, pin 5).

Position Accuracy

GPS position accuracy is degraded by atmospheric distortion, satellite and receiver clock errors, and Selective Availability (S/A). 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 reduced except with differential GPS.

Selective Availability (S/A)

The U.S. Department of Defense, through a program called Selective Availability, intentionally degrades GPS accuracy for civilian users. The S/A 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, DOP, and S/A) can combine to produce large position errors. The DOD's definition of accuracy under S/A is 100 meters 2dRMS (horizontal 2 dimensional, at least 95% of the time).

Position Accuracy (con't.)

Differential GPS (DGPS)

Differential GPS is an effective technique for overcoming the effects of S/A 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, 2 sigma 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.

Coordinate Systems

Once the SVEE6-CM3 achieves its first fix, it commences periodic outputs of position, velocity, and time information. This information is output over the serial communication channel in a format (TSIP, TAIP, or NMEA 0183) controlled in the firmware configuration program. The TSIP protocol is defined in Appendix A, the TAIP protocol is described in Appendix C, and the NMEA 0183 protocol is described in Appendix E.

TSIP

In the factory default TSIP configuration, position is output as a 3-dimensional coordinate (X-Y-Z) format. By sending the appropriate TSIP command, the SVeeSix-CM3 position output can be changed to a latitude-longitude-altitude (LLA) coordinate format based on the WGS-84 datum (or any of the available datums listed in Appendix A). The TSIP velocity output format is also 3-dimensional. The default format is X-Y-Z with the option of an East-North-Up (ENU) coordinate format. Time messages and time tags on other messages default to GPS time, but can be switched to UTC (Universal Coordinated Time) by sending the appropriate TSIP command. The 8F super packet is a convenient position, velocity output. UTM coordinate outputs are also available in 8F-17 and 8F-18 super packet outputs.

TAIP

The TAIP protocol only supports position outputs in the LLA format. Velocity information is output in a speed (scalar component) and heading (direction component) format. In TAIP messages, position reports are GPS time tagged, with the exception of the TM message which is always based on UTC.

NMEA 0183

The NMEA 0183 protocol only supports position outputs in the LLA format. Velocity information is output in a speed (scalar component) and heading (direction component) format. In NMEA 0183 messages, time and date information is always based on UTC.

Performance Characteristics

Update Rate

The SVeeSix-CM3 receiver update rate is protocol dependent. Using standard TSIP protocol, GPS solutions are computed and output at half-second intervals (2 Hz). The TAIP message update rate can be scheduled from anywhere from 1 to 9999 seconds. The default TAIP output rate is 5 sec (0.2 Hz). For the standard NMEA protocol, solutions are computed at one-second intervals (1 Hz) and the NMEA 0183 message string (GGA and VTG) is output.

Dynamic Limits

The dynamic operating limits for the SVeeSix-CM3 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 6-2
SVeeSix-CM3 Operating Limits

Dynamic	Operating Limit
Velocity	500 m/s
Acceleration	4 g (39.2 m/s ²)
Jerk	20 m/s ³

Performance Characteristics (con't.)

Re-Acquisition

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 lost signal is not re-acquired within 15 seconds, the receiver initiates a broader frequency search. The SVeeSix-CM3 takes advantage of the last known information about the dynamics of the receiver and the satellite to establish the center frequency and range for the search. Every 15 seconds, until the lost signal is re-acquired, a new center frequency and search range is computed. Each frequency range is searched in 300 Hz increments. The duration of the code search at a given frequency is approximately one second and switches automatically.

If ephemeris or almanac data is available for the lost satellite, then the satellite's velocity is factored into the center frequency calculation. The diminished accuracy of an older almanac is accounted for in the width of the search range. If neither the ephemeris or almanac is available, then the Doppler frequency at last lock is searched for two minutes. If the satellite has not been re-acquired after two minutes, then the maximum expected Doppler frequency, based on satellite dynamics, is searched.

The search width is also increased, if the current position is not accurately known. If the SVeeSix-CM3 is computing velocity or velocity aiding is provided, then the receiver's motion is also factored into the Doppler frequency. If velocity information is not available, then the dynamics code is used to determine the maximum expected Doppler frequency.

The dynamics code is configured in firmware and is set for the likely application (marine, aviation, or land-based) of the GPS module. The code identifies the typical dynamic characteristics (velocity and acceleration) for each application. This information is used to optimize the satellite search algorithms by accounting for the expected dynamics associated with the application.

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

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.

A GPS receiver uses the signals from these GPS "clocks" to correct its own internal clock, which is not as stable or accurate as the GPS atomic clocks. A GPS receiver like the SVeeSix-CM3 outputs 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 one micro-second (nominal)

In addition to serving as a highly accurate standalone 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 nano-seconds. The hardware and software implementation affects the GPS receiver's PPS accuracy level. The receiver's clocking rate determines the PPS steering resolution. The SVeeSix-CM3's clocking rate is 1MHz which corresponds to a steering resolution of 1 μ s (\pm 500 ns). Combined with GPS signal errors, the accuracy of the PPS is approximately \pm 600 ns.

GPS Timing (con't.)

Serial Time Output

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

Note that GPS time differs from UTC (Universal Coordinated Time) by a variable, integer number of seconds, as described below.

$$\text{UTC} = (\text{GPS time}) - (\text{GPS}\backslash\text{UTC offset})$$

As of June 30, 1997, the GPS\UTC offset was 12 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.

Timing Pulse Output (PPS)

A pulse-per-second (PPS), one microsecond wide pulse is available on the SVeeSix-CM3 9-pin interface connector (pin 9). The pulse is sent once per second and the leading 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 leading edge is typically less than 20 nano-seconds wide. The falling edge should never be used for timing applications.

◆NOTE: *The PPS signal output by the SVeeSix-CM3 is generated by an open-collector circuit. If this signal must be furnished to a remote location, the system designer should provide a TTL driver for the timing pulse.*

GPS Timing (con't.)

Determining the Time Tag of the PPS Timing Pulse

Synchronizing to the timing pulse requires both a hardware and software (TSIP) interface. The recommended procedure is described below.

1. Monitor TSIP packet 41. This is an automatic output time packet and is computed to the milli-second level (TTTTT.ttt), or issue TSIP packet 21 (request for time).
2. Examine the milli-second portion (.ttt) of the time response. Since the response time of the receiver to queries is variable, the milli-second portion of the time must be used to identify the next pulse.
3. If the milli-second portion (.ttt) of the time response is within an "acceptable" window, then the time of the next pulse is TTTTT + 1 seconds. The acceptable window is a function of the response time of the receiver and the host system. A good general rule for the acceptable window is: $.125 < .ttt < .875$.
4. If the milli-second portion of the time response is outside of the acceptable window, repeat the entire synchronization process until an "acceptable" response is obtained.

◆ **NOTE:** *If the receiver repeatably returns a time response which falls outside of the acceptable window, issue a soft reset command to break the pattern.*

◆ **NOTE:** *If desired, a special software configuration can be installed to output packet 41 every time a position fix has been computed.*

GPS Timing (con't.)

Time Tagging

Since the response delay of the GPS receiver is variable, the combination of TSIP packets 21 and 41 should not be relied upon for time tagging applications. In a worst case situation, the response delay could be 1.5 seconds. The typical response delay is 0.2 seconds. The time in packet 41 is tagged immediately prior to output. Although the delay caused by the serial interface is relatively fixed, the delay between receipt of packet 21 and transmission of packet 41 is highly variable. For time tagging applications, the host system should synchronize to the GPS timing pulse and generate time tags between pulses on an interrupt basis.

◆ **NOTE:** *Although GPS receivers provide numerous benefits when used in timing systems, they are different than standalone timing receivers. Standalone timing receivers provide important added benefits such as event tagging, integrity monitoring, time code generation and fault tolerance. Trimble encourages the OEM to consider these differences when applying GPS receivers to timing applications.*

Appendix A

Trimble Standard Interface Protocol (TSIP)

This appendix provides the information needed to make use of TSIP and all of its powerful features, which will greatly enhance overall system performance and reduce the total development time required for implementation. The reference tables beginning on page A-3 will help you determine which packets apply to your application. For those applications requiring customization, see page A-15 for a detailed description of key setup parameters. Application guidelines are provided for each TSIP command packet, beginning on page A-25.

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.

Interface Scope

The Trimble Standard Interface Protocol which is used in a large number of Trimble's receiver designs, was originally designed 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 SVeeSix-CM3 Has one bi-directional serial port (*primary port*), and one input only port (*auxiliary port*). At default, the auxiliary port is setup for RTCM SC-104. The primary port can be configured for bi-directional TSIP or TAIP . NMEA is an output only protocol. This appendix addresses the TSIP option.

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 (1 byte, representing 2 hexadecimal digits) 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.

The TSIPCHAT.EXE utility is part of the GPS Tool Kit, which is designed to exercise many of the TSIP command packets. The system integrator can use this utility to test the receivers functionality and adaptability to particular application using TSIP command packets.

Minimum Output Packets

Once the GPS receiver is powered on, the following packets will automatically be output. 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. While there are other packets automatically output, the following packets provide the basic information normally used. **No input packets are required.**

Table A-1

ID	Description
0x41	GPS time
0x42	Single-precision XYZ position (<i>Default</i>)
0x43	Velocity fix (XYZ ECEF) (<i>Default</i>)
0x44	Best-4 satellite selection (<i>Optional</i>)
0x46	Health of receiver
0x4B	Machine code /status
0x4D	All-in-view satellite selection (<i>Optional</i>)

◆ NOTE: See page A-15 for a detailed description of the key receiver setup parameters.

Customizing Receiver Operations

To customize the receiver output for your application, consider implementing the following packets. For a review of the key setup parameters, see page A-15.

Table A-2

Input ID	Description	Output ID
0x21	Current time	0x41
0x22	Mode select (2-D, 3-D, auto)	
0x23	Initial position (XYZ ECEF)	--
0x24	Receiver position fix mode	0x44 or 0x6D
0x26	Receiver health	0x46
0x27	Satellite signal levels	0x47
0x2A	Altitude for 2-D mode	--
0x2B	Initial position (Lat., Lon., Alt.)	--
0x2C	Receiver operating parameters	0x4C
0x2E	GPS time	0x4E
0x35	I/O options	0x55
0x37	Status and values of last position and velocity	0x57 (note 1)
0x3D	Configure channel A	0x3D (primary port configuration)
0x75	Best-4 / High-6-overdetermined	0x76
0x8E-03	Configure Aux. port parameters	0x8F-03
0x8E-14, 0x8E-15	Datum	0x8F-14, 0x8F-15

◆ **NOTE:** *Output is determined by packet 0x35 settings (see Table A-3).*

Automatic Fix Reports

The receiver automatically outputs position and velocity reports at set intervals. Report intervals are controlled by packet 0x35. Use packet 0x35 to control which position and velocity packets are output as well as the output packet intervals. The receiver can also be set to automatically output UTM packets (for details, see command 0x8E-17). The single precision/double precision bit (Byte 0, Bit 4) also affects UTM.

Table A-3

Packet ID	Description
0x42	Single precision XYZ position
0x83	Double-precision XYZ position
0x4A	Single-precision LLA position
0x84	Double-precision LLA position
0x43	Velocity fix (XYZ, ECEF)
0x56	Velocity fix (ENU)
0x5A	Raw Measurement Data
0x5E	Additional Fix Status
0x8F-17	UTM single-precision output
0x8F-18	UTM double-precision output
0x8F-20	Last Fix with Extra Information (binary fixed point)

Refer to Command Packet 0x35 for more information.

Warm Start Packets

If the receiver is connected to a back-up power source such as a lithium battery, the data required to cause a warm start is retained even when main power is turned off. At power on, check the following automatic outputs to ensure a warm start:

- The value of packet 0x4B (byte 1, bit 3) is 0 which indicates that the almanac is complete and current.
- The position in packet 0x42 is correct
- The time in packet 0x41 is correct

Simply turning on main power will cause a warm start.

If, however, 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.

Table A-4

ID	Description
0x2B	Initial position
0x2E	Initial time
0x38 (type 2)	Almanac (for each SV)
0x38 (type 3)	Almanac health
0x38 (type 4)	Ionosphere page
0x38 (type 5)	UTC correction

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. Upon output of packet 82, the sequence is complete and the receiver is ready to accept commands.

Table A-5

Input ID	Description	Notes
0x46	Receiver health	--
0x4B	Machine code/status	--
0x45	Software version	--
0x42	Single precision XYZ position	If double precision is selected, packet 0x83 is output instead.
0x4A	Single precision LLA position	If double precision is selected, packet 0x84 is output instead.
0x41	GPS time	This packet is only output if battery back-up is active and the receiver's real-time clock is operating.
0x82	DGPS position fix mode	--

Differential GPS Packets

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

Table A-6

Input ID	Description	Output ID
0x3D	Aux. port configuration	0x3D
0x60	Differential GPS corrections (types 1 and 9)	--
0x61	Differential corrections (type 2)	--
0x62	Differential Auto or Manual operating mode.	0x82
0x65	Differential correction	0x85
0x77	Maximum age that differential corrections will be used	0x78
0x8E-03	Auxiliary port configuration	0x8F-03

Timing Packets

If you are using the SVEE6-CM3 primarily as a timing module, then the following TSIP control commands may need to be implemented.

Table A-7

Input ID	Description	Output ID
0x21	Get the current GPS time.	0x41
0x22	Setup 1 satellite timing mode if desired.	
0x2C	Setup static mode if desired.	0x4C
0x2F	Request UTC parameters.	0x4F
0x34	Choose the satellite you want in 1 Sat mode.	--
Auto	Bias and bias rate of receiver clock	0x54 (note 1)

◆ **NOTE:** *When the receiver is in the manual or automatic one-satellite mode, it will output packet 0x54 to provide the computed clock-only solution. In static auto mode, the receiver outputs packet 0x54. If it cannot compute positions due to PDOP or lack of satellites, as long as the receiver is still tracking at least 1 satellite to update the receiver's clock.*

Satellite Data Packets

The following packets contain a variety of GPS satellite data.

Table A-8

Input ID	Description	Output ID
0x20	Request almanac	0x40
0x27	Request signal levels	0x47
0x28	Request GPS system message	0x48
0x29	Request almanac health page	0x49
0x2F	Request UTC parameters	0x4F
0x38	Request/load satellite system data	0x58
0x39	Set/request satellite disable or ignore health	0x59
0x3A	Request last raw measurement	0x5A
0x3B	Request satellite ephemeris status	0x5B
0x3C	Request tracking status	0x5C
0x3E, auto	Request tracking status	0x5E (note 1)

◆ **NOTE:** *This packet describes the attributes of a position fix. The information is requested by packet 0x3E or is automatically sent after each fix if bit 2 of AUX Byte in packet 0x35 is set.*

Background Packets

The receiver automatically outputs a set of packets that the user may want to monitor for changes in receiver operations including receiver health, time, almanac pages and ephemeris updates. These messages are output at the rates indicated in the table below.

Table A-9

Input ID	Description	Notes
0x40	Almanac data	Almanac data is output as new pages are received.
0x41	GPS time	If the receiver's GPS clock is set and the receiver is not outputting positions, time is output approximately every 16 seconds. If the receiver is outputting positions, time is output approximately every 2.5 minutes.
0x44 or 0x6D	Mode packets	Mode packets are output approximately every 30 seconds or when a constellation change occurs.
0x46	Receiver health	If the receiver is not outputting positions, receiver health information is output approximately every 16 seconds. If the receiver is outputting positions, receiver health messages are output approximately every 30 seconds. Whenever any bit in the health message changes, receiver health is automatically output.
0x5B	Ephemeris	Ephemeris updates are automatically echoed to the user when received.

◆ **NOTE:** *The background packets listed in this table are automatically output. The only way to turn them off is with a the "Silent TSIP" option. Contact a Trimble representative for more information on this option.*

Advanced Packets

The following packets are recommended for sophisticated users who wish to customize receiver operations.

Table A-10

Input ID	Description	Output ID
0x1D	Clear oscillator offset	--
0x1E	Clear battery back-up, reset	(note 1)
0x25	Soft reset & self test	(note 1)
0x2D	Oscillator offset	0x4D
0x36	Velocity aiding of acquisition	--
0x37	Information about last computed fix	0x57 (note 1)
0x39	Satellite disable or ignore health	0x59 (note 2)
0x3A	Last raw measurement	0x5A
0x3B	Satellite ephemeris status	0x5B
0x3C	Tracking status	0x5C
0x3E	Additional fix parameters	0x5E
0x71	Position filter parameters	0x72
0x73	Height filter control	0x74
0x8E-17	Single precision UTM report	0x8F-17 (note 3)
0x8E-18	Double precision UTM report	0x8F-18 (note 3)
0x8E-19	UTM enable/disable	0x8F-19
0x8E-20	Superpacket 2	0x8F-20

◆ **NOTE:** *Output is determined by packet 0x35 settings. See Table A-5 to determine which messages are output at power-up.*

◆ **NOTE:** *Not all modes of packet 0x39 cause a reply (see the packet 39 description, later in this appendix).*

◆ **NOTE:** *Output is limited to packet 0x35 settings (see Table A-3).*

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 beginning on page A-25.

Table A-11

Input ID	Packet Description	Output ID	Input ID	Packet Description	Output ID
0x1D	Clear oscillator offset	--	0x37	Status and values of last position and velocity	0x57 (note 1)
0x1E	Clear battery backup /reset		0x38	Load satellite system data	0x58
0x1F	Software version	0x45	0x39	Satellite disable	0x59 (note 4)
0x20	Almanac	0x40	0x3A	Last raw measurement	0x5A
0x21	Current time	0x41	0x3B	Satellite ephemeris status	0x5B
0x22	Mode select (2-D, 3-D, auto)	0x44 or 0x6D (note 2)	0x3C	Tracking status	0x5C
0x23	Initial position (XYZ ECEF)	--	0x3D	Main port configuration	0x3D
0x24	Receiver position fix mode	0x44 or 0x6D	0x3E	Additional fix parameters	0x5E
0x25	Soft reset & self-test	(note 1)	0x60	Type 1 differential correction	--
0x26	Receiver health	0x46, 0x4B	0x61	Set differential correction	--
0x27	Signal levels	0x47	0x62	Set/request differential GPS position fix mode	0x82
0x28	GPS system message	0x48	0x65	Differential correction status	0x85 (note 3)
0x29	Almanac health page	0x49	0x71	Position filter parameters	0x72
0x2A	Altitude for 2-D mode	--	0x73	Height filter control	0x74
0x2B	Initial position (Lat., Lon., Alt.)	--	0x75	Best 4 / High-6 (Over-determined) control	0x76
0x2C	Operating parameters	0x4C	0x77	Maximum rate of DGPS corrections	0x78
0x2D	Oscillator offset	0x4D	0x8E-03	Auxiliary port configuration	0x8F-03
0x2E	Set GPS time	0x4E	0x8E-14	Datum	0x8F-14

Table A-11 (continued)

Input ID	Packet Description	Output ID	Input ID	Packet Description	Output ID
0x2F	UTC parameters	0x4F	0x8E-15	Datum	0x8F-15
0x32	Accurate initial position	--	0x8E-17	Single precision output	0x8F-17
0x34	Satellite # for 1-sat mode	--	0x8E-18	Double precision output	0x8F-18
0x35	I/O options	0x55	0x8E-19	UTM enable/disable	0x8F-19
0x36	Velocity aiding of acquisition	--	0x8E-20	Last fix with extra information (fixed point)	0x8F-20

- ◆ **NOTE:** *Output is determined by packet 0x35 settings. See Table A-5 to determine which messages are output at power-up.*
- ◆ **NOTE:** *Entering 1SV mode initiates automatic output of packet 54.*
- ◆ **NOTE:** *No response sent if data is not available.*
- ◆ **NOTE:** *Not all packet 0x39 operations have a response. See packet 0x39 description.*

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 on page A-25.

Table A-12

Output ID	Packet Description	Input ID	Output ID	Packet Description	Input ID
0x3D	Main port configuration	0x3D	0x57	Information about last computed fix	0x37
0x40	Almanac data for sat	0x20	0x58	GPS system data/acknowledge	0x38
0x41	GPS time	0x21	0x59	Sat enable/disable & health heed	0x39
0x42	Single-precision XYZ position	0x37	0x5A	Raw measurement data	0x3A
0x43	Velocity fix (XYZ ECEF)	0x37	0x5B	Satellite ephemeris status	0x3B
0x44	Best-4 satellite selection	0x24	0x5C	Satellite tracking status	0x3C
0x45	Software version information	0x1F	0x5E	Additional fix status	0x3E
0x46	Health of Receiver	0x26	0x6D	All-in-view satellite selection	0x24
0x47	Signal level for all satellites	0x27	0x72	Position filter parameter	0x71
0x48	GPS system message	0x28	0x74	Altitude filter parameter	0x73
0x49	Almanac health for all sats	0x29	0x76	Best-4 / High-6-Over-determined	0x75
0x4A	Single-precision LLA position	0x37	0x78	DC Max Age	0x77
0x4B	Machine code/status	0x26	0x82	Differential position fix mode	0x62
0x4C	Report operating parameters	0x2C	0x83	Double-precision XYZ	0x37
0x4D	Oscillator offset	0x2D	0x84	Double-precision LLA	0x37
0x4E	Response to set GPS time	0x2E	0x85	Differential correction status	0x65
0x4F	UTC parameters	0x2F	0x8F-20	Last fix with extra information (fixed point)	0x8E-20

Table A-12 (continued)

Output ID	Packet Description	Input ID	Output ID	Packet Description	Input ID
0x53	Analog-to-digital readings	0x33	0x8F-03	Auxiliary port configuration	0x8E-03
0x54	One-satellite bias & bias rate	0x22	0x8F-17	UTM single report	0x8E-17
0x55	I/O options	0x35	0x8F-18	UTM double report	0x8E-18
0x56	Velocity fix (ENU)	0x37	0x8F-19	UTM/enable	0x8E-19

Key Setup Parameters

Selecting the correct operating parameters has significant impact on receiver performance. Four packets control the key setup parameters:

- Packet 0x22 (set fix mode)
- Packet 0x2C (set operating parameters)
- Packet 0x35 (set I/O options)
- Packet 0x62 (set DGPS mode)

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 obstruction 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 below lists suggested parameter selections as a function of obstruction and whether accuracy or fix density is important. In this table, NA indicates that the operating parameter is not applicable, DC (don't care) indicates that the user may choose the operating parameter.

These options are in the battery backup RAM. Factory options are available for storing these parameters in the SEEPROM so that battery backup is not required. Contact your Trimble Representative for more details.

Table A-13

Packet	Parameter	Accuracy	Fixes
0x22	Fix mode	Man 3D	AUTO
0x2C	Elevation mask	10	5
0x2C	Signal mask	6.0	4.0
0x2C	DOP mask	6.0	12.0
0x2C	DOP switch	NA	8.0
0x35	Fix time	ASAP	DC
0x35	Output time	When computed	DC
0x35	Sync meas.	OFF	OFF
0x35	Min. projection	ON	DC
0x62	DGPS mode	Man ON	AUTO

Key Setup Parameters (continued)

The default values in Table A-13 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 four key packets which control the receiver operating parameters: packet 0x22, packet 0x2C, packet 0x35 and packet 0x62.

Packet 0x22 - Set Fix Mode

Packet 22 is used to choose the appropriate position fix mode for your application: 2-D, 3-D or AUTO. The default mode is AUTO 2-D Clock Hold where the receiver first attempts to obtain a 3-D solution with a DOP below both the DOP mask and DOP switch. If this is not possible, then the receiver attempts to obtain a 2-D solution with a DOP less than the DOP mask. This mode supplies fairly continuous position fixes even when there is frequent obstruction. This mode is preferable for most land or air applications, where altitude changes are occurring and there is occasional obstruction.

The highest accuracy fix mode is 3-D manual, where altitude is always calculated along with the latitude, longitude, and time. However, this requires four satellites with a PDOP below the PDOP mask set in packet 2C in order to obtain a position. Normally, this will provide the most accurate solution. Thus, if only 3-D solutions are desired, then the user should request 3-D manual mode. Depending on how the DOP mask is set, this may be restrictive when the receiver is subjected to frequent obstruction, or when the geometry is poor due to an incomplete constellation.

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

Key Setup Parameters (continued)

Packet 0x22 (con't.)

High accuracy users should avoid this mode and should expect fixes with accuracy's 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 error induced by SA, in which case horizontal accuracy is improved.

Packet 0x2C - Set Operating Parameters

Packet 0x2C defines the extreme conditions under which the receiver will be operating, and the set of usable satellites based on the satellite geometry at the user's position. There are four parameters:

- (a) Dynamics Code The 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 low speed environment and will revert to user entered altitude in 2-D auto. In AIR mode, the search and re-acquisition routines are optimized for high acceleration conditions.
- (b) 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 which can cause corruption of the signal, and multipathing. 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 tradeoff 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.

Key Setup Parameters (continued)

Packet 0x2C (con't.)

- (c) 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 mask has been set to 2.2 to improved tracking capability. The mask should only be lowered cautiously since this mask is also used to minimize the effects of jammers and reflected signals on the receiver. 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 obstruction 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.

- (d) DOP Mask and Switch The DOP mask is the maximum DOP limit for any 2-D or 3-D position solution will be made. The DOP switch is the level at which the receiver stops attempting a 3-D solution, and tries for a 2-D solution when in automatic 2-D, 3-D mode. The switch level has no affect on either manual mode. Raising the DOP mask will generally increase the fix density during obstruction, 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.

- ◆ **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.*

Key Setup Parameters (continued)

Packet 0x35 - Set I/O Options

Packet 0x35 is used to control the format and timing of the position and velocity output. Bytes 0 and 1 control the message output format (see page A-33). Byte 2 contains the five time parameters described below: Time Type, Fix Computation Time, Output Time, Synchronized Measurements and Minimized Projection. Byte 3, the auxiliary byte, controls the output of additional fix data. Byte 3 contains three bits: bit 0 controls the output of raw measurements (Packet 0x5A), bit 1 controls whether the raw measurements output in packet 0x5A are doppler smooth, and bit 2 is the additional fix status bit - setting this bit will cause packet 0x5E to be output with each fix.

(See page A-33 for a complete description of packet 0x35.)

The following descriptions pertain to packet 0x35, byte 2.

- (a) Time Type This bit defines whether the time tags associated with a position fix are in GPS time or UTC time. The default is GPS time.
- (b) Fix Computation Time This bit controls the time and frequency of position fixes. The default is ASAP which, when a satellite is in a normal continuous tracking mode, provides a 2 Hz fix rate and time-of-applicability of the fixes is at 0.25 seconds and 0.75 seconds within each GPS second.

Alternatively, in the integer second mode, the most recent measurements are projected to next integer second, and the solution is then valid at this time. The benefit of this mode is the standard fix time and a 1 Hz output rate. The drawbacks are that some measurement projection is performed and that the fix may be slightly older than with the default option. This mode also matches to the output rate of NMEA.

- (c) Output Time This bit defines whether fixes are automatically output when computed or only sent in response to a packet 0x37 request. The default is automatic output .
- (d) Synchronized Measurements This bit controls whether all satellite range measurements are required to have the same time tag. The default is OFF. Slightly older measurements are tolerated (on the order of 3-5 seconds) to provide solutions when obstructions make it impossible to obtain exactly concurrent measurements from each satellite.

Key Setup Parameters (continued)

Packet 0x35 (con't.)

When this bit is ON, all measurements are required to have the same time tag. This only applies to a six-channel receiver, where selected satellites are tracked continuously on their own channel. This mode is used only when the user application requires all satellite measurements to be identical to the position time tag. If a satellite is lost which is in the selected set for the solution, then no fix will be made until a new selection is made.

The Synchronized measurement mode combined with the minimized projection timing mode (see next paragraph) allows absolutely no measurement projection. However, obstructions may reduce the fix density when there are limited satellites. Use this mode cautiously.

- (e) Minimized Projection This bit controls the time of the position fix relative to the time of the satellite range measurements. The default mode is OFF. In this mode, the time of solution is the time at which the GPS position fix is computed. Thus, all measurements are projected by an interval which is roughly the amount of time it takes to compute the solution. This approach minimizes the latency between the time tag of the computed solution and the solution output. The drawback is that the measurement projection (which is only about 100 ms) may induce some error during high accelerations.

Alternatively, when minimized projection is ON, the time of the solution is the time of the most recent measurements. Thus, if all measurements are taken at exactly the same time, there is no measurement projection. If a selected satellite's measurement time lags the most recent measurement, then it is projected to this time. The difference is that the fix will have more latency than a fix provided with the above timing option. This is the best choice for users performing non real-time error analysis, or non real-time DGPS solution-space corrections. This is also the preferable mode for users integrating GPS with other sensors, where communication lags are the dominant latencies, and thus the time lag between the applicability and availability of the fix is small.

- ◆ **NOTE:** *When the position filter is ON (default), then minimized projection is automatically enabled regardless of how this bit is set.*

Key Setup Parameters (continued)

Packet 0x62 - Set DGPS Mode

Packet 0x62 is used to set the differential GPS operating mode. The default mode is OFF. If differential corrections are available, the recommended 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 only computes solutions 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 0x77.

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. In differential OFF mode, the receiver will not use corrections even if they are valid. If accuracy is critical, use MANUAL mode. If fix density is critical, AUTO DGPS is the recommended mode.

Packet Structure

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

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

<DLE> is the byte 0x10, <ETX> is the byte 0x03, and <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 ('unstuffed') after receiving the packet (see *send_cmd()*, *tsip_input_proc()* in TSIP_IFC.C). 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 as illustrated below. 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 (see *bputsingle()* and *bgetsingle()* in TSIP_IFC.C, for an example).

Integer is a 16 bit unsigned number sent in two's complement format.

Single (float, or 4 byte REAL) is sent as a series of four bytes; it has a precision of 24 significant bits, roughly 6.5 digits.

Double (8 byte REAL) is sent as a series of eight bytes; it has a precision of 52 significant bits, a little better than 15 digits.

Packet Descriptions

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 in Hertz as a Single real value.

Command Packet 0x1E - Clear Battery Back-up, 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 equal to the ASCII letter "K," 0x4B .

CAUTION
All almanac, ephemeris, current position, mode, and communication port setup information is lost by the execution of this command. In normal use this packet should not be sent. 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.

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 bytes. The GPS receiver returns packet 0x45.

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.

Command Packet 0x21 - Request Current Time

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

Packet Descriptions (continued)

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. This selection is held in battery-backed memory.

Mode	Data Byte Value
Automatic	0
Time only (0-D)	1
Horizontal only (2-D)	3
3-D only	4
Auto 2D/2D-CH	5
Auto 3D/2D/2D-CH	6 (default value)

The 1-satellite (0-D) mode uses a single satellite to determine receiver clock error (time) and error rate (frequency) when the position is known precisely. In this mode, the GPS receiver computes no positions or velocities. Instead, the GPS receiver sends packet 0x54 with the clock bias and bias rate. This can be used for time transfer applications and to enable the GPS receiver to maintain the accuracy of the one PPS (Pulse Per Second) output even if a full position fix cannot be done.

Clock-Hold Modes: (available only with Nav version 5.0 or higher)

Algorithms have been added to generate a model of the clock frequency solution. When the 2D or 3D DOP is above the DOP mask, or when there are only two satellites available, then a new HDOP is computed based on a 2D fix where the clock is extrapolated. If the resulting HDOP is less than the new clock-hold DOP mask, then 2D clock-hold fixes will be performed for up to a maximum time-out.

To enable this new mode, the receiver must be in one of the new auto modes. In auto 3D/2D/2D-CH (clock-hold) mode, 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 threshold is exceeded, then the clock uncertainty is removed, and the 2D HDOP with the clock hold constraint is computed. If this HDOP satisfies the clock hold DOP mask, then a fix is allowed. Otherwise, no fixing is allowed until tracking conditions change favorably.

Likewise, in auto 2D/2D-CH mode, the receiver is asked to perform only 2D solutions (using fixed or reference altitude) with a HDOP less than the DOP mask. If this criteria is not satisfied, then a HDOP with the clock uncertainty obliterated is computed. If this HDOP satisfies the clock hold DOP mask, then fixing is allowed. Otherwise, no fixing is allowed for the current tracking conditions.

Packet Descriptions (continued)

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.

The X-axis points toward the intersection of the equator and the Greenwich meridian, the Y-axis points toward the intersection of the equator and the 90° meridian, and the Z-axis points toward the North Pole.

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

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 0x44, or 0x6D depending on whether the receiver is in Over-determined navigation mode.

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 startup 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.

Packet Descriptions (continued)

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.

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.

Command Packet 0x28 - Request GPS System Message

This packet requests the GPS system ASCII message sent with the navigation data by each satellite. This packet contains no data. The GPS receiver returns packet 0x48.

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 0x49.

Command Packet 0x2A - Altitude for 2-D Mode

This packet provides the altitude to be used for Manual 2-dimensional (3 satellite) mode. This altitude is also used for Auto 2-D mode when the dynamics code is set to SEA. This packet contains one Single number (4 bytes) specifying the altitude in meters, using the WGS-84 model of the earth or MSL geoid altitude depending on I/O options (set by packet 0x35). This altitude value is held in battery-backed memory.

If a set altitude is not provided, the receiver will use the altitude of the previous 3-D fix (altitude-hold mode).

◆ **NOTE:** *Sending packet 0x2A with one data byte equal to 0xFF will cancel altitude-set mode and return to altitude-hold mode without the need to clear battery-backed RAM.*

Packet Descriptions (continued)

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. See the description for packet 0x23.

The data format is shown below.

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

Command Packet 0x2C - Set/Request Operating Parameters

This packet optionally 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 page A-15 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 2-D/3-D mode will switch from 3-D to 2-D position solutions. If 4 or more satellites are available and the resulting PDOP is not greater than the DOP switch value, then 3-D fixes are calculated. Otherwise, 2-D fixes are calculated. The DOP switch is effective only in the automatic 2-D/3-D mode.

Packet Descriptions (continued)

Command Packet 0x2C (con't.)

Byte	Item	Type/Units	Default	Byte 0 Value/Velocity
0	Dynamics code	Byte/---	1 - Land	(0) current value left unchanged (1) land/<120 knots (2) sea/<50 knots (3) air/<800 knots (4) static/stationary
1-4	Elevation angle mask	Single/radians	0.1745 or 10°	
5-8	Signal level mask	Single/---	4	
9-12	PDOP mask	Single/---	12	
13-16	PDOP switch (3-D or 2-D)	Single/---	5	

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

Mode 4 selection informs the GPS receiver that it is stationary. Any position fix computed or provided via the data channels is assumed to be accurate indefinitely. When the dynamics code is set to static (byte value = 4) and the fix mode is automatic (set by packet 0x22), then the GPS receiver enters automatic 1-satellite mode when a position fix cannot be performed but there is at least one usable satellite. In this mode, no positions or velocities are computed. Instead, the GPS receiver sends packet 0x54 with the clock bias and bias rate. As long as the GPS receiver is truly stationary, this mode can be used for time transfer applications and to enable the GPS receiver to maintain the accuracy of the one PPS (Pulse Per Second) output even if a full position fix cannot be done.

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

Packet Descriptions (continued)

Command Packet 0x2D - Request Oscillator Offset

This packet requests the calculated frequency 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.

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 number 0 starting January 6, 1980. The seconds count begins at the midnight which begins each Sunday morning.

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

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.

Command Packet 2F - Request UTC Parameters

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

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 and in time transfer (one-satellite mode) applications. 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.

Packet Descriptions (continued)

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 approximate 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 and in time transfer (one-satellite mode) applications. 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.

Command Packet 0x34 - Satellite Number For One-Satellite Mode

This packet allows the user to control the choice of the satellite to be used for the one-satellite mode. This packet contains one byte. If the byte value is 0, the GPS receiver chooses the usable satellite with the highest elevation above the horizon. This automatic selection of the highest satellite is the default action, and the GPS receiver does this unless it receives this packet. If the byte value is from 1 to 32, the packet specifies the PRN number of the satellite to be used. This selection is not kept in battery-backed memory.

If the receiver is in Over-Determined Clock mode, a value not equal to 0 will disable this mode. A subsequent value of 0 will return the receiver to Over-determined Clock mode.

Packet Descriptions (continued)

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. See page A-15 for a detailed description of the key setup parameters for your application.

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 indicated below in the packet. 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. The GPS receiver returns packet 0X55 .

Byte	Parameter Name	Bit Position	Default Bit Value	Option	Associated Packet
0	Position	0 (LSB)	1	XYZ ECEF Output 0: off 1: on	42 or 83
		1	0	LLA Output 0: off 1: on	4A or 84
		2	0	LLA ALT Output 0: HAE (current datum) 1: MSL geoid WGS-84	4A or 84
		3	0	ALT input 0: HAE (current datum) 1: MSL geoid WGS-84	2A
		4	0	Precision-of-position output 0: Send single-precision packet 1: Send double-precision packet	42/4A/8E-17 83/84/8E-18

Packet Descriptions (continued)

In the table below, the following abbreviations apply: 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).

Command Packet 0x35 (continued)

Byte	Parameter Name	Bit Position	Default Bit Value	Option	Associated Packet
0	Position	5	0	Superpacket Output 0: Output no Super Packets 1: Enable all Super Packets	8F-20
		6-7	0	Unused	
1	Velocity	0	1	XYZ ECEF Output 0: Off 1: On	43
		1	0	ENU Output 0: Off 1: On	56
		2-7	0	Unused	
2	Timing	0	0	Time type 0: GPS time 1: UTC	
		1	0	Fix computation time 0: ASAP 1: Next integer sec	
		2	0	Fix output time 0: When computed 1: Only on request	
		3	0	Synchronized measurements 0: Off 1: On	

◆ **NOTE:** Refer to pages A-84 through A-88 for the associated superpacket output. Packet 0x8E must be used to specify which superpacket is to be output.

Packet Descriptions (continued)

Command Packet 0x35 (con't.)

Byte	Parameter Name	Bit Position	Default Bit Value	Option	Associated Packet
2	Timing	4	0	Minimize Projection 0: Off 1: On	
		5-7	0	Unused	
3	Auxiliary	0	0	Raw measurements 0: Off 1: On	5A
		1	0	Doppler smoothed codephase 0: Raw 1: Smoothed	5A
		2	0	Additional Fix Status 0: Off 1: On	5E
		3 - 7		Unused	

Packet Descriptions (continued)

Command Packet 0x36 - Velocity Aiding of Acquisition

In this packet the user provides velocity information to the GPS receiver from an external source to aid in satellite acquisition and re-acquisition.

Byte	Item	Type/Units	Byte 0 Value/Meaning
0	Coordinate select	Byte	0: ECEF 1: ENU (East, North, Up)
1	Velocity aiding enable flag	Byte	0: Disable velocity aiding 1: Enable velocity aiding (see note below)
2 - 5	X or East velocity	Single meters/second	
6 - 9	Y or North velocity	Single meters/second	
10 - 13	Z or Up velocity	Single meters/second	

◆ **NOTE:** *If the velocity aiding enable flag is set to "1," the GPS receiver assumes that the velocity data is accurate to 25 meters per second or better and that it can be used for aiding. The GPS receiver continues to use this data until another packet 0x36 is sent with the aiding enable flag set to "0" (to disable velocity aiding). Once aiding has begun, the GPS receiver must be informed (via a new packet 0x36) of any velocity changes greater than 25 meters per second until velocity aiding is disabled. Once acquisition occurs, the aiding data is ignored; but if acquisition later is lost, then the aiding data is used again.*

Packet Descriptions (continued)

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 packet 0x57 and the appropriate position packet 0x42 or 0x4A, or 0x83 or 0x84, and the appropriate velocity packet 0x43 or 0x56, based on the I/O options in effect.

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.

Byte	Item	Type	Value	Meaning
0	Operation	Byte	1 2	Request data from SVeeSix; Load data into SVeeSix
1	Type of data	Byte	1 2 3 4 5 6	Not used Almanac Health page, T_oa, WN_oa Ionosphere UTC Ephemeris
2	Sat PRN#	Byte	0 1 - 32	Data that is not satellite - ID specific satellite PRN number
3	Length (n)	Byte		Number of bytes of data to be loaded
4 to n+3	Data		n Bytes	

CAUTION

Proper structure of satellite data is critical to SVeeSix 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 reload.

Packet Descriptions (continued)

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, 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.

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".

Byte	Item	Type	Value	Meaning
0	Operation	Byte	1	Enable for selection (default)
			2	Disable for selection
			3	Request enable - or - disable status of all 32 satellites
			4	Heed health on satellite (default)
			5	Ignore health on satellite
			6	Request heed - or - ignore health on all 32 satellites
1	Satellite #	Byte	0	All 32 satellites
			1-32	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.

Packet Descriptions (continued)

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.

Byte	Item	Type	Value	Meaning
0	Satellite #	Byte	0 1-32	All satellites in the current tracking set Desired Satellites

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.

Byte	Item	Type	Value	Meaning
0	Satellite #	Byte	0 1-32	All satellites in the current tracking set Desired Satellites

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.

Byte	Item	Type	Value	Meaning
0	Satellite #	Byte	0 1-32	All satellites in the current tracking set Desired Satellites

Packet Descriptions (continued)

Command / Report Packet 0x3D - Primary Port Configuration

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.

Packet 0x3D is unique in that it is both an input and an output packet. 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, 1 stop bit and no parity.

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 On with packet 0x62.

◆ **NOTE:** *In most 2 port versions of the receiver, 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 9600,8,odd,1.*

Packet Descriptions (continued)

Command Packet 0x3D (continued)

Byte	Item	Type	Units
0	XMT Baud Rate code	Byte	0: 50 baud 1: 110 4: 300 5: 600 0: 1200 1: 2400 4: 4800 5: 9600
1	RCV Baud Rate code	Byte	0: 50 baud 1: 110 4: 300 5: 600 0: 1200 1: 2400 4: 4800 5: 9600
2	Parity and # bits/char code	Byte	xxxxppbb ppp: 0: even parity 1: odd parity 4: no parity bb: 2: 7 3: 8
3	Stop bits code	Byte	7: 1 stop bit 15: 2 stop bits
4	Language mode for Transmission	Byte	0: Packets 1: Off 5: NMEA (Note 1)
5	Language mode for Reception	Byte	0: Packets 1: RTCM SC-104 (Note 2)

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

◆ **NOTE:** *The standard NMEA output is GGA and VTG at 1 second intervals.*

◆ **NOTE:** *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 0x8E-03). Only one port may be set to receive RTCM at a time, not both.*

Packet Descriptions (continued)

Command Packet 0x3E - Request Additional Fix Parameters

This packet is sent to request the attributes of a position fix, i.e. the number of old measurements used in the fix, whether differential Doppler velocity is available, and whether the fix has converged. The response is Packet 0x5E. Note also that the I/O options can be set by the fourth byte of Command Packet 0x35 to output Report Packet 0x5E continuously.

Report Packet 0x40 - Almanac Data Page

This packet provides almanac data for a single satellite. The GPS receiver sends this packet on request (packet 0x20) and when the data is received from a satellite. The data format is shown below.

Byte	Item	Type	Units
0	satellite	Byte	(Identification number)
1	T_zc	Single	Seconds
5	week number	Integer	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	Mo	Single	Radians

These symbols are defined in ICD-GPS-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.

Packet Descriptions (continued)

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 15 seconds when not doing fixes and occur approximately every 150 seconds when doing fixes. The data format is shown below.

Byte	Item	Type	Units
0-3	GPS time of week	Single	Seconds
4-5	GPS week number	Integer	Weeks
6-9	GPS/UTC offset	Single	Seconds

- ◆ **NOTE:** *GPS time differs from UTC by a variable integral number of seconds. UTC = (GPS time) - (GPS/UTC offset).*

CAUTION

The GPS week number runs from 0 to 1023 and then cycles back to week number 0. Week number 0 began January 6, 1980. For version 5.10 firmware and later, the week number will be an "Extended GPS week number" from Jan 6, 1980.

The seconds count begins with "0" each Sunday morning at midnight GPS time. A negative 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.

Approximate Time Accuracy	Time Source	Sign (TOW)	Packet 46 Status Code
None	No time at all	-	01
Unknown	Approximate time from real-time clock or packet 2E	+	01
20 to 50 msec + clock drift	Time from satellite	+	not 01
Full accuracy	Time from GPS solution	+	00

- ◆ **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.*

Packet Descriptions (continued)

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.

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. At start-up, this packet or packet 0x83 is also sent with a negative time-of-fix to report the current known position. Packet 0x83 provides a double-precision version of this information.

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 if selected by the I/O "timing" option. The data format is shown below.

Byte	Item	Type	Value
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.

Packet Descriptions (continued)

Report Packet 0x44 - Best 4 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, 3-D or 2-D). The GPS receiver sends this packet in response to packet 0x24 and whenever a new satellite selection is attempted. If the receiver is in (over-determined) mode, packet 0x6D is sent instead of packet 0x44. In best 4 mode, only packet 0x44 will be generated. The GPS receiver attempts a new selection every 30 seconds and whenever satellite availability and tracking status change. The data format is shown below.

Byte	Item	Type	Value	Meaning
0	Mode	Byte	01	Auto, 1-satellite, 0-D
			03	Auto, 3-satellites, 2-D
			04	Auto, 4-satellites, 3-D
			0x11	Manual, 1-satellite, 0-D
			0x13	Manual, 3-satellites, 2-D
			0x14	Manual, 4-satellites, 3-D
1-4	4 satellite numbers	4 Bytes	4 satellite numbers	
5-8	PDOP	Single		PDOP
9-12	HDOP	Single		HDOP
13-16	VDOP	Single		VDOP
17-20	TDOP	Single		TDOP

PDOP value of zero indicates that the GPS receiver is not doing fixes, usually because there are not enough healthy usable satellites for position fixes. In this case, the satellite number list contains up to four of the satellites which are usable. Empty satellite number-bytes contain zero. Negative PDOP values indicate that the PDOP is greater than the PDOP mask value and therefore the GPS receiver is not performing fixes.

Packet Descriptions (continued)

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.

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

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

Packet Descriptions (continued)

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, during an update cycle, when a new satellite selection is attempted, and when the receiver detects a change in its health. Packet 0x4B is always sent with this packet. The data format is given in the following table.

Byte	Item	Type	Value	Meaning
0	Status code	Byte	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
			0x0A	Only 2 usable satellites
			0x0B	Only 3 usable satellites
			0x0C	The chosen satellite is unusable
1	Test codes	Byte		

Packet Descriptions (continued)

Report Packet 0x46 (continued)

The test codes in Byte 1 of packet 0x46 are encoded into individual bits within the byte. The bit positions and their meanings are shown below.

Test Code Bit Position	Meaning if bit value = 1
0 (LSB)	RAM dead at Power-up. (note 1)
1	Signal Processor error (note 1)
2	Alignment error, channel or chip 1 (note 1)
3	Alignment error, channel or chip 2 (note 1)
4	Antenna feed line fault (Open or Short)
5	Excessive reference frequency error (note 2)
6	(Unused)
7 (MSB)	(Unused)

- ◆ **NOTE:** *After this condition is detected, this bit remains set until the receiver is reset.*
- ◆ **NOTE:** *This bit is "1" if the last computed reference frequency error indicated that the reference oscillator is out of tolerance. (Packet 0x2D requests the oscillator offset and packet 0x4D returns the oscillator offset to the user.)*

Packet Descriptions (continued)

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

Byte	Item	Type
0	Count	Byte
1	Satellite number 1	Byte
2- 5	Signal level 1	Single
6	Satellite number 2	Byte
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 and the absolute value of signal level field is the last known signal level of that satellite.

The signal level provided is measured in arbitrary measuring unites (AMU's) See report packet 0x5A for a description of these unites.

Report Packet 0x48 - GPS System Message

This packet provides the 22-byte ASCII message carried in the GPS satellite navigation message. The receiver sends this packet in response to packet 0x28 and when this data is received from a satellite.

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

Packet Descriptions (continued)

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. First byte is for satellite #1, and so on. The receiver sends this packet in response to packet 0x29 and when this data is received from a satellite.

Byte	Item
1	health of satellite # 1
2	health of satellite # 2
---	---
---	---
---	---
32	health of satellite # 32

In each data byte of this packet, a value "0" indicates that the satellite is healthy; all other values indicate that the satellite is unhealthy.

Packet Descriptions (continued)

Report Packet 0x4A - Single-precision LLA Position Fix

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. The data format is shown below

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
12-15	Clock Bias	Single	Meters
16-19	Time-of-Fix	Single	Seconds

The LLA conversion is done according to the datum selected using packet 0x8E-14. The default is WGS-84. Altitude is referred to the WGS-84 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 last known position. Held in battery back-up RAM. Packet 0x84 provides a double-precision version of this information.

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 π (PI). The value of the constant PI as specified in ICD-GPS-200 is 3.1415926535898.

The MSL option is only valid with the WGS-84 datum. When using other datums, only the HAE option is valid.

Packet Descriptions (continued)

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.

Byte	Item	Type/Value	Status/Meaning
0	Machine ID	Byte	6-channel receiver
1	Status 1	Byte	the Status 1 status codes are encoded into individual bits within the byte:
2	Status 2	Byte	Super packets supported

The status codes are encoded into individual bits within the bytes. The bit positions and their meanings are shown below.

Status 1 Bit Position	Meaning if bit value = 1
0 (LSB)	Synthesizer Fault (Not Used)
1	No time set at powerup
2	A-to-D Converter Fault (Not Used)
3	The almanac stored in the receiver is not complete
4 - 7	Not used

Packet Descriptions (continued)

Report Packet 0x4C - Report Operating Parameters

This packet provides several operating parameter values of the receiver. The receiver sends this packet in response to packet 0x2C. The data string is four Single values. 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 DOP mask sets the maximum DOP with which position fixes are calculated. The DOP switch sets the threshold for automatic 3-D/2-D mode. If 4 or more satellites are available and the resulting PDOP is not greater than the PDOP mask value, then 3-dimensional fixes are calculated.

Byte	Item	Type/Units	Default	Byte 0 Value/Velocity
0	Dynamics code	Byte /20	6-channel receiver	(0) current value left unchanged (1) land/<120 knots (2) sea/<50 knots (3) air (default)/< 800 knots (4) static/stationary
1-4	Elevation angle mask	Single/Radians	0.1745 or 10°	
5-8	Signal level mask	Single /---	2.2	
9-12	DOP mask	Single /---	12.0	
13-16	DOP switch (3-D or 2-D)	Single /---	8.0	

This information is held in battery-backed memory.

Packet Descriptions (continued)

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.

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.

Value	Meaning
ASCII "Y"	The receiver accepts the time entered via packet 0x2E. The receiver has not yet received the time from a satellite.
ASCII "N"	The receiver does not accept the time entered via packet 0x2E. The receiver has received the time from a satellite and uses that time. The receiver disregards the time in packet 0x2E.

Report Packet 4F - UTC Parameters

This packet is sent in response to command packet 0x2F 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, to get UTC time from GPS time, subtract $_T_{LS}$ seconds. The other information contained in this packet indicates when the next leap second is scheduled to occur..

Byte	Value	Type
0-7	A0	Double
8-11	A1	Single
12-13	$_T_{LS}$	Integer
14-17	T_{OT}	Single
18-19	WN_T	Integer
20-21	WN_{LSF}	Integer
22-23	DN	Integer
24-25	$_T_{LSF}$	Integer

Packet Descriptions (continued)

Report Packet 0x55 - I/O Options

This packet provides current I/O options in effect in response to packet 0x35 request. The data format is the same as for packet 0x35 and is repeated below for convenience.

In the table below, the following abbreviations apply: 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).

Byte	Parameter Name	Bit Position	Default Bit Value	Option	Associated Packet
0	Position	0 (LSB)	1	XYZ ECEF Output 0: off 1: on	42 or 83
		1	0	LLA Output 0: off 1: on	4A or 84
		2	0	LLA ALT Output 0: HAE WGS-84 1: MSL geoid	4A or 84
		3	0	ALT input 0: HAE WGS-84 1: MSL geoid	2A
		4	0	Precision-of-position output 0: Single-precision packet 0x4,0x4A, or 0x8E-17. 1: Double-precision packet 0x83,0x84, or 0x8E-1B	
		5	0	Superpacket output 0: off 1: enabled all superpackets	
		6-7	0	unused	

Packet Descriptions (continued)

Command Packet 0x55 (continued)

Byte	Parameter Name	Bit Position	Default Bit Value	Option	Associated Packet
1	Velocity	0	1	XYZ ECEF Output 0: off 1: on	43
		1	0	ENU Output 0: off 1: on	56
		2-7	0	unused	
2	Timing	0	0	Time type 0: GPS time 1: UTC	
		1	0	Fix computation time 0: ASAP 1: next integer sec	
		2	0	Output time 0: when computed 1: only on request	37
		3	0	Synchronized measurements 0: off 1: on	
		4	0	Minimize Projection 0: off 1: on	
		5-7	0	Unused	
		3	Auxiliary	0	0
3	Auxiliary	1	0	Doppler smoothed codephase 0: raw 1: smoothed	5A
		2	0	Additional Fix Status 0: off 1: on	5E
		3 - 7		Unused	

Packet Descriptions (continued)

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: (1) each time that a fix is computed; (2) in response to packet 0x37 (last known fix). The data format is shown below.

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

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

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.

Byte	Item	Type/Units	Byte 0 Value/Velocity
0	Source of information	Byte/ - - -	2200/Temporary no fix 01/regular fix 02/initialization diagnostic 04/initialization diagnostic 05/entered by packet 23 or 2B 06/entered by packet 31 or 32 08/default position after RAM battery fail
1	Mfg. diagnostic	Byte/ - - -	
2-5	Time of last fix	Single/seconds, GPS time	
6-7	Week of last fix	Integer/weeks, GPS time	

Packet Descriptions (continued)

Report Packet 0x58 - Satellite System Data/Acknowledge from Receiver

This packet provides GPS data (almanac, ephemeris, etc.). The receiver sends this packet under the following conditions: (1) on request; (2) in response to packet 0x38 (acknowledges the loading of data). The data format is shown below.

Byte	Item	Type	Value	Meaning
0	Operation	Byte	1 2	Acknowledge Data Out
1	Type of data	Byte	1 2 3 4 5 6	Not used Almanac Health page, T_oa, WN_oa Ionosphere UTC Ephemeris
2	Sat PRN #	Byte	0 1 to 32	Data that is not satellite ID-specific Satellite PRN number
3	Length (n)	Byte		Number of bytes of data to be loaded
4 to n+3	Data	n Bytes		

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

Packet Descriptions (continued)

Packet 0x58 ALMANAC data:

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

◆ NOTE: *All angles are in radians.*

Packet Descriptions (continued)

Packet 0x58 ALMANAC HEALTH data:

Byte	Item	Type	Reference Information
4	week # for health	Byte	(cf. ICD-200, Sec 20.3.3.5.1.3)
5-36	SV_health	Byte	(cf. ICD-200, Sec 20.3.3.5.1.3)
37	t_oa for health	Byte	(cf. ICD-200, Sec 20.3.3.5.1.3)
38	current t_oa	Byte	units = seconds/2048
39-40	current week #	Integer	

Packet 0x58 IONOSPHERE data:

Byte	Item	Type	Reference Information
4-11	---	---	compact storage of the following info
12-15	alpha_0	Single	(cf. ICD-200, Sec 20.3.3.5.1.9)
16-19	alpha_1	Single	(cf. ICD-200, Sec 20.3.3.5.1.9)
20-23	alpha_2	Single	(cf. ICD-200, Sec 20.3.3.5.1.9)
24-27	alpha_3	Single	(cf. ICD-200, Sec 20.3.3.5.1.9)
28-31	beta_0	Single	(cf. ICD-200, Sec 20.3.3.5.1.9)
32-35	beta_1	Single	(cf. ICD-200, Sec 20.3.3.5.1.9)
36-39	beta_2	Single	(cf. ICD-200, Sec 20.3.3.5.1.9)
40-43	beta_3	Single	(cf. ICD-200, Sec 20.3.3.5.1.9)

Packet 0x58 UTC data:

Byte	Item	Type	Reference Information
4-16	---	---	compact storage of the following info
17-24	A_0	Double	(cf. ICD-200, Sec 20.3.3.5.1.8)
25-28	A_1	Single	(cf. ICD-200, Sec 20.3.3.5.1.8)
29-30	delta_t_LS	Integer	(cf. ICD-200, Sec 20.3.3.5.1.8)
31-34	t_ot	Single	(cf. ICD-200, Sec 20.3.3.5.1.8)
35-36	WN t	Integer	(cf. ICD-200, Sec 20.3.3.5.1.8)
37-38	WN_LSF	Integer	(cf. ICD-200, Sec 20.3.3.5.1.8)
39-40	DN	Integer	(cf. ICD-200, Sec 20.3.3.5.1.8)
41-42	delta_t_LSF	Integer	(cf. ICD-200, Sec 20.3.3.5.1.8)

Packet Descriptions (continued)

Packet 0x58 EPHEMERIS data:

Byte	Item	Type	Reference Information
4	sv_number	Byte	SV PRN number
5-8	t_ephem	Single	time of collection
9-10	weeknum	Integer	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
11	codeL2	Byte	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
12	L2Pdata	Byte	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
13	SVacc_raw	Byte	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
14	SV_health	Byte	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
15-16	IODC	Integer	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
17-20	T_GD	Single	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
21-24	t_oc	Single	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
25-28	a_f2	Single	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
29-32	a_f1	Single	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
33-36	a_f0	Single	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
37-40	SVacc	Single	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
41	IODE	Byte	(cf. ICD-200, Sec 20.3.3.4)
42	fit_interval	Byte	(cf. ICD-200, Sec 20.3.3.4)
43-46	C_rs	Single	(cf. ICD-200, Sec 20.3.3.4)
47-50	delta_n	Single	(cf. ICD-200, Sec 20.3.3.4)
51-58	M_0	Double	(cf. ICD-200, Sec 20.3.3.4)
59-62	C_uc	Single	(cf. ICD-200, Sec 20.3.3.4)
63-70	e	Double	(cf. ICD-200, Sec 20.3.3.4)
71-74	C_us	Single	(cf. ICD-200, Sec 20.3.3.4)
75-82	sqrt_A	Double	(cf. ICD-200, Sec 20.3.3.4)
83-86	t_oe	Single	(cf. ICD-200, Sec 20.3.3.4)
87-90	C_ic	Single	(cf. ICD-200, Sec 20.3.3.4)
91-98	OMEGA_0	Double	(cf. ICD-200, Sec 20.3.3.4)
99-102	C_is	Single	(cf. ICD-200, Sec 20.3.3.4)

◆ NOTE: *All angles are in radians.*

Packet Descriptions (continued)**Packet 0x58 NAV data (continued)**

Byte	Item	Type	Reference Information
103-110	i_0	Double	(cf. ICD-200, Sec 20.3.3.4)
111-114	C_rc	Single	(cf. ICD-200, Sec 20.3.3.4)
115-122	omega	Double	(cf. ICD-200, Sec 20.3.3.4)
123-126	OMEGADOT	Single	(cf. ICD-200, Sec 20.3.3.4)
127-130	IDOT	Single	(cf. ICD-200, 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, OMEWGADOT
163-170	ODOT_n	Double	derived from OMEGADOT

Packet Descriptions (continued)

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.

Byte	Item	Type	Value	Meaning
0	Operation	Bytes	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	Satellite #	32 Bytes (1 byte per satellite)	0 1	(Depends on byte 0 value.) Enable satellite selection or heed satellite's health. Default value. 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 set for all satellites.

Packet Descriptions (continued)

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. If the I/O auxiliary option for "raw data" has been selected, the receiver also sends this packet in response to packet 0x3A. The data format is shown below.

Byte	Item	Type	Units
0	Satellite PRN Number	Byte	----
1	Sample Length	Single	msec
5	Signal Level	Single	
9	Code phase	Single	1/16th chip
13	Doppler	Single	Hertz
17	Time of Measurement	Double	sec

APPLICATION NOTE: Packet 0x5A provides the raw satellite signal measurement information used in computing a fix.

The satellite PRN (Byte 0) number is a unique identification for each of the 32 GPS satellites.

The sample length (Byte 1) is the number of milliseconds over which the measurement was averaged. thus if the sample length is 428, then the receiver tracked the satellite and collected the measurement over a 428 millisecond period. The receiver uses a 500 millisecond dwell time per satellite, however, if the channel is sequencing on several satellites, the sample length will be closer to 400 milliseconds due to re-acquisition and loop setting times.

The signal level (Byte 5) is a linear approximation of C/N0 which is stated in antenna amplitude measurement units (AMU's), a Trimble devised unit. An approximate correlation of AMU levels to C/N0 follows:

5 AMU's	—	-20 dB SNR
16 AMU's	—	-10 dB SNR
26 AMU's	—	- 5 dB SNR

◆ NOTE: $SNR_{(\pm 3)} = 20 \log((\text{signal counts}/\text{noise counts}) * (BW/2))$ where: *signal counts* = 64 * AMU; *noise counts* = 90, and *BW* = 1000Hz.

Packet Descriptions (continued)

Report Packet 0x5A – Raw Measurement Data

The C/N0 is affected by five basic parameters: 1) signal strength from the GPS satellite, 2) receiver/antenna gain, 3) pre-amplifier noise figure, 4) receiver noise bandwidth, and 5) accumulator sample rate and statistics. The approximation is very accurate from 0 to 25 AMU's.

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 resolution is 1/16th of a C/A code chip, this corresponds to:

$$\begin{aligned}
 1/16 * C/A \text{ code chip} & \quad - \quad 977.517\text{ns}/16 \quad - \quad 61.0948 \text{ ns} \\
 & \quad - \quad 61.0948 * \text{speed of light, m/s} \\
 & \quad - \quad 18.3158 \text{ meter}
 \end{aligned}$$

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:

$$\begin{aligned}
 C/A \text{ code epoch} * \text{speed of light} & \quad = \quad 1 \text{ ms} * \text{speed of light, m/s} \\
 & \quad - \quad 300\text{km (approx.)} \\
 & \quad - \quad 299.792458 \text{ km (precise)}
 \end{aligned}$$

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 that the receiver occasionally adjusts its clock to maintain time accuracy within ± 0.5 milliseconds, at which time the integer millisecond values for all satellites are adjusted upward or downward by one millisecond.

Packet Descriptions (continued)

Report Packet 0x5B – Satellite Ephemeris Status

This packet is sent in response to packet 0x3B and when a new ephemeris (based on IODE) is received. It contains information on the status of the ephemeris in the receiver for a given satellite. The structure of packet 0x5B is as follows.

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

SV PRN Number is from 1 to 32 representing the satellite PRN number. Time of Collection is the GPS time when this ephemeris data was collected from the satellite. Health is the 6-bit ephemeris health. IODE, toe, and Fit Interval Flag are as described in ICD-GPS-200. SV Accuracy (URA) is converted to meters from the 4-bit code as described in ICD-GPS-200.

Packet Descriptions (continued)

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 below.

Byte	Item	Type	Units	Meaning
0	Satellite PRN number	Bytes		1-32 Satellites
1	Channel and Slot code	Byte		Bit position within byte 1: 2 - 0 (LSB) 0 0 0 (LSB) slot 1 0 0 1 slot 2 0 1 0 slot 3 0 1 1 slot 4 1 0 0 slot 5 <u>1 0 1</u> slot 6 2 1 0
				Bit position within byte 1 7(MSB) 3 (channel number beginning with 0)(MSB) 0 0 0 0 channel 1: used by all receivers 0 0 0 1 channel 2: 6-channel receivers 0 0 0 1 0 channel 3: 6-channel receivers 0 0 0 1 1 channel 4: 6-channel receivers 0 0 1 0 0 channel 5: 6-channel receivers <u>0 0 1 0 1</u> channel 6: 6-channel receivers 7 6 5 4 3
2	Acquisition flag	Byte		0 Never acquired 1 Acquired 2 Re-opened search
3	Ephemeris flag	Byte		0 Flag not set 1 Good ephemeris for this satellite (<4 hours old, good health)

◆ **NOTE:** *Channel and slot is an internal coding of the hardware tracking channel and of the slot within the channel to which the specified satellite currently is assigned.*

Packet Descriptions (continued)

Report Packet 0x5C (continued)

Byte	Item	Type	Units	Meaning
4 - 7	Signal level	Single		Same as packet 0x47
8-11	GPS time of last measurement	Single	Seconds	< 0 No measurements have been taken ≥ 0 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 seconds. 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	Old measurement flag	Byte		0 Flag not set >0 The last measurement is too old to use for a fix computation.
21	Integer msec flag	Byte		0 Don't have good knowledge of integer millisecond range to this satellite 1 Msec from sub-frame data collection 2 Verified by a bit crossing time 3 Verified by a successful position fix 4 Suspected msec error
22	Bad data flag	Byte		0 Flag not set 1 Bad parity 2 Bad ephemeris health
23	Data collection flag	Byte		0 Flag not set >0 The receiver currently is trying to collect data from this satellite.

Packet Descriptions (continued)

Report Packet 0x5E - Additional Fix Status

This packet describes attributes of a position fix. The information is requested by packet 0x3E or sent after each fix if bit 2 of AUX Byte in packet 0x35 is set.

Byte	Bit	Meaning
0	0 – 2	# of measurements in current fix that were used in a previous fix.
	3	1: No differential doppler velocity available 0: Differential doppler velocity available (3-channel receiver only)
	4	1: Fix still converging (when status code = 0, i.e. doing fixes) 0: Fix converged
	5 – 7	Unused
1	0 – 2	# of measurements in current fix that are old (3-5 s)
	3 – 7	Unused

The least significant three bits of byte one of this packet contain the number of measurements used in the fix which were considered old. (Use of an old measurement immediately causes a new satellite selection.) Some latency is desirable to "self-aid" the receiver, since a solution which has some projection error is probably good enough to help re-acquisition of lost satellites, and is probably better than no fix at all. These fixes are now flagged as containing old measurements with this packet.

The least significant three bits (Bits 0-2) of byte zero of packet 0x5E contain the number of measurements used in the current solution that were also used in a previous solution. This gives an indication of how much independent information is contained in each fix. For a three-channel sequencing receiver, the channel allocation and fix rate may make it impossible for a new measurement to be taken from each satellite between fixes which are less than a second apart. Thus, it is possible to re-use a measurement in consecutive fixes even though the measurement is not considered old based on the current satellite distribution on sequencing channels. This information is useful when integrating the receiver with additional sensors.

The fourth bit (Bit 3) of this byte flags fixes whether Differential Doppler velocity was available. The fifth bit (Bit 4) of byte zero is used to flag fixes which are computed but are not output since the receiver is converging after being in an approximate position mode. In this case, the receiver states that it is doing fixes but no positions are being output. This condition is now flagged with this bit.

Packet Descriptions (continued)

Command Packet 0x60 - Type 1 Differential GPS Corrections

This packet provides the SVeeSix with differential corrections from RTCM SC-104 record types 1 and 9, in the TSIP format. There is no response to this packet. The units and scale factors are as defined by RTCM-104 version 1. If byte 3 bit 7 is set, the unit and scale factors are defined by RTCM SC-104 version 2. If bit 6 is set, the corrections are as in RTCM Type 9 records. The format for this packet is as follows:

Byte	Bit	Item	Type	Units
0 - 1	All	Modified z-count	Word	.6 SEC
2	All	Station health	Byte	
3	6	Type 9 flag	Bit	0 = Type 1 1 = Type 9
	0 - 5	Number of SV's in packet	Bit	

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" power. The receiver will not use corrections with scale factor >4.

Byte	Item	Type	Units
4+ (N*5)	SV PRN & Scale factor (UDRE)	Byte	
5+ (N*5)	Range correction	Word	RTCM-104
7+ (N*5)	Range-rate correction	Byte	RTCM-104
8+ (N*5)	IODE	Byte	

◆ **NOTE:** *Packets 0x60 and 0x61 are not supported in the TSIPCHAT software toolkit. Software routines to decode RTCM messages and to code them into packet 0x60 and 0x61 format are available.*

◆ **NOTE:** *Packets 0x60 is identical to TAIP message DC.*

Packet Descriptions (continued)

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 as follows:

Byte	Item	Type	Units
0 – 1	Modified z-count	Word	.6 SEC
2 (set MSB)	Number of SV's in packet	Byte	
The next 3 bytes are repeated as a group for each satellite:			
3+ (N*3)	SV PRN & Scale factor	Byte	
4+ (N*3)	Delta range correction	Word	RTCM-104
5+ (N*3)	Delta Range correction	Byte	RTCM-104

The units and scale factors are as defined by the selected version of RTCM-104. The scale factor given for the specific SV is from the most recent packet 0x60. Delta range corrections are scaled by 0.02 meters times 2 raised to the "scale" power.

◆ NOTE: *Packets 0x61 is identical to TAIP message DD.*

Packet Descriptions (continued)

Command Packet 0x62 - Request/Set Differential Position Fix Mode

This packet requests or sets 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 contain an unusable value (between 4 and FF)

The following modes can be set:

- 0 Ignore DGPS (Differential off)
- 1 Requires DGPS (Differential on) (default)
- 2 or 3 Use DGPS if available.

"GPS" (mode 0) sets the GPS receiver to do position solutions without differential corrections, even if the differential corrections are available.

"Requires DGPS" (mode 1) sets the GPS receiver to do position solutions only if valid differential correction data are available.

"Use DGPS if available" (data byte value = either 2 or 3): The GPS receiver automatically sets itself to mode 2 (differential currently off) if the GPS receiver is not receiving differential correction data for all satellites in a constellation which meets all other masks; and the GPS receiver automatically sets itself to mode 3 (differential currently on) if the GPS receiver is receiving differential correction data for all satellites in a constellation which meets all other masks. Packet 0x82 which the GPS receiver sends in response to receiving packet 0x62, indicates whether the GPS receiver currently is in mode 2 or 3.

An attempt to set a mode outside this set results in simply requesting packet 0x82. The selected mode (manual GPS, manual DGPS, or automatic) is held in battery-backed memory.

Packet Descriptions (continued)

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.

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, 3-D or 2-D). This packet has variable length equal to 16+nsvs (minimum 4), 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 over-determined fix or whenever a new satellite selection is attempted. In Best 4 mode, only packet 0x44 will be generated. The GPS receiver attempts a new selection every 30 seconds and whenever satellite availability and tracking status change. The data format is shown below.

Byte	Item	Type	Meaning		
0	Over-determined mode	Byte	<u>Bit</u>	<u>Value</u>	<u>Meaning</u>
			0-2	3	2D
				4	3D
			3	0	Auto
				1	manual
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	Byte			

Packet Descriptions (continued)

Command Packet 0x71 - Set/Request/Disable Position Filter

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, with the parameter defaults shown in parentheses.

Byte	Type	Value
0	Byte	enable = 1, disable = 0
1-4	Single	0.0625
5	Byte	1
6	Byte	1
7	Byte	0
8	Byte	6
9-12	Single	0.1
13-16	Single	100.0
17-20	Single	1.21
21-24	Single	1,000,000.0
25	Byte	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.*

Packet Descriptions (continued)

Report Packet 0x72 - Position Filter Parameters

This packet provides a list of parameters used in the position filter. It is currently used principally for diagnostic purposes and to show whether the filter is on.

Byte	Item	Type	Value
0-1	PF	Integer	0 (filter is off) 1 (filter is on)
2-5	FLT1	Single	
6-7	CHR1	Integer	
8-9	CHR2	Integer	
10-11	CHR3	Integer	
12-13	CHR4	Integer	
14-17	FLT2	Integer	
18-21	FLT3	Integer	
22-25	FLT4	Single	
26-29	FLT5	Single	
30-31	CHR5	Integer	

Packet Descriptions (continued)

Command Packet 0x73 - Set/Request/Disable Altitude Filter

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:

Byte	Type	Value
0 - 3	Single	Count Where: count > 1, count is the averaging constant (gain = 1/count) count = 1, altitude filter is turned off count = 0, resets the filter parameters to default

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.

Packet Descriptions (continued)

Report Packet 0x74 - Altitude Filter Parameter

This packet provides the parameter used in the altitude filter. The data string has one Single, equal to the number of fixes averaged in the altitude filter. If the value is -1, the altitude filter is currently disabled.

Command Packet 0x75 - Set/Request / High-8-Overdetermined Mode

This command sets the constellation mode of the receiver. The receiver returns packet 0x76. (Refer to page 6-7 Over -Determined modes.)

To request a specific mode, the command is sent with no data bytes.

To set the mode, a single data byte is sent. The data byte can have one of three values:

0 = Best-4 mode

1 = High-6 (Over-determined) mode

2 = High-8 (over-determined smart sequencing) mode (default)

Report Packet 0x76 - Best-4 / High-6-Overdetermined Mode

This packet shows whether the receiver is in High-8, High 6 mode, or Best 4. It returns one byte:

0 = Best-4 mode

1 = High-6 (Over-determined) mode

2 = High-8 (Over-determined smart sequencing) mode (default)

Packet Descriptions (continued)

Command Packet 0x77 - Set/Request Maximum Age of Differential Corrections

This command sets the maximum age at which differential corrections will still be used by the receiver. The default is 60 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.

Byte	Type	Value
0-1	Integer	Maximum Age (seconds)

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.

Byte	Type	Value
0-1	Integer	Maximum Age (seconds)

Packet Descriptions (continued)

Report Packet 0x 82 - 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.

This 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:

- 0 Ignore DGPS (Differential off)
- 1 Requires DGPS (Differential on)
- 2 Auto GPS (Differential currently off)
- 3 Auto DGPS (Differential currently on)

Ignore DGPS (mode 0): The receiver does position solutions without differential corrections, even if the differential corrections are available.

Requires DGPS (mode 1): The receiver only does position solutions if valid differential correction data are available.

DGPS if available (mode 2): 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.

DGPS if available (mode 3): The receiver is receiving differential correction data for all satellites in a constellation which meets all other masks, and is doing differential position solutions.

Packet Descriptions (continued)

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 below.

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. At start-up, if the I/O double precision option is selected, this packet is also sent with a negative time-of-fix to report the current known position.

Packet 0x42 provides a single-precision version of this information.

Packet Descriptions (continued)

Report Packet 0x 84 - 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 below.

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. At start-up, this packet is also sent with a negative time-of-fix to report the current known position.

Packet 0x4A provides a single-precision version of this information.

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 π (PI). The value of the constant PI as specified in ICD-GPS-200 is 3.1415926535898.

Packet Descriptions (continued)

Report Packet 0x 85 - 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 as follows:

Byte	Item	Type	Units
0	Satellite PRN number	Byte	
1	Summary status code	Byte	
2	Station health	Byte	
3	Satellite health (UDRE)	Byte	
4	IODE 1	Byte	
5	IODE 2	Byte	
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

The summary status code is encoded as follows:

Value	Status
0	Good correction data
1	Good delta correction data
2	Station health bad (5 or 7)
3	Data too old (60 seconds)
4	UDRE too high (>4)
5	IODE mismatch with ephemeris
6	Satellite not in current Type1 message

Custom OEM Packets

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-14, 0x14 is the sub-code that indicates the superpacket type. Therefore the ID code for OEM packets is 2 bytes long followed by the data.

TSIP Superpackets

Superpackets describes those packets which reduce the I/O traffic with the receiver and facilitate interpretation to a modem or data acquisition device with limited programming facilities.

◆ NOTE: *TSIP Superpackets 0x8F-20 is incorporated into the firmware revisions 4.06 or later.*

There are three versions of the Superpacket: UTM Single precision (0x8F-17), UTM double precision (0x8F-18, and binary fixed point with velocity (0x8F-20). There is a procedure for asking the receiver to automatically send Superpackets rather than the current position packet (0x4A or 0x84) when a new position is calculated. The 0x8E-20 command is used to specify which Superpacket(s) are to be automatically output. The packets are:

0x8E-17	Request UTM single precision.
0x8E-18	Request UTM double precision
0x8E-20	Request last fix information (binary fixed-point)
0x8F-17	Last fix UTM single precision.
0x8F-18	Last fix UTM double precision
0x8F-20	Last fix with extra information (binary fixed-point)

TSIP Superpackets (continued)

Command Packet 0x8E-03 - Set / Request Auxiliary Configuration

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

◆ **NOTE:** *The Auxiliary port on the SVeeSix-CM3 is input only. However packet 0x8E-03 requires a valid value for the output language field even though it has no effect. It is recommended that the output language is always set to equal 1 (Off). The 0x8E-03 command may be used on the CM3 to change the language mode from RTCM to TSIP packets. This change must be completed before issuing a 3D command to configure the primary port to receive RTCM.*

TSIP Superpackets (continued)

Command Packet 0x8E-03 (con't.)

Byte	Item	Type	Units
0	Sub-packet ID	Byte	Always 0 x 03
1	XMT Baud Rate code	Byte	0: 50 baud 8: 2400 1: 110 9: 4800 4: 300 11: 9600 5: 600 12: 38.4K 6:1200 28: 19.2K
2	RCV Baud Rate code	Byte	0: 50 baud 8: 2400 1: 110 9: 4800 4: 300 11: 9600 5: 600 12: 38.4K 6:1200 28: 19.2K
3	Parity and # bits/char code	Byte	xxxxppbb ppp: 0 even parity 1 : odd parity 4 : no parity bb: 2: 7 3: 8
4	Stop bits code	Byte	7: 1 stop bit 15: 2 stop bits
5	Language mode for Transmission	Byte	0: Packets 1: off 5: NMEA
6	Language mode for Reception	Byte	0: Packets 1: RTCM SC-104

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

TSIP Superpackets (continued)

Command Packet 0x8E-14 - Datum Parameters

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.

There are three modes of operation for this packet;

Query, set standard datum, set special datum.

To query send the 0x8E-14 command with no data bytes. The receiver will return report packet 0x8F-14 which specifies which datum is currently in use.

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

Byte	Type	Value
0	Superpacket ID	0x14
1-2	Integer	Datum index

TSIP Superpackets (continued)

Command Packet 0x8E-14 - Datum Parameters (continued.)

Alternatively, the unit will accept a 40 byte input packet containing 5 double precision floating point value representing the ellipse. The first 3 are DX, DY and DZ which represent an offset in meters from the ECEF origin for the ellipse. The fourth parameter is the semi-major axis of the ellipse (called the a-axis) and is also in meters. The fifth parameter is the eccentricity of the ellipse and is dimensionless.

CAUTION

The GPS receiver does not perform an integrity check on the datum values. If unusual inputs are used, the output will be equally unusual.

Byte	Type	Value	Units
0	Superpacket ID	0x14	
1-8	Double	DX	Meters
9-16	Double	DY	Meters
17-24	Double	DZ	Meters
25-32	Double	A-axis	Meters
33-40	Double	Eccentricity Squared	none

◆ NOTE: *Eccentricity Squared is related to flattening by the following equation:*

$$e^2 = 2p - p^2$$

Command Packet 0x8E-15 – Request Current Datum Values

This packet contains no data. The response to this packet is 0x8F-15.

This command packet is identical to 0x8E-14.

◆ NOTE: *0x8E-14 and 0x8E-15 are identical, they provide backward compatibility, for older receivers.*

TSIP Superpackets (continued)

Command Packet 0x8E-17 - UTM Single Precision Output

Enabling UTM causes packet 0x8F-17 to be output automatically, depending on the setting of the single precision switch in packet 0x35. Setting byte 0, bit 4 of packet 0x35 controls whether single precision packet 0x8F-17 is output. If UTM only output is desired then use command packet 0x35 to turn off XYZ and LLA output.. If command packet 0x8E-17 is sent with no data bytes, the current status is reported with an 0x8F-19 reply. Use 0x8E-19 to turn UTM on or off, by adding either an "E" for Enable or a "D" for Disable to the optional data byte, this will result in an 0x8F-19 reply.

Byte	Description	Type	Value
No Bytes	Output		Latest Superpacket UTM
0	Disables	Integer	UTM Super packet
1	Enable	Integer	Superpacket for auto output

- ◆ **NOTE:** *Using 0x8E-17 with no bytes, or 0x8E-17 with byte value equal to one will change Command packet 35 / and Report packet 0x55 automatically.*

TSIP Superpackets (continued)

Command Packet 0x8E-18 - UTM Double Precision Output

Enabling UTM causes packet 0x8F-18 to be output automatically. Setting byte 0, bit 4 of packet 0x35 controls whether single precision packet 0x8F-17 is output or double precision 0x8F-18 is output. If UTM only output is desired then use command packet 0x35 to turn off XYZ and LLA output.. If command packet 0x8E-18 is sent with no data bytes, the current status is reported with an 0x8F-19 reply. Use 0x8E-19 to turn UTM on or off, by adding either an "E" for Enable or a "D" for Disable to the optional data byte, this will result in an 0x8F-19 reply.

Byte	Description	Type	Value
No Bytes	Output		Latest Double precision UTM
0	Disables	Integer	UTM Double precision
1	Enable	Integer	Double precision for auto output

- ◆ **NOTE:** Using 0x8E-18 with no bytes, or 0x8E-18 with byte value equal to one will change Command packet 0x35 / and Report packet 0x55 automatically.

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.

Byte	Description	Type	Value
0	UTM Status	Char	'E' = Enable, 'D' = Disable

TSIP Superpackets (continued)

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.

Byte	Item	Type	Meaning
0	Sub-packet id	Byte	Id for this sub-packet (always 0x01)
1	Mark for Auto-report (cf. bit 5 of packet 35)	Byte	0 = do not auto-report 1 = mark for auto-report

◆ **NOTE:** *Auto-report requires that superpacket output is enabled. Refer to command packet 0x35.*

Report Packet 0x8F-14 - 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-14. If a built in datum is being used both the datum index and the 5 double precision values for that index will be returned. If the receiver is operating on a custom user entered datum the datum index will be set to -1 and the 5 values will be displayed. These 5 values describe an ellipsoid to convert ECEF XYZ coordinate system into LLA.

Byte	Type	Value
0	Byte	Id for this sub-packet (always 0x15)
1-2	Integer	Datum Index (-1 for custom)
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: $e^2=2\rho-\rho^2$*

TSIP Superpackets (continued)

Report Packet 0x8F-15 - Current Datum Values

This packet is the same as 0x8F-14 and is used for backward compatibility for older receivers.

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

Report Packet 0x8F-17 - UTM Single Precision Output

Byte	Description	Type	Value
0	Grid Band	Char	
1 - 2	Grid Zone	Integer	
3 - 6	Northing	Single	Meters
7 - 10	Easting	Single	Meters
11 - 14	Altitude	Single	Meters
15 - 18	Clock Bias	Single	Meters
19 - 22	Time of Fix	Single	Seconds

Report Packet 0x8F-18 - UTM Double Precision Output

Byte	Description	Type	Value
0	Grid Band	Char	
1 - 2	Grid Zone	Integer	
3 - 10	Northing	Double	Meters
11 - 18	Easting	Double	Meters
19 - 26	Altitude	Double	Meters
27 - 34	Clock Bias	Double	Meters
35 - 38	Time of Fix	Single	Seconds

Report Packet 0x8F-19 - UTM Status Report

Byte	Description	Type	Value
0	UTM Status	Char	'E' = Enable, 'D' = Disable

TSIP Superpackets (continued)

Report Packet 0x8F-20 - Last Fix with Extra Information (binary fixed point)

This packet provides information concerning the time and origin of the previous position fix. This is the last-calculated fix; it could be quite old. The receiver sends this packet in response to packet 8E-20; it also can replace automatic reporting of position and velocity packets. This packet is similar to packets 0x8F-01 and 0x8F-02, except it has complete information for Inverted Differential GPS post-processing. The data format is shown below.

Byte	Item	Type	Meaning
0	Sub packet ID	Byte	Id for this sub-packet (always 0x20)
1	KeyByte	Byte	Reserved for Trimble DGPS Post-processing
2-3	East velocity	Integer	Units 0.005 m/s or 0.020 m/s (see Byte 24). Overflow = 0x8000
4-5	North Velocity	Integer	Units 0.005 m/s or 0.020 m/s (see Byte 24). Overflow = 0x8000
6-7	Up Velocity	Integer	Units 0.005 m/s or 0.020 m/s (see Byte 24). Overflow = 0x8000
8-11	Time of Week	Unsigned long integer	GPS Time in milliseconds
12-15	Latitude	Long Integer	WGS-84 latitude, units = 2^{-31} semicircle. Range = -2^{30} to 2^{30} .
16-19	Longitude	Long Integer	WGS-84 longitude east of meridian, units = 2^{-31} semicircle. Range = 0 to 2^{32} .
20-23	Altitude	Long Integer	Altitude above WGS-84 ellipsoid, mm.
24	Velocity Scaling		When bit 0 is set to 1 velocities in Bytes 2 thru 7 have been scaled to 0.020 m/s
25	Reserved		
26	Datum		Datum index + 1 0=unknown (V5.0 only)

TSIP Superpackets (continued)

Report Packet 0x8- 20 - Last Fix with Extra Information (binary fixed point) (con't.)

Byte	Type	Type	Meaning
27	Fix Type	Byte	Type of fix. This is a set of bit flags. 0 (LSB) 0: Fix was available 1: No fix available 1 0: Fix is autonomous 1: Fix was corrected with RTCM 2 0: 3D fix 1: 2D fix 3 0: 2D fix used last-calculated altitude 1: 2D fix used entered altitude 4 0: unfiltered 1: position or altitude filter on 5-7 unused (always 0)
28	Number of SV's	Byte	Number of satellites used for fix. Will be zero if no fix was available.
29	UTC offset	Byte	Number of leap seconds between UTC time and GPS time.
30-31	Week	Integer	GPS time of fix, weeks
32-47	Fix SV's		Repeated groups of 2 bytes, one for each satellite. There will always be 8 of these groups. The bytes are 0 if group N/A. The following table describes the contents of each group.
48-56	Ionosphere Parameters	Chars	The broadcast ionospheric parameters.

Bytes in 32-47	Item/Type	Meaning
0	PRNX / Byte	Satellite number and IODC - IODE. PRN = the lower six bits of PRNX. IODC = (PRNX/64) X 256 + IODE
1	IODE / Byte	

Total length of data in packet is thus 41 + 3n bytes, where n is the number of satellites.

Datums

Index	DX	DY	DZ	A-axis	Eccentricity	Description
0	0	0	0	6378137.000	0.00669437999014	<i>/*WGS-84*/</i>
1	-128	481	664	6377397.155	0.00667437311265	<i>/*Tokyo from old J6 values*/</i>
2	-8	160	176	6378206.400	0.00676865799761	<i>/*NAD-27*/</i>
3	-9	151	185	6378206.400	0.00676865799761	<i>/*Alaska/Canada*/</i>
4	-87	-98	-121	6378388.000	0.00672267002233	<i>/*European*/</i>
5	-133	-48	148	6378160.000	0.00669454185459	<i>/*Australian*/</i>
6	0	0	4	6378135.000	0.00669431777827	<i>/*WGS-72*/</i>
7	0	0	0	6378137.000	0.00669438002290	<i>/*NAD-83*/</i>
8	0	0	0	6378137.000	0.00669437999014	<i>/*NAD-02*/</i>
9	0	0	0	6378137.000	0.00669437999014	<i>/*Mexican*/</i>
10	0	0	0	6378137.000	0.00669437999014	<i>/*Hawaiian*/</i>
11	0	0	0	6378137.000	0.00669437999014	<i>/*Astronomic*/</i>
12	0	0	0	6378137.000	0.00669437999014	<i>/*U S Navy*/</i>
13	-87	-98	-121	6378388.000	0.00672267002233	<i>/*European*/</i>
14	-134	-48	149	6378160.000	0.00669454185459	<i>/*Australian 1984*/</i>
15	-166	-15	204	6378249.145	0.00680351128285	<i>/*Adindan-Mean*/</i>
16	-165	-11	206	6378249.145	0.00680351128285	<i>/*Adindan-Ethiopia*/</i>
17	-123	-20	220	6378249.145	0.00680351128285	<i>/*Adindan-Mali*/</i>
18	-128	-18	224	6378249.145	0.00680351128285	<i>/*Adindan-Senegal*/</i>
19	-161	-14	205	6378249.145	0.00680351128285	<i>/*Adindan-Sudan*/</i>
20	-43	-163	45	6378245.000	0.00669342162297	<i>/*Afgooye-Somalia*/</i>
21	-150	-250	-1	6378388.000	0.00672267002233	<i>/*Ain El Abd-Bahrain*/</i>
22	-491	-22	435	6378160.000	0.00669454185459	<i>/*Anna 1 Astro 1965*/</i>
23	-143	-90	-294	6378249.145	0.00680351128285	<i>/*Arc 1950-Mean*/</i>
24	-138	-105	-289	6378249.145	0.00680351128285	<i>/*Arc 1950-Botswana*/</i>
25	-125	-108	-295	6378249.145	0.00680351128285	<i>/*Arc 1950-Lesotho*/</i>
26	-161	-73	-317	6378249.145	0.00680351128285	<i>/*Arc 1950-Malawi*/</i>
27	-134	-105	-295	6378249.145	0.00680351128285	<i>/*Arc 1950-Swaziland*/</i>
28	-169	-19	-278	6378249.145	0.00680351128285	<i>/*Arc 1950-Zaire*/</i>
29	-147	-74	-283	6378249.145	0.00680351128285	<i>/*Arc 1950-Zambia*/</i>
30	-142	-96	-293	6378249.145	0.00680351128285	<i>/*Arc 1950-Zimbabwe*/</i>
31	-160	-6	-302	6378249.145	0.00680351128285	<i>/*Arc 1960-Mean*/</i>
32	-160	-6	-302	6378249.145	0.00680351128285	<i>/*Arc 1960-Kenya*/</i>

Datums (continued)

Index	DX	DY	DZ	A-axis	Eccentricity	Description
33	-160	-6	-302	6378249.145	0.00680351128285	<i>/*Arc 1960-Tanzania*/</i>
34	-205	107	53	6378388.000	0.00672267002233	<i>/*Ascension Isl 1958*/</i>
35	145	75	272	6378388.000	0.00672267002233	<i>/*Astro Beacon E 1945*/</i>
36	114	-116	-333	6378388.000	0.00672267002233	<i>/*Astro B4 Sorol Atoll*/</i>
37	-320	550	-494	6378388.000	0.00672267002233	<i>/*Astro Dos 71/4*/</i>
38	124	-234	-25	6378388.000	0.00672267002233	<i>/*Astro Station 1952*/</i>
39	-133	-48	148	6378160.000	0.00669454185459	<i>/*Australian Geo 1966*/</i>
40	-127	-769	472	6378388.000	0.00672267002233	<i>/*Bellevue (IGN)*/</i>
41	-73	213	296	6378206.400	0.00676865799761	<i>/*Bermuda 1957*/</i>
42	307	304	-318	6378388.000	0.00672267002233	<i>/*Bogota Observatory*/</i>
43	-148	136	90	6378388.000	0.00672267002233	<i>/*Compo Inchauspe*/</i>
44	298	-304	-375	6378388.000	0.00672267002233	<i>/*Canton Island 1966*/</i>
45	-136	-108	-292	6378249.145	0.00680351128285	<i>/*Cape*/</i>
46	-2	151	181	6378206.400	0.00676865799761	<i>/*Cape Canaveral mean*/</i>
47	-263	6	431	6378249.145	0.00680351128285	<i>/*Carthage*/</i>
48	175	-38	113	6378388.000	0.00672267002233	<i>/*Chatham 1971*/</i>
49	-134	229	-29	6378388.000	0.00672267002233	<i>/*Chua Astro*/</i>
50	-206	172	-6	6378388.000	0.00672267002233	<i>/*Corrego Alegre */</i>
51	-377	681	-50	6377397.155	0.00667437223180	<i>/*Djakarta (Batavia)*/</i>
52	230	-199	-752	6378388.000	0.00672267002233	<i>/*DOS 1968*/</i>
53	211	147	111	6378388.000	0.00672267002233	<i>/*Easter Island 1967*/</i>
54	-87	-98	-121	6378388.000	0.00672267002233	<i>/*Euro 1950-Mean*/</i>
55	-104	-101	-140	6378388.000	0.00672267002233	<i>/*Euro 1950-Cyprus*/</i>
56	-130	-117	-151	6378388.000	0.00672267002233	<i>/*Euro 1950-Egypt*/</i>
57	-86	-96	-120	6378388.000	0.00672267002233	<i>/*Euro 1950-Eng/Scot*/</i>
58	-86	-96	-120	6378388.000	0.00672267002233	<i>/*Euro 1950-Eng/Ire*/</i>
59	-84	-95	-130	6378388.000	0.00672267002233	<i>/*Euro 1950-Greece*/</i>
60	-117	-132	-164	6378388.000	0.00672267002233	<i>/*Euro 1950-Iran*/</i>
61	-97	-103	-120	6378388.000	0.00672267002233	<i>/*Euro 1950-Sardinia*/</i>
62	-97	-88	-135	6378388.000	0.00672267002233	<i>/*Euro 1950-Sicily*/</i>
63	-87	-95	-120	6378388.000	0.00672267002233	<i>/*Euro 1950-Norway*/</i>
64	-84	-107	-120	6378388.000	0.00672267002233	<i>/*Euro 1950-Port/Spain*/</i>

Datums (continued)

Index	DX	DY	DZ	A-axis	Eccentricity	Description
65	-86	-98	-119	6378388.000	0.00672267002233	<i>/*European 1979*/</i>
66	-133	-321	50	6378388.000	0.00672267002233	<i>/*Gandajika Base*/</i>
67	84	-22	209	6378388.000	0.00672267002233	<i>/*Geodetic Datum 1949*/</i>
68	-100	-248	259	6378206.400	0.00676865799761	<i>/*Guam 1963*/</i>
69	252	-209	-751	6378388.000	0.00672267002233	<i>/*GUX 1 Astro*/</i>
70	-73	46	-86	6378388.000	0.00672267002233	<i>/*Hjorsey 1955*/</i>
71	-156	-271	-189	6378388.000	0.00672267002233	<i>/*Hong Kong 1963*/</i>
72	209	818	290	6377276.345	0.00663784663020	<i>/*Indian-Thai/Viet*/</i>
73	295	736	257	6377301.243	0.00663784663020	<i>/*Indian-India/Nepal*/</i>
74	506	-122	611	6377340.189	0.00667053999999	<i>/*Ireland 1965*/</i>
75	208	-435	-229	6378388.000	0.00672267002233	<i>/*ISTS O73 Astro 1969*/</i>
76	89	-79	-202	6378388.000	0.00672267002233	<i>/*Johnston Island 1961*/</i>
77	-97	787	86	6377276.345	0.00663784663020	<i>/*Kandawala*/</i>
78	145	-187	103	6378388.000	0.00672267002233	<i>/*Kerguelen Island*/</i>
79	-11	851	5	6377304.063	0.00663784663020	<i>/*Kertau 1948 */</i>
80	94	-948	-1262	6378388.000	0.00672267002233	<i>/*La Reunion*/</i>
81	42	124	147	6378206.400	0.00676865799761	<i>/*L.C. 5 Astro*/</i>
82	-90	40	88	6378249.145	0.00680351128285	<i>/*Liberia 1964*/</i>
83	-133	-77	-51	6378206.400	0.00676865799761	<i>/*Luzon-Phillippines*/</i>
84	-133	-79	-72	6378206.400	0.00676865799761	<i>/*Luzon-Mindanao*/</i>
85	41	-220	-134	6378249.145	0.00680351128285	<i>/*Mahe 1971*/</i>
86	-289	-124	60	6378388.000	0.00672267002233	<i>/*Marco Astro*/</i>
87	639	405	60	6377397.155	0.00667437223180	<i>/*Massawa*/</i>
88	31	146	47	6378249.145	0.00680351128285	<i>/*Merchich*/</i>
89	912	-58	1227	6378388.000	0.00672267002233	<i>/*Midway Astro 1961*/</i>
90	-92	-93	122	6378249.145	0.00680351128285	<i>/*Minna*/</i>
91	-247	-148	369	6378249.145	0.00680351128285	<i>/*Nahrwan-Masirah*/</i>
92	-249	-156	381	6378249.145	0.00680351128285	<i>/*Nahrwan-UAE*/</i>
93	-243	-192	477	6378249.145	0.00680351128285	<i>/*Nahrwan-Saudia*/</i>
94	616	97	-251	6377483.865	0.00667437223180	<i>/*Namibia*/</i>
95	-10	375	165	6378388.000	0.00672267002233	<i>/*Naparima</i>
96	-8	159	175	6378206.400	0.00676865799761	<i>/*NAD 27-Western US*/</i>
97	-9	161	179	6378206.400	0.00676865799761	<i>/*NAD 27-Eastern US*/</i>
98	-5	135	172	6378206.400	0.00676865799761	<i>/*NAD 27-Alaska*/</i>

Datums (continued)

Index	DX	DY	DZ	A-axis	Eccentricity	Description
99	-4	154	178	6378206.400	0.00676865799761	<i>/*NAD 27-Bahamas*/</i>
100	1	140	165	6378206.4	0.00676865799761	<i>/*NAD 27-San Salvador*/</i>
101	-10	158	187	6378206.4	0.00676865799761	<i>/*NAD 27-Canada*/</i>
102	-7	162	188	6378206.4	0.00676865799761	<i>/*NAD 27-Alberta/BC*/</i>
103	-22	160	190	6378206.4	0.00676865799761	<i>/*NAD 27-East Canada*/</i>
104	-9	157	184	6378206.4	0.00676865799761	<i>/*NAD 27-Manitoba/Ont*/</i>
105	4	159	188	6378206.4	0.00676865799761	<i>/*NAD 27-NW Ter/Sask*/</i>
106	-7	139	181	6378206.4	0.00676865799761	<i>/*NAD 27-Yukon*/</i>
107	0	125	201	6378206.4	0.00676865799761	<i>/*NAD 27-Canal Zone*/</i>
108	-3	143	183	6378206.4	0.00676865799761	<i>/*NAD 27-Caribbean*/</i>
109	0	125	194	6378206.4	0.00676865799761	<i>/*NAD 27-Central Amer*/</i>
110	-9	152	178	6378206.4	0.00676865799761	<i>/*NAD 27-Cuba*/</i>
111	11	114	195	6378206.4	0.00676865799761	<i>/*NAD 27-Greenland*/</i>
112	-12	130	190	6378206.4	0.00676865799761	<i>/*NAD 27-Mexico*/</i>
113	0	0	0	6378137.0	0.00669438002290	<i>/*NAD 83-Alaska*/</i>
114	0	0	0	6378137.0	0.00669438002290	<i>/*NAD 83-Canada*/</i>
115	0	0	0	6378137.0	0.00669438002290	<i>/*NAD 83-CONUS*/</i>
116	0	0	0	6378137.0	0.00669438002290	<i>/*NAD 83-Mex/Cent Am*/</i>
117	-425	-169	81	6378388.0	0.00672267002233	<i>/*Observatorio 1966*/</i>
118	-130	110	-13	6378200.0	0.00669342162297	<i>/*Old Egyptian 1907*/</i>
119	61	-285	-181	6378206.4	0.00676865799761	<i>/*Old Hawaiian-mean*/</i>
120	89	-279	-183	6378206.4	0.00676865799761	<i>/*Old Hawaiian-Hawaii*/</i>
121	45	-290	-172	6378206.4	0.00676865799761	<i>/*Old Hawaiian</i>
122	65	-290	-190	6378206.4	0.00676865799761	<i>/*Old Hawaiian</i>
123	58	-283	-182	6378206.4	0.00676865799761	<i>/*Old Hawaiian</i>
124	-346	-1	224	6378249.15	0.00680351128285	<i>/*Oman*/</i>
125	375	-111	431	6377563.4	0.00667053999999	<i>/*Ord Sur Brit '36-Mean*/</i>
126	375	-111	431	6377563.4	0.00667053999999	<i>/*OSB-England*/</i>
127	375	-111	431	6377563.4	0.00667053999999	<i>/*OSB-Isle of Man*/</i>
128	375	-111	431	6377563.4	0.00667053999999	<i>/*OSB-Scotland/Shetland*/</i>
129	375	-111	431	6377563.4	0.00667053999999	<i>/*OSB-Wales*/</i>
130	-307	-92	127	6378388.0	0.00672267002233	<i>/*Pico De Las Nieves*/</i>
131	-185	165	42	6378388.0	0.00672267002233	<i>/*Pitcairn Astro 1967*/</i>
132	16	196	93	6378388.0	0.00672267002233	<i>/*Prov So Chilean 1963*/</i>

Datums (continued)

Index	DX	DY	DZ	A-axis	Eccentricity	Description
133	-288	175	-376	6378388.0	0.00672267002233	<i>/*Prov S.American 1956-Mean*/</i>
134	-270	188	-388	6378388.0	0.00672267002233	<i>/*Prov S.American 1956-Bolivia*/</i>
135	-270	183	-390	6378388.0	0.00672267002233	<i>/*Prov S.American 1956-N Chile*/</i>
136	-305	243	-442	6378388.0	0.00672267002233	<i>/*Prov S.American 1956-S Chile*/</i>
137	-282	169	-371	6378388.0	0.00672267002233	<i>/*Prov S.American 1956-Colom*/</i>
138	-278	171	-367	6378388.0	0.00672267002233	<i>/*Prov S.American 1956-Ecuador*/</i>
139	-298	159	-369	6378388.0	0.00672267002233	<i>/*Prov S.American 1956-Guyana*/</i>
140	-279	175	-379	6378388.0	0.00672267002233	<i>/*Prov S.American 1956-Peru*/</i>
141	-295	173	-371	6378388.0	0.00672267002233	<i>/*Prov S.American 1956-Venez*/</i>
142	11	72	-101	6378206.4	0.00676865799761	<i>/*Puerto Rico*/</i>
143	-128	-283	22	6378388.0	0.00672267002233	<i>/*Quatar National*/</i>
144	164	138	-189	6378388.0	0.00672267002233	<i>/*Qornoq*/</i>
145	-225	-65	9	6378388.0	0.00672267002233	<i>/*Rome 1940*/</i>
146	-203	141	53	6378388.0	0.00672267002233	<i>/*Santa Braz*/</i>
147	170	42	84	6378388.0	0.00672267002233	<i>/*Santo (DOS)*/</i>
148	-355	21	72	6378388.0	0.00672267002233	<i>/*Sapper Hill 1943*/</i>
149	-57	1	-41	6378160.0	0.00669454185459	<i>/*S. American 1969-Mean*/</i>
150	-62	-1	-37	6378160.0	0.00669454185459	<i>/*S. American 1969-Argentina*/</i>
151	-61	2	-48	6378160.0	0.00669454185459	<i>/*S. American 1969-Bolivia*/</i>
152	-60	-2	-41	6378160.0	0.00669454185459	<i>/*S. American 1969-Brazil*/</i>
153	-75	-1	-44	6378160.0	0.00669454185459	<i>/*S. American 1969-Chile*/</i>
154	-44	6	-36	6378160.0	0.00669454185459	<i>/*S. American 1969-Colombia*/</i>
155	-48	3	-44	6378160.0	0.00669454185459	<i>/*S. American 1969-Ecuador*/</i>
156	-53	3	-47	6378160.0	0.00669454185459	<i>/*S. American 1969-Guyana*/</i>

Datums (continued)

Index	DX	DY	DZ	A-axis	Eccentricity	Description
157	-61	2	-33	6378160.0	0.00669454185459	<i>/*S. American 1969-Paraguay*/</i>
158	-58	0	-44	6378160.0	0.00669454185459	<i>/*S. American 1969-Peru*/</i>
159	-45	12	-33	6378160.0	0.00669454185459	<i>/*S. American 1969-Trin/Tob*/</i>
160	-45	8	-33	6378160.0	0.00669454185459	<i>/*S. American 1969-Venezuela*/</i>
161	7	-10	-26	6378155.0	0.00669342162297	<i>/*South Asia*/</i>
162	-499	-249	314	6378388.0	0.00672267002233	<i>/*Southeast Base*/</i>
163	-104	167	-38	6378388.0	0.00672267002233	<i>/*Southwest Base*/</i>
164	-689	691	-46	6377276.345	0.00663784663020	<i>/*Timbalai 1948 */</i>
165	-148	507	685	6377397.16	0.00667437223180	<i>/*Tokyo-Mean*/</i>
166	-146	507	687	6377397.16	0.00667437223180	<i>/*Tokyo-Korea*/</i>
167	-158	507	676	6377397.16	0.00667437223180	<i>/*Tokyo-Okinawa*/</i>
168	-632	438	-609	6378388.0	0.00672267002233	<i>/*Tristan Astro 1968*/</i>
169	51	391	-36	6378249.15	0.00680351128285	<i>/*Viti Levu 1916*/</i>
170	102	52	-38	6378270.0	0.00672267002233	<i>/*Wake-Eniwetok */</i>
171	-265	120	-358	6378388.0	0.00672267002233	<i>/*Zanderij */</i>
172	-384	664	-48	6377397.16	0.00667437223180	<i>/*Bukit Rimpah*/</i>
173	-104	-129	239	6378388.0	0.00672267002233	<i>/*Camp Area Astro*/</i>
174	-403	684	41	6377397.16	0.00667437223180	<i>/*Gunung Segara*/</i>
175	-333	-222	114	6378388.0	0.00672267002233	<i>/*Herat North*/</i>
176	-637	-549	-203	6378388.0	0.00672267002233	<i>/*Hu-Tzu-Shan*/</i>
177	-189	-242	-9	6378388.0	0.00672267002233	<i>/*Tananarive Observ. 1925*/</i>
178	-155	171	37	6378388.0	0.00672267002233	<i>/*Yacare*/</i>
179	- 146.43	507.89	681.46	6377397.155	0.00667437223180	<i>/*Tokyo GSI coords */</i>

Reference Documents

Unless otherwise indicated the issue of each document which was in effect on 1 May 1987 is the issue to be used.

SS-GPS-300B

System Specification for the NAVSTAR Global Positioning System

ICD-GPS-200

NAVSTAR GPS Space Segment/Navigation User Interfaces

17035

Trimble Advanced Navigation Sensor Specification and User's Manual Rev. A
October 1990

RTCM (SC-104)

RTCM Recommended Standards For Differential NAVSTAR GPS Service
Version 2.0. RTCM Special Committee No. 104. Published by the Radio
Technical Commission For Maritime Services Washington D.C. January 1 1990.

GPS - A Guide to the Next Utility

Trimble 1990 - an introduction in non-mathematical terms to the GPS system.

Proceedings - Institute of Navigation Washington DC

A series of 3 abstracts published between 1980 & 1986 of papers from the
Journal of the Institute of Navigation. Essential source material for any system
designer.

Appendix B

TSIP User's Guide

This appendix provides explicit instructions for each of the programs contained in the OEM GPS Tool Kit, and guidelines for using the source code as template for integrated systems applications.

The OEM GPS Tool Kit program disk (PN 34152-01) 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-DOS 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 OEM GPS Tool Kit program disk includes the following programs:

- TSIPCHAT.EXE** reads TSIP reports and prints them to the screen. It also allows the user to exercise TSIP commands, by translating keystroke codes into TSIP commands which are output over the serial port. When data input is required, TSIPCHAT prompts the user for the information. TSIPCHAT can also log TSIP reports in binary format, and can set time on a PC, based on time information from the GPS module.
- TSIPPRNT.EXE** interprets a binary TSIP data stream, such as logged by TSIPCHAT, and prints it to a file. Source code is provided.
- 34055-XX.EXE** configures the standard temperature receiver's protocol to (TAIP, TSIP or NMEA). This file will work only for standard temperature receivers.
34057-XX.EXE configures the extended temperature receiver's protocol to (TAIP, TSIP or NMEA). This file will work only for extended temperature receivers.
Where XX is the protocol desired: 61=TSIP , 62=NMEA, 63=TAIP
- RTCM_MON.EXE** monitors a serial port carrying RTCM differential corrections, translates the messages and prints them to the screen.
- TCHAT.EXE** is a simplified version of TSIPCHAT. It provides a good working basis for GPS development. Source code is provided. The program is Microsoft Visual C and Borland C compatible.

TSIPCHAT

TSIPCHAT is a program that provides full visibility into the TSIP interface.

Starting TSIPCHAT

To start the program, type TSIPCHAT.

As TSIPCHAT starts, it displays a list of commands in the upper half of the console screen (command window) and a running account of automatic reports not requested in the bottom half of the screen (auto window). It also sets the serial port to the default settings of 9600 baud, 8-Odd-1.

If the receiver is alive and outputting positions, position reports scroll immediately in the auto window. If the auto window is empty, type 'v' to test if the receiver is connected properly to the computer. If the serial port is properly connected, the receiver responds within a second with the receiver software version numbers; otherwise "waiting for reply" remains on the screen. An auto-report of receiver health is sent every 30 seconds, even if satellites are not being tracked.

Report Packets

When a TSIP report packet is issued by the receiver, it is received by TSIPCHAT, translated into a printable form and put on the screen. If the report packet has been specifically requested by a command, it is put in the command (upper) window; otherwise, it is reported in the auto (lower) window.

The common automatic reports are the navigation reports: position, velocity, and health data. The '^O' command can change the content of these auto-reports or turn them on and off. Other automatic reports include almanac, ephemeris status, and almanac health page when decoded; and receiver health, machine code status, and satellite selection at regular intervals.

TSIPCHAT (continued)

Command Packets

TSIPCHAT uses keystroke codes to send TSIP command packets to the receiver. For instance, the keystroke 'v' sends the TSIP command packet 0x1F, requesting a TSIP report packet 0x45 listing the software versions. A complete list of keystrokes and their associated TSIP commands can be called up by the keystroke '?'.

Many TSIP command packets require user-provided data or parameters. For instance, a request for a satellite almanac report packet requires the satellite identifier (SV PRN). In such cases, TSIPCHAT will prompt the user for inputs. For any of the following three type of prompts, pressing the “<ESCAPE>” key aborts the whole command:

- 1) prompt for number: to enter a numerical value, type the value and hit <ENTER>. If no value is typed, the value entered will be 0.
- 2) prompt for selection: to select from a number of choices, cycle through the choices with the <SPACE BAR> and select with <ENTER>. An index 0 - 9 associated with the choice is shown in parentheses; this index can be typed in for direct access of the choice.
- 3) prompt for confirmation: to confirm when asked, type 'y' or 'Y'. Any other keystroke will be 'negative', including just the <enter> key.

TSIPCHAT (continued)

Serial Port Control

Use caution when using the “^U” command. Control of the receiver can be lost.

To control the serial port settings on main channel, Channel A of the SVeeSix, use the '^U' command. A single port receiver may only have Channel A; when that is reset, control of the receiver may be lost. In such cases the receiver must be hard-reset by clearing the battery backed RAM. (Remove battery backup power).

To control the serial port settings on the computer, use the keystroke '^I'. This keystroke does not generate a TSIP packet. It prompts for the parameters for the buffered serial port. On start-up, the program automatically sets the port parameters to **9600 baud, 8-odd-1**. If the port parameters are changed from the default during the execution of TSIPCHAT, upon exit the program asks if the serial port is to be reset to the default.

File Storage

TSIPCHAT provides an options for file storage, of the raw binary TSIP stream.

The native binary stream records the data coming off the serial port into a file. To turn data collection on and off, use the keystroke '^F'. The user has the option to append to a previously existing file. All report packet bytes are recorded into the file, whether translatable into packets or not. The recorded binary data stream can be translated into an ASCII file with the program TSIPPRNT.

TSIPCHAT (continued)

Quick-Start Almanac Get and Load (con't.)

A stored almanac can allow the receiver to be "warm-started", reducing time to first fix. If the receiver is started 'cold', with no almanac data in memory, it performs a search for satellites in the sky, which can take a few minutes. If the receiver has a recent almanac of satellite orbits, fixes begin within a minute. The receiver responds most quickly if loaded with time, frequency offset, last position, and a recent almanac. There is a command sequence for getting an almanac from the receiver and storing in a file named 'GPSALM.DAT', and a reverse command sequence for reading a file named 'GPSALM.DAT' on the computer and loading it into the receiver. These command sequences use the command packet 0x38 and the report packet 0x58.

The keystroke for the get-and-store sequence is '!', and for the read-and-load sequence is '@'. It is useful to record a fresh almanac every few days. Before storing a new almanac on the PC the receiver must have been operating continuously for about fifteen minutes, otherwise an incomplete almanac will be stored, causing the receiver to go into cold search mode. Check the receiver health to see if the message "Almanac not complete and current" is being reported. Once this message is no longer displayed it is safe to save the Almanac data.

Setting PC Time from the Receiver

TSIPCHAT includes the capability to set the PC clock to UTC time from the GPS satellite signal. (GPS time differs from UTC time by leap seconds.) The keystroke 'z' requests a time set (command packet 0x21, report packet 0x41). A special sequence is required the first time the request is made during execution of the program. The user is prompted for the local time zone offset and then requested to press 'z' again, at which time the time set operation is completed. The user time zone offset is '0' for UTC/GMT; 5 for EST, 4 for EDT; 8 for PST, 7 for PDT; and negative numbers if ahead of (east of) GMT. Allowable range is 13 hours, plus or minus. The accuracy of this software method is approximately ± 0.5 seconds.

Exiting TSIPCHAT

To exit the program, hit the <ESCAPE> key.

TSIPCHAT (continued)

Source Code

Sample Source code is provided with TSIPPRNT and TCHAT. This sample source programs were designed to provide a template for the user interface with the TSIP receiver. In particular, TSIP_IFC.C contains routines that define the interface with the TSIP receiver. These should be re-used in the system integrator's code.

TSIPCHAT is created by compiling under a Borland compiler with the macros PORT_INPUT, and BORLAND defined and with the include file TSIPINCL.H. The following routines must be compiled:

TSIPCHAT.C (main)

TSIP_UTL.C

TSIP_CMD.C

TSIP_RPT.C

TSIP_ALM.C

TSIP_IFC.C

TSIP_SIO.C

TSERIAL.C

TSIPPRNT

TSIPPRNT translates TSIP report packet byte streams into readable reports. It uses the same report interface routines as TSIPCHAT, but uses 'printf' rather than 'cprintf' so that output can be redirected to a file.

The command line for console output is:

```
TSIPPRNT tsip_filename
```

where *tsip_filename* is the name of a stream of TSIP report packets collected directly from the receiver output port or from TSIPCHAT. The command line for re-directing output to a file is:

```
TSIPPRNT tsip_filename > ascii_filename
```

Full source code is provided. TSIPPRNT is created by compiling under any C compiler and with the include file TSIPINCL.H. The following routines must be compiled:

```
TSIPPRNT.C (main)
```

```
TSIP_RPT.C
```

```
TSIP_IFC.C
```

TSIPPRNT code can be easily modified by the user to supply any ASCII output file format that is required by adjusting the report interpreter routines in TSIP_RPT.C, provided the necessary information is contained in the binary input file. Software flow follows that of TSIPCHAT, except with no user-interactive and command features.

RTCM_MON

RTCM_MON translates RTCM SC-104 Version 2.0 (Differential GPS correction) byte streams off a serial port. It is designed to be configured to the same port parameters as the TSIP receiver. RTCM streams can best be tested by using the TSIP receiver itself as a decoder, using TSIPCHAT and the '/' command (packet 0x65) which returns packet 0x85 listing all differential RTCM messages decoded. RTCM_MON is provided in case the user prefers to use a direct connection to a computer serial port to decode an RTCM stream.

The RTCM_MON command line has no arguments. When listening to the serial port, characters will be printed on the screen. RTCM 6-of-8 bytes are identified by the first two bits (binary 01xxxxxx) and all other bytes are reported as non-RTCM bytes. Once the program locks onto the RTCM preamble and framing, it begins to report differential correction messages for each of the satellites.

To exit the program, press <ESCAPE>.

Bit-Slipping

Even though the RTCM bytes are 6 bits of data and fit neatly into a 8-bit byte once the lead bits '01' are attached, some reference receivers do not align the RTCM data onto 8-bit boundaries for the serial link ("bit-slipping"). RTCM_MON automatically searches for bit-slipping.

Serial Port Parameters

The default at start-up is 9600 baud, 8-odd-1. The serial port parameters on the computer can be adjusted by typing '^I'. The program will prompt for new serial port parameters.

Caution
The RRM source will probably require a null-modem connection to the PC serial port.

TCHAT

TCHAT is a simplified version of Tsipchat. That provides a good basis for GPS software development.

The command line syntax is:

TCHAT -c[port number] <optional file name>

where <optional file name> is the name where bytes received directly from the receiver will be collected.

Full source code is provided. Unlike Tsipchat TCHAT can be compiled under both Microsoft and Borland Compilers. It uses the same source code modules as TSIPCHAT. The following modules comprise TCHAT:

- TCHAT.C (main)
- TSIP_RPT.C
- TSIP_IFC.C
- TSERIAL.C

Software flow follows the same as TSIPCHAT, except that the display and user interfaces have been greatly simplified. It is recommended that software developer's become familiar with TCHAT before studying the source code to TSIPCHAT.

Appendix 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 or fleet 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.

Overview

This table specifies which messages are supported by the SVeeSix-CM3 v5.10. The letters Q, R, S, and F/D are for the Query, Response, Set, Frequency/Distance message formats. Any message that can be set for Frequency can be set for Distance as well.

Supported TAIP Messages

Message	Meaning	CM3
AL	Altitude/Vertical Velocity	Q,R,S,F/D
AP	Auxiliary Port Parameters	Q,R,S
CP	Compact Position Solution	Q,R,S,F/D
DC	Differential Corrections	S
DD	Delta Differential Corrections	S
ID	Vehicle ID	Q,R,S,F/D
IP	Initial Position	Q,R,S
LN	Long Navigation Message	Q,R,F/D
PT	Port Characteristic	Q,R,S
PV	Position/Velocity Solution	Q,R,S,F/D
RM	Reporting Mode - ID, CS, EC, FR, CR	Q,R,S
RT	Reset	S
ST	Status	Q,R,F/D
TM	Time/Date	Q,R,S,F/D
VR	Version Number	Q,R,F/D

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 a query or on a scheduled basis. Each sentence has the following general format:

>ABB{C};ID=DDDD][;*FF]<

where:

>	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,
<	the delimiting character.

Notation:

{x}	signifies that x can occur any number of times.
[x]	signifies that x may optionally occur once.

Start of New Message

The '>' character (ASCII code 62 decimal) is used to specify the start of a new sentence.

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:

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	Set command to download time to the GPS receiver
D	Specify minimum distance traveled and minimum and maximum time interval for the next report

Details on the use of message qualifiers are given in the last section of this appendix, *Communication Using TAIP*.

- ◆ **NOTE:** *All TAIP message characters must be in uppercase.*

Message Identifier

A unique two character message identifier consisting of letters of alphabet is used to identify different type messages.

Data String

The format and length of the data string are dictated by the message qualifier and the message identifier. It can consist of any printable ASCII character with the exception of the '>', '<', and ';' characters. A detailed descriptions of each message format is given later. Most messages are length sensitive and unless otherwise specified, field separators including space are not used.

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.

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.

Message Delimiter

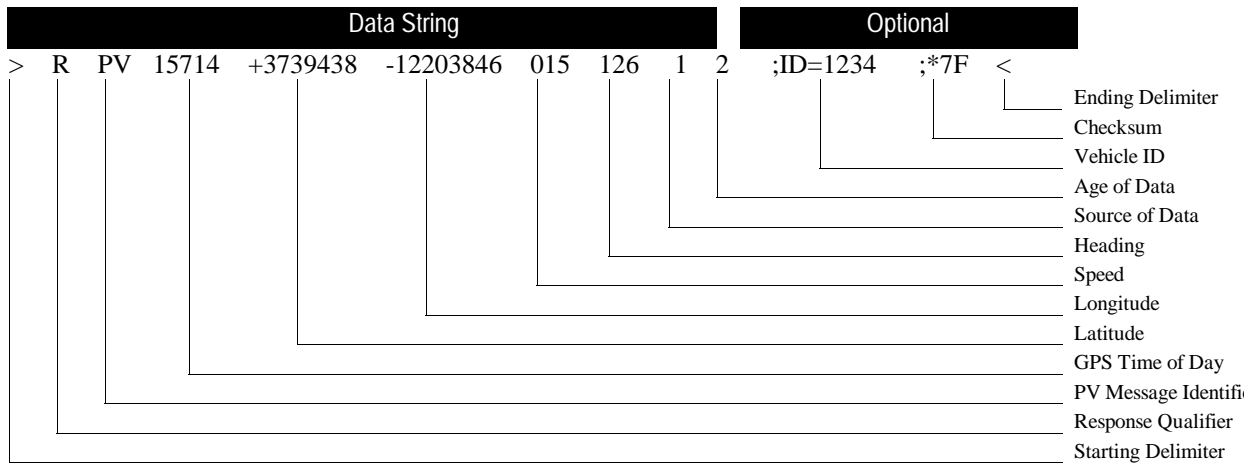
The '<' character signifies end of a sentence and is used as the message delimiter.

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+3739438-12203846015 126 1 2 ;ID=1234 ;*7F<



Data String Information

GPS Time of Day : 15714 seconds, 04:21:54 GPS (time of last fix)
 Latitude: +37.39438 degrees
 Longitude: -122.03846 degrees
 Speed: 15 MPH
 Heading: 126 degrees
 Source of Data: 3D GPS
 Age of Data: Fresh (<10 seconds)

◆ NOTE: Refer to the discussion of the PV message data string for more detail on how this message is interpreted.

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.

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,

$$0.39438 \times 60 = 23.6628 \text{ minutes}$$

Retain the integer (23) portion as the minutes then multiply the decimal fraction by 60 to convert to seconds,

$$0.6628 \times 60 = 39.768 \text{ seconds}$$

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).*

Message Data Strings

The following table lists all the TAIP messages currently defined and comments regarding their application:

Identifier	Message Name	Comments
AL	Altitude/Vertical Velocity	
AP	Auxiliary Port Characteristic	<i>dual port units only</i>
CP	Compact Position Solution	
DC	Differential Corrections	
DD	Delta Differential Corrections	
ID	Vehicle ID	
IP	Initial Position	
LN	Long Navigation Message	
PR	Protocol	
PT	Port Characteristic	
PV	Position/Velocity Solution	
RM	Reporting Mode	
RT	Reset	
ST	Status	
TM	Time/Date	
VR	Version Number	

The data string format of each message is described in the following pages.

◆ **NOTE:** *Your 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:** *All TAIP message characters must be in uppercase.*

AL Altitude/Up Velocity

Data String Format: AAAAABBBBBBCCCCDE

Item	# of Char	Units	Format	Value
GPS Time of day	5	Sec	AAAAA	
Altitude	6	Meters	BBBBBB	Above mean sea level in WGS-84
Vertical Velocity	4	MPH	CCCC	
Source	1	N/A	D	0 = 2D GPS
				1 = 3D GPS
				2 = 2D DGPS
				3 = 3D DGPS
				6 = DR
				8 = Degraded DR
				9 = Unknown
Age of Data Indicator	1	N/A	E	2 = Fresh, <10 sec
				1 = Old, <10 sec
				0 = No Fix Yet
Total	17			

◆ **NOTE:** *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).*

AP Auxiliary Port Characteristic

This message defines the characteristics for the auxiliary port. On SVEeSix family, 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.

Data String Format: *AAAA,B,C,D,E,F*

Item	Bytes	Units	Format	Value
Baud Rate	4	N/A	<i>AAAA</i>	9600, 4800, 2400, 1200, 0300
# of data bits	1	N/A	<i>B</i>	7 or 8
# of stop bits	1	N/A	<i>C</i>	1 or 2
Parity	1	N/A	<i>D</i>	N = None, O = Odd, E = Even
Auxiliary Port Number	1	N/A	<i>E</i>	1
Reserved	1	N/A	<i>F</i>	0

Total # of bytes 10

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: *The inclusion of '0' in the reserved field.*
- ◆ NOTE: *The AP command applies only to receivers with dual serial ports.*
- ◆ NOTE: *The AP command requires commas between data fields.*

CP Compact Position Solution

Data String Format: *AAAAA BBBCCCC DDDDEEEEF G*

Item	# of Char	Units	Format	Value
GPS Time of day	5	Sec	<i>AAAAA</i>	
Latitude	7	Deg	<i>BBBCCCC</i>	positive north, WGS-84
Longitude	8	Deg	<i>DDDDEEEEE</i>	positive west, WGS-84
Source	1	N/A	<i>F</i>	0 = 2D GPS 1 = 3D GPS 2 = 2D DGPS 3 = 3D DGPS 6 = DR 8 = Degraded DR 9 = Unknown
Age of Data Indicator	1	N/A	<i>G</i>	0 = No Fix Yet 1 = Old, >10 sec 2 = Fresh, <10 sec
Total # of char	22			

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).*

DC Differential Corrections

This message provides the sensor with differential corrections from RTCM-104 record types 1 and 9. The values are numerical values written out in hex format, thus for each byte of data there is a two digit hex number.

Data String Format: *AAAABBCC{DDEEEFFGG}*

Item	# of Char	Type	Units	Format
Modified Z-count	4	WORD	.6 sec	AAAA
Station health	2	BYTE	N/A	BB
Number of SV's	2	BYTE	N/A	CC

The next 5 bytes (10 characters) are repeated for each SV

Item	# of Char	Type	Units	Format
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

The units and scale factors are as 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 three bits. The scale factor has only three acceptable values: 0 for “use with low scale factor”, 4 for “use with high scale factor”, and 7 for “don’t use”. Range corrections are scaled by 0.02 meters for low scale factor and 0.32 meters for high scale factor; range-rate corrections are scaled by 0.002 m/sec for low scale factor and 0.032 m/sec for high scale factor.

- ◆ **NOTE:** *The DC and DD TAIP messages are provided to enclose differential corrections within the TAIP format.*
- ◆ **NOTE:** *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:** *The TAIP software toolkit, GPSSK, does not support DC and DD messages.*

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.

Data String Format: *AAAABB{CCDDDD}*

Item	# of Char	Type	Units	Format
Modified Z-count	4	WORD	.6 sec	<i>AAAA</i>
Number of SV's	2	BYTE	N/A	<i>BB</i>

The next 3 bytes (6 characters) are repeated for each SV

Item	# of Char	Type	Units	Format
SV PRN & scale factor	2	BYTE	N/A	<i>CC</i>
Delta Range Correction	4	WORD	RTCM-104	<i>DDDD</i>

The units and scale factors are as 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 three bits. The scale factor has only three acceptable values: 0 for “use with low scale factor”, 4 for “use with high scale factor”, and 7 for “don’t use”. Delta Range corrections are scaled by 0.02 meters for low scale factor and 0.32 meters for high scale factor.

- ◆ **NOTE:** *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.*

- ◆ **NOTE:** *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:** *The TAIP software toolkit, GPSSK, does not support DC and DD messages.*

ID Identification Number

This message is used to report or set the vehicle's (or sensor's) unique, four character, alpha-numeric, user assigned ID.

Data String Format: AAAA

Item	# of Char	Units	Format	Value
Vehicle ID	4	N/A	AAAA	The default at cold start is '0000'

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).*

IP Initial Position

Data String Format: *AAABBBBCCCC*

Item	# of Char	Units	Format	Value
Initial Latitude	3	Deg	<i>AAA</i>	The default at cold start is '0000'
Initial Longitude	4	Deg	<i>BBBB</i>	
Initial Altitude	5	10 Meters	<i>CCCCC</i>	

This is a very coarse initial position that the user can provide to aid the sensor in obtaining its first fix. This is specially 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 (+/-).*

Example

The following message will set the initial position to 37° North, 122° West, altitude 10 meters.

```
>SIP+37-122+0001<
```

LN Long Navigation Message

Data String Format:

AAAAA BBBCCDDDDDD EEEEE FFFFFFFF GGGGGG GHHIII JKKKKL MMMNOO {PPQQ} RRRRRR
RRRRST

Item	# of Char	Units	Format	Value
GPS Time of day	8	Sec	AAAAA.BBB	
Latitude	10	Deg	CCC.DDDDDDD	positive north, WGS-84
Longitude	11	Deg	EEEE.FFFFFFF	positive west, WGS-84
Altitude above MSL	9	Ft	GGGGGGG.HH	
Horizontal Speed	4	MPH	III.J	
Vertical Speed	5	MPH	KKKK.L	
Heading	4	Deg	MMM.N	degrees from True North increasing clockwise
Number of SV's used	2	N/A	OO	

The following two entries (4 characters) are repeated for each SV used:

Item	# of Char	Units	Format	Value
SV Id	2	N/A	PP	
IODE (2 digit hex)	2	N/A	QQ	
Reserved	10	N/A	RRRRRRRRRR	
Source	1	N/A	S	0 = 2D GPS, 1 = 3D GPS, 2 = 2D DGPS, 3 = 3D DGPS, 6 = DR, 8 = Degraded DR, 9 = Unknown
Age of Data Indicator	1	N/A	T	0 = No Fix Yet 1 = Old >10 sec 2 = Fresh <10 sec

Total # of bytes = 65 + (Number of SVs used times 4)

◆ 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).

◆ NOTE: The LN message is capable of satellites ID's and IOD's of up to eight satellites.

PT Port Characteristic

Data String Format: *AAAA,B,C,D*

Item	# of Char	Units	Format	Value
Baud Rate	4	N/A	<i>AAAA</i>	0300, 1200, 2400, 4800, or 9600
# of data bits	1	N/A	<i>B</i>	7 or 8
# of stop bits	1	N/A	<i>C</i>	1 or 2
Parity	1	N/A	<i>D</i>	N = None, O = Odd, E = Even

Total: 10 (including commas)

This message defines the characteristics for the primary TAIP port. Most TAIP using sensors use the following default port characteristics (consult the *Installation and Operator's Manual*):

4800 baud
8 data bits
1 stop bit
No parity

◆ **NOTE:** *The characteristics set by this message will be stored in the sensor's memory. The SVeeSix-CM3 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:** *If you do not use battery back-up, all port characteristics will reset to the default after power is removed.*

◆ **NOTE:** *The PT command uses commas between data fields.*

PR Protocol

(Not supported by SVeeSix-CM3)

PV Position/Velocity Solution

Data String Format: *AAAABBBCCCDDDDDEEEEEFFGGGHI*

Item	# of Char	Units	Format	Value
GPS Time of Day	5	Sec	<i>AAAAA</i>	
Latitude	8	Deg	<i>BBB.CCCCC</i>	
Longitude	9	Deg	<i>DDDD.EEEEE</i>	
Speed	3	MPH	<i>FFF</i>	
Heading	3	Deg	<i>GGG</i>	
Source	1	N/A	<i>H</i>	0 = 2D GPS 1 = 3D GPS 2 = 2D DGPS 3 = 3D DGPS 6 = DR 9 = Unknown
Age of data indicator	1	N/A	<i>I</i>	0 = No Fix Yet 1 = Old > 10 Sec 2 = Fresh < 10 Sec
Total	30			

Position is in latitude (positive north) and longitude (positive east) WGS-84. Heading is in degrees from True North increasing clockwise. 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).*

RM Reporting Mode

Data String Format: [;ID_FLAG=A][;CS_FLAG=B][;EC_FLAG=C] [;FR_FLAG=D] [;CR_FLAG=E]

Item	# of Char	Units	Format	Value
ID Flag	1	N/A	A	T = True, F = False
CS Flag	1	N/A	B	T = True, F = False
EC Flag	1	N/A	C	T = True, F = False
FR Flag	1	N/A	D	T = True, F = False
CR Flag	1	N/A	E	T = True, F = False

- ID** Flag dictates whether the unit is to include the vehicles ID with each report.
- CS** Flag dictates 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.

Example The following command will turn checksums off and carriage return on:

```
>SRM;CS_FLAG=F;CR_FLAG=T<
```

- ◆ **NOTE:** *The use of semicolon before the flag name.*

RT Reset

Item	# of Char	Units	Format	Value
RT	0	N/A	Char	Warm start
RTCOLD	4	N/A	Char	Cold start

- ◆ **NOTE:** *The only valid qualifier is the Set command "S".*

The Save_Config data string is the only method of saving the TAIP protocol definition to Serial EEPROM.

Example: >SRT< This command will warm start the GPS receiver .

>SRTCOLD< This command will cold start the GPS receiver.

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.*

Item	# of Char	Units	Format	Value
Tracking Status Code	2		AA	See Table Below
Status Codes - Nibble 1	1		B	See Table Below
Status Codes - Nibble 2	1		C	See Table Below
Machine ID	2		DD	See Table Below
Status Codes - Nibble 3	1		E	Not currently used
Status Codes - Nibble 4	1		F	See Table Below
Reserved	2		GG	Not currently used

ST Status (continued)

Tracking Status Code

Value of AA	Meaning
00	Doing position fixes
01	Don't have GPS time yet
02	Not used
03	DOP is too high
08	No usable satellites
09	Only 1 usable satellites
0A	Only 2 usable satellites
0B	Only 3 usable satellites (Manual 3D Mode)
0C	Chosen satellite is unusable

◆ **NOTE:** *In the tables below, an X in a column means that fault is being reported.*

Status Codes – Nibble 1

Value of B	Antenna feedline fault (open or short)
00	No Problem
01	1

Status Codes – Nibble 2

Value of C	Battery Back-up Failed
00	No Problem
01	1

◆ **NOTE:** *(1) After this error is detected, its bit remains set until the sensor is reset. (2) This bit is "1" if the last computed reference frequency error indicated that the reference oscillator is out of tolerance.*

ST Status (continued)**Status Codes – Nibble 4**

Value of F	Stored Almanac is not complete or current	Battery Powered Timer./Clock Fault
00	No Problem	No Problem
02		1
08	1	
0A	1	1

◆ **NOTE:** (1) *After this error is detected, its bit remains set until the sensor is reset.* (2) *This bit is "1" if the last computed reference frequency error indicated that the reference oscillator is out of tolerance.*

TM Time/Date

Data String Format: *AABBCCDDDEEFFGGGGHHIIJKLLLL*
 UTC Time of Day

Item	Bytes	Units	Format	Value
Hours	2	Hours	AA	0-23
Minutes	2	Min	BB	0-59
Seconds	5	Sec	CC.DDD	0-59.999
Date; Day	2	Day	EE	1-31
Date; Month	2	Month	FF	1-12
Date; Year	4	Year	GGGG	1997-2016
GPS/UTC Time Offset	2	Sec	HH	
Current Fix Source	1	N/A	I	0 = 2D GPS 1 = 3D GPS 2 = 2D DGPS 3 = 3D DGPS 6 = DR 8 = Degraded DR 9 = Unknown
Number of Usable SV's	2	N/A	JJ	0-8
GPS/UTC Offset Flag	1	N/A	K	
Reserved	5	N/A	LLLL	
Total #	28			

◆ **NOTE:** *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.*

◆ **NOTE:** *The TM message is supported under the Set qualifier which allows you to download time to a GPS receiver that does not have a real-time clock. Fields AA through GGGG must be downloaded but the remaining fields may be filled with zeros (0) to create a total data stream of 28 characters. For optimum warm-start performance, downloaded time must be accurate to ±5 minutes (use UTC, not local time).*

◆ **NOTE:** *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.*

VR Version Number

Data String Format:

XXXXXXX ;VERSION A.AA(BB/BB/BB); CORE VERSION C.CC(DD/DD/DD); E

Item	Bytes	Units	Format	Value
Product Name	n	N/A	N/A	
Major Version Number	4	N/A	A.AA	
Major Release Date	8	N/A	BB/BB/BB	Month/Day/Year
Core Version Number	4	N/A	C.CC	
Core Release Date	8	N/A	DD/DD/DD	Month/Day/Year
Copyright Text	Variable	N/A	E	

- ◆ **NOTE:** *The length of this message is variable based upon copyright text string.*
- ◆ **NOTE:** *The phrase Core Version refers to the signal processing firmware version.*

Communication Using TAIP

Communication with the unit takes place in four different ways. Message qualifiers are used to differentiate between these.

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, PR, PT, PV, RM, ST, TM, and VR.

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, CP, ID, LN, PV, ST, TM, and VR.

◆ **Note:** *What is 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.*

Scheduled Reporting Distance Interval

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. All messages using the F qualifier can use the D qualifier.

The message format used with the D qualifier is shown below:

```
>DAABBBBCCCCEEEFFFFF[;ID=GGGG][;*HH]<
```

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 that 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).*

◆ *For 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 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, PR, PT, PV, RM, ST, TM, and VR.

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, PR, PT, PV, RM, RT and TM.

The set qualifier may be used with the AL, CP, or PV message to set more precise initial position data into the GPS sensor than can be set with the IP message.

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 SVEESIX-CM3 D;VERSION 4.06 (5/18/94); CORE VERSION 1.17  
(11/20/93); COPYRIGHT (C) 1991, 1992, 1993, 1994 TRIMBLE  
NAVIGATION,LTD.;*38<
```

Notice that 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<
```

Most Placer family sensors are 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<
```

Notice that 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'.

Appendix 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.

The GPSSK Files

GPSSK is included on the on 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

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.

The GPSSK Files (continued)

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.

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.

Connecting the GPS Sensor

Consult the *Installation and Operator's Manual* for information on installation, power requirements and cables specific to your Placer family 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 most Placer family sensors. 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.*

Appendix E

NMEA 0183

This appendix provides a brief overview of the NMEA protocol and describes both the standard and optional messages offered by the SVeeSix.

NMEA 0183 is an interface protocol created by the National Marine Electronics Association. The latest release of NMEA 0183 is Version 2.00. 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 SVeeSix 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.

For a complete copy of the NMEA 0183 standard, contact:

National Marine Electronics Association
Executive Director
PO Box 50040
Mobile, Alabama 36605

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 (d7=0)
Parity	None (Disabled)
Stop Bits	1

The **GPSSK.EXE** program will display NMEA 0183 messages in the lower portion of the screen, once the COM ports setting in GPSSK match the above information. The NMEA 0183 messages will have the notation \$GP at the beginning of each sentence. The next three characters are the actual NMEA 0183 messages. This information is comma delimited.

Any standard communication program (Windows Terminal™, Win 95 Hyperterm™, Procomm™) will also display NMEA messages.

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 sensor like the SVeeSix. 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. Checksums and checksum delimiters are optional for most NMEA 0183 messages.
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.

◆ **NOTE:** *Software developers should use "," comma delimiters for parsing through the NMEA Sentence, as the field length may vary between the commas.*

NMEA 0183 Message Options

The standard NMEA 0183 version of the SVEESix outputs two messages: GGA (NMEA Version 2) and VTG. These messages are output at a 1 second interval with the "GP" talker ID and without checksums.

For a nominal fee, Trimble can offer a custom mix of the messages listed in table E-2. In addition, the talker ID, output interval, and checksum selections can be modified to fit your application requirements. To investigate custom NMEA 0183 firmware, contact your Trimble Navigation representative.

Table E-2
SVEESix NMEA Messages

Standard	Message	Description
✓	GGA	GPS Fix Data (NMEA Version 2)
	GGA	GPS Fix Data (NMEA Version 1)
	GLL	Geographic Position - Latitude/Longitude
	GSA	GPS DOP and Active Satellites
	GSV	GPS Satellites in View
	RMC	Recommended Minimum Specific GPS/Transit Data
✓	VTG	Track Made Good and Ground Speed
	ZDA	Time & Date

The format for each message in table E-2 is described in more detail in the next section.

◆ **NOTE:** *When using the configuration disk only standard messages will be installed (GGA, VTG). If a non-standard message is required contact your Trimble representative.*

NMEA 0183 Message Formats

GGA - GPS Fix Data

The GGA message includes time, position and fix related data for the GPS receiver.

GGA,hhmmss,1111.111,a,nnnnn.nnn,b,t,uu,v.v,w.w,M,x.x,M,y.y,zzzz

Field	Description
hhmmss	UTC of Position.
1111.111,a	Latitude, N (North) or S (South).
nnnnn.nnn,b	Longitude, E (East) or W (West).
t	GPS Quality Indicator: 0 = No GPS, 1 = GPS, 2 = DGPS.
uu	Number of Satellites in Use.
v.v	Horizontal Dilution of Precision (HDOP).
w.w, M	Antenna Altitude in Meters, M = Meters.
x.x, M	Geoidal Separation in Meters, M = Meters. Geoidal separation is the difference between the WGS-84 earth ellipsoid and mean-sea-level.
y.y	Age of Differential GPS Data. Time in seconds since the last Type 1 or 9 Update.
zzzz	Differential Reference Station ID (0000 to 1023).

- ◆ **NOTE:** *The GGA message provides 3 decimal points of precision in non-differential mode and 4 decimal points of accuracy differential mode.*

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.

GLL,llll.ll,a,nnnnn.nn,b,hhmmss,A

Field	Description
llll.ll,a	Latitude, N (North) or S (South).
nnnnn.nn,b	Longitude, E (East) or W (West).
hhmmss	UTC of Position.
A	Status: A = Valid, V= Invalid.

NMEA 0183 Message Formats (continued)

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.

GSA,a,k,ll,mm,nn,oo,pp,qq,rr,ss,tt,uu,vv,ww,x.x,y.y,z.z

Field	Description
a	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.
k	Current Mode: 1 = Fix Not Available, 2 = 2D, 3 = 3D.
ll, mm, nn, oo, pp, qq, rr, ss, tt, uu, vv, ww	PRN numbers of the satellites used in the position solution. When less than 12 satellites are used, the unused fields are null.
x.x	Position Dilution of Precision (PDOP).
y.y	Horizontal Dilution of Precision (HDOP).
z.z	Vertical Dilution of Precision (VDOP).

NMEA 0183 Message Formats (continued)

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.

GSV,h,i,jj,kk,ll,mmm,nn,oo,pp,qqq,rr,ss,tt,uuu,vv,ww,xx,yyy,zz

Field	Description
h	Total Number of GSV Messages.
i	Message Number: 1 to 3.
jj	Total Number of Satellites in View.
kk	Satellite PRN Number.
ll	Satellite Elevation in Degrees (90° Maximum).
mmm	Satellite Azimuth in Degrees True (000 to 359).
nn	Satellite SNR (Null When Not Tracking).
oo,pp,qqq,rr	PRN, Elevation, Azimuth and SNR for Second Satellite.
ss,tt,uuu,vv	PRN, Elevation, Azimuth and SNR for Third Satellite.
ww,xx,yyy,zz	PRN, Elevation, Azimuth and SNR for Fourth Satellite.

NMEA 0183 Message Formats (continued)

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.

RMC,hhmmss,A,llll.ll,a,yyyy.yy,a,x.x,x.x,xxxxxx,x.x,a*hh

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
12	Checksum (Mandatory for RMC)

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).

VTG,v.v,T,w.w,M,x.x,N,y.y,K

Field	Description
v	Track made Good in Degrees True
w.w	Track made Good in Degrees Magnetic
x.x	Speed Over the Ground (SOG) in Knots
y.y	Speed Over the Ground (SOG) in Kilometer per Hour

NMEA 0183 Message Formats (continued)

ZDA - Time & Date

The ZDA message contains UTC, the day, the month, the year and the local time zone.

ZDA,hhmmss,xx,xx,xxxx,xx,xx

Field	Description
1	UTC
2	Day (01 to 31)
3	Month (01 to 12)
4	Year
5	Local Zone Description Hours (± 13 hours). Local zone description is the number of whole hours added to local time to obtain UTC. The zone description is always negative for eastern longitudes.
6	Local Zone Description Minutes. Local zone description minutes using the same sign convention as local zone hours.

◆ **NOTE:** *Fields #5 and #6 are null fields in the SVeeSix output. A GPS receiver cannot independently identify the local time zone offsets.*

Appendix F

Specifications and Mechanical Drawings

The SVeeSix-CM3 module is designed for embedded industrial computing or control, mobile computing or data collection, precision timing, and vehicle tracking applications. The SVeeSix-CM3 offers exceptional performance in even the harshest operating environments. This appendix includes the system specifications and mechanical drawings for the SVeeSix-CM3 receiver module and the miniature magnetic mount GPS antenna.

GPS Receiver

General

L1 frequency (1575.42 MHz), C/A code (Standard Positioning Service), 6-channel, continuous tracking, differential ready

Position Accuracy

2 to 5 meters (1 Sigma) steady state conditions (no Selective Availability) with differential

15 meters (SEP) steady state conditions without differential

Velocity Accuracy

0.1 m/sec. (1 Sigma) steady state conditions

Time Accuracy

UTC to nearest microsecond with 1 pulse per second available

Datum

WGS-84 (220 options plus one custom slot)

Acquisition Rate

Momentary signal interruption: 2 seconds typical

Momentary power interruption: less than 30 seconds with RAM battery backup

Cold start: 2 to 5 minutes

Dynamics

Velocity: 515 m/sec. (maximum)

Acceleration: 4g (39.2 m/sec.²)

Jerk: 20 m/sec.³

Environmental Characteristics

Temperature

Receiver board:	Operating,	-10°C to + 60°C (standard) -40°C to +85°C (optional)
	Storage,	-55°C to +85°C
GPS Antenna:	Operating,	-40°C to +85°C

Vibration

0.008g ² /Hz	5Hz-20 Hz
0.05g ² /Hz	20Hz-100Hz
-3dB/octave	100Hz-900Hz

Specifications comply with SAE J1211 requirements

Altitude

-400 to +18,000 meters MSL

Humidity

95% R.H. non-condensing @ +60°C

Physical Characteristics

Size

Receiver board: 82.5 mm x 46.5 mm x 14.7 mm (3.25" x 1.83" x 0.58")

Weight

Receiver board: 32 g (0.075lb)

Power

Prime Power: +5 volts DC (+5%, -3%); 240 ma (1.20 watts nominal) with active antenna

RAM Backup: optional +3.2 to +5 volts DC input via 8-pin header J3; 1 micro amp

Input/Output

Interface

One TTL level, bi-directional, serial I/O port on J3 8-pin header

One TTL level, input only, serial I/O port on J3 8-pin header
(differential units only)

Protocols Available

TSIP: Trimble Standard Interface Protocol; binary data I/O provides maximum bi-directional control over all GPS board functions. Sample C source code interface routines are available.

TAIP: Trimble ASCII Interface Protocol; uses printable ASCII characters for easy integration with mobile data terminals, mobile data modems, and personal computers. Supports scheduled or polled responses. Sample C source code interface routines are available.

NMEA 0183: Industry standard ASCII protocol for marine electronics applications. Supports NMEA sentences GGA and VTG.

Custom protocols available upon request.

Pulse Per Second

Timing

Rising edge of pulse synchronized to UTC within 1 microsecond, nominal

Pulse Width

1 microsecond wide pulse; rising edge is 20 nanoseconds or less, depending upon distributed capacitance in cable

Output

TTL level signal

RF Interference

Jamming

Resistant to broadband noise jamming where jamming-to-signal power ratio is 20 dB or less, measured at the antenna/preamplifier interface when input signal is at -160 dBW

Burnout

Protected from damage by RF signals at frequencies 100 MHz or more from the L1 frequency (1575.42 MHz) with received power up to one watt at the antenna

Glossary

2-D	Two Dimensional. A 2-D position is defined as latitude and longitude. Altitude is assumed to be fixed.
2-D GPS mode	A procedure of determining a 2-D position using signals received from the best (or only) three available GPS satellites. Altitude is assumed to be known and constant. A 2-D 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 approximately 95% of the position solutions will fall.
3-D	Three Dimensional. A 3-D position is defined as latitude, longitude, and altitude.
3-D GPS mode	A procedure of determining a 3-D position using signals received from the best (or only) four available GPS satellites. A 3-D 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 2-D or 3-D position using signals received from GPS satellites. The solution automatically transitions between 2-D and 3-D 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.

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. In regards to SVeeSix, 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 Placer GPS sensor is shipped with factory default configuration settings; the settings were determined by Trimble Navigation.
DGPS	see <i>differential GPS</i>
DGPS reference station	A device that tracks all GPS satellites in view and calculates and transmits differential corrections.
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 <i>differential GPS</i>
dilution of precision	A scaling factor used to translate measurement or ranging accuracy to position accuracy. Standard terms for the GPS application are: <ul style="list-style-type: none"> 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 <i>dilution of precision</i> .

DOP constellation switch	A value, based on PDOP, that defines when the GPS receiver/processor should switch between 2-D and 3-D GPS modes. The PDOP constellation switch is only active when the GPS mode of operation is set to Auto.
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.
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 as a function of time. 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.
GD	GPS with differential corrections applied.
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.
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 even 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
masks	See <i>satellite masks</i> .
maximum DOP	A measure of the maximum Dilution of Precision (DOP) that is acceptable in order for the GPS processor to determine a location solution (see DOP).
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.
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 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.
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.
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 DOP.
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 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).
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, as used in this product, is defined in full in Appendix C.
- 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.
- URA** Satellite user range accuracy. The URA is sent by the satellite and is computed by the GPS operators. It is a statistical indicator 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.

Index

2D mode 6-8
3D mode 6-9
2 mm mating I/O connectors 4-4
6-channel receiver 1-1, 6-6

A

Acceleration 6-14
Accessories 1-4
Accuracy 6-11
Altitude 6-9
 MSL/HAE 6-9
Antenna 1-5, 1-6
 bulkhead (Hard Mount) 1-4, 1-6
 Bullet II 1-6
 cable 1-3, 1-4, 1-5
 SMB connector 1-4
 location 1-5
 magnetic mount 1-3, 1-5
 non-magnetic 1-3
Architecture 6-1, 6-6
Automatic 3D/ 2D/ 2D CH 6-9
Automatic message reports 1-2

B

Battery back-up 4-3, 4-5
Baud rate 5-4
Board level receivers 1-3
Bullet II 1-6

C

CMOS TTL 1-1, 1-4, 4-3
Coarse/Acquisition (C/A) code 6-2
Communication 5-3
Configuration port 3-4
Configuration program 3-2
see also individual protocols
 configuration port 3-4
Configuration data 4-5
Coordinate systems 6-12
 NMEA 6-10, 6-11, 6-13, 6-17
 TAIP 6-11, 6-13, 6-14
 TSIP 6-3, 6-5, 6-6, 6-8, 6-9, 6-11,
 6-13, 6-14, 6-17, 6-18, 6-19

D

Data bits 5-4, 5-9, 5-10
Differential GPS P-3, 1-1, 1-3, 5-9, 5-10
 accuracy 6-2, 6-5, 6-7, 6-9, 6-12
 NMEA 5-3, 5-5, 5-7, 5-10
 operating modes 6-6, 6-8, 6-10, 6-11
 DGPS Automatic 6-10
 DGPS Off 6-10
 DGPS On 6-10
 RTCM SC-104 5-9, 6-11, 6-12
 selective availability 6-6, 6-12, 6-16
 serial port connection 5-9
 TAIP 5-10
 TSIP 5-10
DOP Mask 6-5
DOP Switch 6-5
DUART 4-7
Dynamic limits 6-14

E

Elevation mask 6-5

F

Firmware 1-1 *see also* Protocol
Fix modes 6-6, 6-8
 2D mode 6-8, 6-9
 3D mode 6-9
 2D/3D automatic 6-9
 one satellite timing 6-8, 6-9

G

Global Positioning System
see GPS
GPS P-3
 accuracy 6-12
 almanac 4-5, 6-2, 6-15
 clocks 6-16
 ephemeris 4-5, 6-2, 6-15
 operation 6-2
 2D mode 6-8, 6-9
 3D mode 6-9
 2D/3D automatic 6-9
 one satellite timing 6-8, 6-9

- performance 5-8, 6-14, 6-15
- re-acquisition 6-15
- satellite masks 6-5
- selective availability 4-7, 6-12
- time offset 5-6
- time to first fix 6-3, 6-4
 - cold start 6-3
 - garage search strategy 6-4
 - hot start 6-4
 - warm start 6-3
- timing 6-16
 - serial time output 6-17
 - synchronization 6-18
 - time tagging 6-19
 - timing pulse output 6-17
- UTC 5-6

GPSSK 5-2, Appendix D
 GPS Toolkit Disk 1-3

H

Hardware integration 4-1
see also Installation

- interface 4-2, 4-3, 4-4
- power 4-5, 4-6

I

Installation

- configuration software 3-2, 3-4
- hardware 2-5, 3-3, 4-2

 Interface cable 2-2, 2-4

- connection 2-4, 4-2, 4-3, 4-4

J

Jerk 6-14

M

Mask settings 6-5

- elevation 6-5
- DOP Mask 6-5
- DOP Switch 6-5
- SNR 6-5

 Magnetic mount antenna 1-5
see also Antenna
 Mounting 4-7

- receiver module 1-4

MSL/HAE 6-9

N

NMEA 0183 1-2, 5-4, 5-5

- differential GPS operation 5-10
- output 6-13
- protocol selection 3-4, 5-4
- update rate 6-14

O

OEM GPS Toolkit Diskette 3-4
 Operation 6-1

- differential GPS modes 6-10, 6-11
 - DGPS Automatic 6-10
 - DGPS Off 6-10
 - DGPS On 6-10
- dynamic limits 6-14
- GPS fix modes 6-8
 - 2D mode 6-8
 - 3D mode 6-8
 - 2D/3D /2D CH automatic 6-9
 - one satellite timing 6-8
 - over-determined mode 6-6, 6-7
- re-acquisition 6-15
- update rate 6-14

 Over-determined mode 6-6, 6-7

P

Parity 5-4, 5-9, 5-10
 Position reports 2-10
 Power 2-2, 2-3, 2-5, 2-6

- consumption 1-1, 2-6
- connection 2-2, 2-5, 2-8, 2-10
- input 1-4, 4-3, 4-5, 4-7
- interface cable 2-2, 2-5, 2-10
- receiver 4-3, 4-5
- requirements 4-6

 PPS 2-2, 2-3, 6-16, 6-17
 Protocol 1-1, 1-2, 1-3, 1-4, 2-1, 2-9, 3-1, 3-2, 3-4

- communication 5-3
- configuration program 3-2, 3-4
- selection 3-4, 5-4

see also individual protocols

R

RAM

configuration data 4-5

Re-acquisition 6-15

READ.ME file 3-1

Receiver 1-3, 1-4

accuracy 6-12 *see also* GPS

architecture 6-1, 6-6

communication 5-3

mounting 4-7

output 6-13

performance 5-1, 6-14, 6-15

operation 6-6

power 4-5, 4-6

serial interface 4-7

Ribbon cable 4-3, 4-4

ROM 1-1, 1-3

RS-232 3-3, 4-7, 5-1

RS-422 4-7

RTCM SC-104 5-9, 5-10, 6-11, 6-12

see also Differential GPS

S

S/A 4-7, 6-12

Satellite *see* GPS

Satellite masks 6-6

Selective Availability 4-7, 6-11

Serial interface 1-1, 1-4, 4-2, 4-3, 4-4, 4-7

CMOS TTL level 1-1, 4-3, 4-7

one pulse-per-second 1-1, 4-7

port characteristics 3-2, 5-4, 5-9

Signal to Noise Ratio 6-5

SNR 6-5

Software interface 5-1

SPDRIVE 2-6

Starter kit 1-1, 1-3, 2-1, 2-2, 3-1, 3-4, 5-3, 6-10

protocol configuration 3-1, 3-2

Startup 5-2

Stop bits 5-4, 5-9

T

TAC 2-10

TAIP 1-2, 2-1, 3-1, 3-2, 3-4, 5-3, 5-4, 6-11,

6-13, 6-14

configuration program 3-4

differential GPS operation 5-9, 5-10

output 6-13

update rate 6-14

Technical Assistance 2-10

Temperature option 1-3

Time to first fix 6-3, 6-4

see also GPS

cold start 6-3

garage search strategy 6-4

hot start 6-4

warm start 6-3

Timing 4-7, 6-16

accuracy 4-7

operation 5-6

Trimble ASCII Interface Protocol

see TAIP

Trimble Standard Interface Protocol

see TSIP

TSIP 1-2, 2-1, 2-9, 3-1, 3-2, 3-4, 5-3, 5-4

configuration program 3-4

differential GPS operation 5-9, 5-10, 6-6

interface program 2-9

output 6-13

packets 60 and 61 5-9, Appendix A

satellite mask 6-5

update rate 6-14

TSIPCHAT 2-9, 2-10

command window 2-10

configuration 3-4

report window 2-10

U

Update rate 6-14

UTC time 5-6, 6-13

see also GPS

W

Week Number Roll-over 5-7, 5-8

V

Velocity 6-14

