A Trimble Standard Interface Protocol

The Trimble Standard Interface Protocol (TSIP) provides commands that the system designer may use 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.

TSIP is a simple bidirectional, binary packet protocol used in a wide variety of Trimble GPS receivers. TSIP offers a broad range of command packets and report packets that provide the GPS user with maximum control over the Palisade. Palisade TSIP data packets are always less than 256 bytes in length.

This appendix provides the information needed to make judicious use of the powerful TSIP features, to greatly enhance overall system performance, and to reduce the total development time. The reference tables beginning on page A-3 will help you determine which packets apply to your application. For those applications requiring customization, see Table A-12 for a detailed description of the key setup parameters. Application guidelines are provided for each TSIP command packet, beginning on page A-7.

A.1 Interface Scope

The Trimble Standard Interface Protocol is used in a large number of Trimble GPS modules and navigation receivers. The Palisade receiver features a primary bidirectional port and one output-only port, which may be configured to generate one or more comprehensive time packets. Palisade's primary port supports bidirectional TSIP communication.

The TSIP protocol is based on the transmission of packets of information between the user equipment and the GPS sensor. 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. The receiver transmits some of the information (position and velocity solutions, etc.) automatically when it is available, while other information is transmitted only on request. Additional packets may be defined for particular products and these will be covered in the specifications for those products as necessary.

A.2 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-1 Packets Output at Power-Up

Output ID	Description	Notes
46	Receiver health	--
4B	Machine code/status	--
45	Software version	--
42	single precision XYZ position	If double precision is selected, packet 83 is output instead.
4A	single precision LLA position	If double precision is selected, packet 84 is output instead.
41	GPS time	
82	DGPS position fix mode	--

A.3 Receiver Warm Start

You can warm start the receiver by sending each of the following commands after the receiver has completed its internal initialization and has output packet 82.

Table A-2 Receiver Warm Start Commands

Input ID	Description
2B	initial position (LLA)
2E	initial time
38 (type 2)	almanac (for each SV)
38 (type 3)	almanac health
38 (type 4)	ionosphere page
38 (type 5)	UTC correction

A.4 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-3 Background Packets

Output ID	Description	Notes
40	almanac data	Almanac data is output as new pages are received.
41	GPS time	If the receiver's GPS clock is set and the receiver is not outputting positions, time is output approximately every 16 seconds. Output approximately every 2.5 minutes if the receiver is doing position fixes.
46	receiver health	Output approximately every 16 seconds, if the receiver is not outputting positions. Output approximately every 30 seconds if the receiver is doing position fixes. Whenever any bit in the health message changes, receiver health is automatically output.
6D	mode packet	Output approximately every 30 seconds or when a constellation change occurs.

*

Note – The background packets listed in this table are automatically output. It is possible to turn off background packets. For more information on this option, see Command Packet 8E-4D – Automatic Packet Output Mask, page A-90.

A.5 Automatic Position and Velocity Reports

The receiver automatically outputs position and velocity reports at set intervals. Report intervals are controlled by packet 35.

Table A-4 Automatic position and Velocity Reports

Output ID	Description
42	single precision XYZ position
83	double-precision XYZ position
4A	single-precision LLA position
84	double-precision LLA position
43	velocity fix (XYZ ECEF)
54	See Note
56	velocity fix (ENU)

Note – When the receiver is in the Manual or Overdetermined Timing mode, it outputs packet 54 to provide the computed clock-only solution.

A.6 Timing Packets

If you are using the GPS receiver as a primary timing system, you may wish to implement the following TSIP control commands.

Table A-5 Timing Packets

Input ID	Description	Output ID
21	get the current GPS time	41
22	set up Overdetermined Timing mode if desired	
2C	set up static mode if desired	4C
2F	request UTC parameters	4F
34	choose the satellite for 1 SV timing mode	
BB	set static mode; set OD timing mode	BB
8E-4A	set PPS characteristics	8F-4A

Palisade is capable of outputting combinations of the following packets on Port A.

Table A-6 Port A Timing Packets

Input ID	Description	Output ID
Auto	Comprehensive time	8F-0B
Auto	Primary UTC Time	8F-AD
Auto	NMEA	ZDA

A.7 Satellite Data Packets

The following packets request data transmitted by the GPS satellites and satellite tracking information.

Table A-7 Satellite Data Packets

Input ID	Description	Output ID
20	request almanac	40
27	request signal levels	47
28	request GPS system message	48
29	request almanac health page	49
2F	request UTC parameters	4F
38	request/load satellite system data	58
39	set/request satellite disable or ignore health	59
3A	request last raw measurement	5A
3B	request satellite ephemeris status	5B
3C	request tracking status	5C

A.8 Customizing Receiver Operations

To customize the receiver output for your application, consider the following packets. For a review of the key setup parameters, see page A-17.

Table A-8 Customizing Receiver Operations

Input ID	Description	Output ID
21	request current time	41
22	position fix mode select (2-D, 3-D, auto)	
23	initial position (XYZ ECEF)	
24	request receiver position fix mode	6D
26	request receiver health	46 and 4B
27	request satellite signal levels	47
2A	altitude for 2-D mode	4A
2B	initial position (LLA)	
2C	request receiver operating parameters	4C
2E	GPS time	4E
35	set input/output options	55
37	status and values of last position and velocity	57 (Note 1)
3D	Configure channel A	3D
BB	set/request receiver configuration	BB
BC	set/request port configuration	BC
8E-14	set datum value	
8E-15	request datum values	8F-15
8E-4A	set PPS characteristics	8F-4A

Note 1: Output is determined by packet 35 settings (see Table A-3).

A.9 Advanced Packets

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

Table A-9 Advanced Packets

Input ID	Description	Output ID
1D	clear oscillator offset	--
1E	clear memory, reset	(Note 1)
25	soft reset and self test	(Note 1)
2D	oscillator offset	4D
37	information about last computed fix	57 (Note 3)
39	satellite disable or ignore health	59 (Note 2)
3A	last raw measurement	5A
3B	satellite ephemeris status	5B
3C	tracking status	5C
BB	set receiver configuration parameters	BB
8E-4A	set PPS characteristics	8F-4A
8E-20	Fixed Point Superpacket	8F-20

Note 1: Output is determined by packet 35 settings. See Table A-1 to determine which messages are output at power-up.

Note 2: Not all modes of packet 39 cause a reply (see the packet 39 description, later in this appendix).

Note 3: Output is determined by packet 35 settings.

A.10 Command Packets Sent to the Receiver

The table below summarizes the command packets sent to the receiver. In some cases, the response packets depend on user-selected options. Table A-10 includes a short description of each packet, and the associated output packet. These selections are covered in the packet descriptions beginning on page A-25.

Table A-10 Command Packets Sent to the Receiver

Input	Packet Description	Output ID
1D	Clear oscillator offset	
1E	Clear memory/reset	(note 1)
1F	Software version	45
20	Almanac	40
21	Current time	41
22	Fix Mode select (2-D, 3-D, auto)	6D (note 2)
23	Initial position (XYZ ECEF)	
24	Receiver position fix mode	6D
25	Soft reset and self-test	(note 1)
26	Receiver health	46, 4B
27	Signal levels	47
28	GPS system message	48
29	Almanac health page	49
2A	Altitude for 2-D mode	4A
2B	Initial position (LLA)	
2C	Operating parameters	4C
2D	Oscillator offset	4D
2E	Set GPS time	4E
2F	UTC parameters	4F
31	Accurate initial position (XYZ Cartesian ECEF)	
32	Accurate initial position (LLA)	
34	Satellite # for 1-sat mode	
35	I/O options	55
37	Status and values of last position and velocity	57 (note 1)

Table A-10 Command Packets Sent to the Receiver (Continued)

38	Load satellite system data	58
39	Satellite disable	59 (note 3)
3A	last raw measurement	5A
3B	Satellite ephemeris status	5B
3C	Tracking status	5C
3D	Main port configuration	3D
BB	Set receiver configuration	BB
BC	Set port configuration	BC
8E-14	Set new datum	
8E-15	Current datum values	8F-15
8E-20	last fix (fixed point)	8F-20
8E-41	Manufacturing parameters	8F-41
8E-42	Production parameters	8F-42
8E-45	Revert to default settings	8F-45
8E-4A	Set PPS characteristics	8F-4A
8E-4B	Survey limit	8F-4B
8E-4D	Packet Output Mask	8F-4D
8E-0B	8F-0B output configuration	8F-A5/8F-0B
8E-AD	8F-AD output configuration	8F-A5/8F-AD

Note 1: Output is determined by packet 35 settings.

Note 2: Entering 1SV mode initiates automatic output of packet 54.

Note 3: Not all packet 39 operations have a response. See packet 39 description.

A.11 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-11 Report Packets Sent by GPS Receiver to User

Output ID	Packet Description	Input
3D	main port configuration	3D
40	almanac data for sat	20
41	GPS time	21
42	single-precision XYZ ECEF position	37
43	velocity fix (XYZ ECEF)	37
45	software version information	1F
46	health of receiver	26
47	signal level for all satellites	27
48	GPS system message	28
49	almanac health for all sats	29
4A	single-precision LLA position	37
4B	machine code/status	26
4C	report operating parameters	2C
4D	oscillator offset	2D
4E	response to set GPS time	2E
4F	UTC parameters	2F
54	one-satellite bias and bias rate	22
55	I/O options	35
56	velocity fix (ENU)	37
57	information about last computed fix	37
58	GPS system data/acknowledge	38
59	sat enable/disable and health heed	39

Table A-11 Report Packets Sent by GPS Receiver to User (Continued)

5A	raw measurement data	3A
5B	satellite ephemeris status	3B
5C	satellite tracking status	3C
6D	all-in-view satellite selection	24
83	double-precision XYZ	37
84	double-precision LLA	37
BB	set receiver configuration	BB
BC	set port configuration	BC
8F-20	last fix with extra information (fixed point)	8E-20
8F-41	manufacturing parameters	8E-41
8F-42	production parameters	8E-42
8F-45	Revert to default settings	8E-45
8F-4A	PPS characteristics	8E-4A
8F-4B	Survey limit	8F-48
8F-AD	UTC Event Time	Event/Auto
8F-0B	comprehensive time	Auto/Event

A.12 Key Setup Parameters

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

- Packet 22 (set fix mode)
- Packet 2C (set operating parameters)
- Packet 35 (set I/O options)
- Packet BB (set receiver configuration)

The default values in Table A-12 enable the receiver to operate well under the most varied and demanding conditions. A user can choose to optimize the receiver for a particular application if the receiver is required to perform in a specific or limited environment, and if dynamics and expected level of obscuration are understood. The user should be warned that when the receiver is exposed to operating conditions different from the conditions described by the user setup, the specifically tuned receiver's performance may be degraded when compared to a receiver with the default options.

Table A-12 lists suggested parameter selections as a function of obscuration 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.

Table A-12 Key Setup parameters

Packet	Parameter	Accuracy	Fixes
22	Fix mode	Man 3D	AUTO
2C	Elevation mask	10	5
2C	Signal mask	6.0	0.0
2C	PDOP mask	6.0	12.0
2C	PDOP switch	NA	8.0
35	Fix time	ASAP	DC
35	Output time	When computed	DC
35	Sync meas.	OFF	OFF
35	Min. projection	ON	DC

For a complete examination of the four key configuration parameter packets, see the descriptions of packet 22, packet 2C, packet 35 and packet BB.

A.13 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. 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. Only the fractional part of the mantissa for real numbers, SINGLE and DOUBLE, is reported because the leading bit on the mantissa is always 1. Specifically:

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 (a, b, c, d, e, f, g, h); it has a precision of 52 significant bits, a little better than 15 digits.

A.14 Packet Descriptions

A.14.1 Command Packet 1D – Clear Oscillator Offset

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

Table A-13 Command Packet 1D - Clear Oscillator Offset

Byte	Item	Type	Value	Response
0	Operation	Byte	"C," 43 hex	clear the oscillator offset

To set the oscillator offset, four data bytes are sent: the oscillator offset in Hertz relative to L1 as a SINGLE real value. The oscillator offset is automatically updated when the receiver is doing fixes.

Table A-14 Command Packet 1D - Set Oscillator Offset

Byte	Item	Type	Value	Response
0-3	Offset	Single	Offset in Hertz	None

A.14.2 Command Packet 1E – Clear Memory, then Reset

This packet commands the GPS receiver to clear all data and to perform a software reset. This packet contains one data byte, an ASCII letter corresponding to the requested function:

Table A-15 Cold Start

Byte	Item	Type	Value	Response
0	Operation	Byte	"K," 4B hex	receiver performs a cold start

Table A-16 Factory Re-Start

Byte	Item	Type	Value	Response
0	Operation	Byte	"F," 46 hex	receiver re-initializes factory defaults, and then cold starts

Table A-17 Compatibility Re-Start

Byte	Item	Type	Value	Response
0	Operation	Byte	"C," 43 hex	receiver re-initializes defaults to be compatible with firmware version 7.02, and then cold starts

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 by using the TSIPCHAT command "@" to load it back into the receiver memory.

A.14.3 Command Packet 1F – 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 45 hex.

A.14.4 Command Packet 20 – 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 40 hex.

A.14.5 Command Packet 21 – Request Current Time

This packet requests current GPS time. This packet contains no data. The GPS receiver returns packet 41 hex.

A.14.6 Command Packet 22 – Position Fix Mode Select

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

Table A-18 Command Packet 22

Data Byte Value	Mode
0	2D/ 3D Automatic
1	1D Time only
3	Horizontal only (2-D)
4	3-D only
5	n/a
6	n/a
10	Over-Determined Time (default)

For a detailed discussion of each position fix mode, see Chapter 5, System Operation.

Selecting any non-timing mode with this packet cancels the self survey and forces the receiver into that navigation mode indefinitely.

Selecting a timing mode using packet 22 immediately sets the receiver to use the last calculated position for timing.

In overdetermined mode the GPS receiver computes no positions, instead the receiver sends packet 54 hex 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 PPS (Pulse Per Second) output even if a full position fix cannot be done. Any position error will propagate to the correctness of the time solution.

A.14.7 Command Packet 23 – 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 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^{o} meridian, and the Z-axis points toward the North Pole. The cold start default LLA position is 0, 0, 0.

The data format is shown below.

Table A-19 Command Packet 23

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

A.14.8 Command Packet 24 – Request GPS Receiver Position Fix Mode

This packet requests the current position fix mode of the GPS receiver. This packet contains no data. The GPS receiver returns packet 6D.

A.14.9 Command Packet 25 – Initiate Soft Reset & Self Test

This packet commands the GPS receiver to perform a software reset. 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-1). The GPS receiver sends packet 45 hex only on power-up and reset (or on request). If packet 45 appears unrequested, either the GPS receiver power was cycled or the GPS receiver was reset.

A.14.10 Command Packet 26 – Request Health

This packet requests health and status information from the GPS receiver. This packet contains no data. The GPS receiver returns packet 46 hex and 4B hex.

A.14.11 Command Packet 27 – Request Signal Levels

This packet requests signal levels for all satellites currently being tracked. This packet contains no data. The GPS receiver returns packet 47 hex.

A.14.12 Command Packet 28 – 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 48 hex.

A.14.13 Command Packet 29 – Request Almanac Health Page

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

A.14.14 Command Packet 2A – Altitude for 2-D Mode

This packet provides the altitude to be used for Manual 2-dimensional navigation 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 35).

If a set altitude is not provided, the receiver will use the altitude of the previous 3-D fix (altitude-hold mode). Sending packet 2A with one data byte equal to 0xFF will cancel altitude-set mode and return the reference altitude to 0. The altitude setting is stored in non-volatile memory.

The receiver must be configured to Manual 2-D navigation mode using packet 0xBB in order to use the fixed altitude survey mode. The reference altitude will be used in 2-D survey from both warm and cold start.

*

Note – If the receiver altitude is set above 18,000 m, the receiver will be forced to reset each time it acquires satellites. This is implemented to conform with the COCOM industry standard.

A.14.15 Command Packet 2B – 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 23. The cold start default LLA position is 0, 0, 0.

The data format is shown below.

Table A-20 Command packet 2B

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

A.14.16 Command Packet 2C – Set/Request Operating Parameters

This packet optionally sets the operating parameters of the GPS receiver or requests the current values. The four parameters are described below and in Table A-21.

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 environment and reverts to user entered altitude in 2-D auto. In AIR mode, the search and re-acquisition routines are optimized for high acceleration conditions.

Elevation Mask

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

Frequent constellation switching is undesirable because position jumps may be experienced when Selective Availability 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 10° and provides a reasonable trade-off of the benefits and drawbacks.

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. This mask should only be lowered with caution since it is also used to minimize the effects of jammers and reflected signals on the receiver. Users who require high accuracy can use a slightly higher mask of 6.0-8.0, since weaker measurements may be noisier and are often caused by reflected signals, which provide erroneous ranges.

Make sure that the elevation and SNR masks are not set too low. The satellite geometry is sometimes improved considerably by selecting low elevation satellites. These satellites are, however, subject to significant signal degradation by the greater ionospheric and tropospheric attenuation that occurs. They are also subject to more obscuration by the passing scenery when the receiver is in a moving vehicle. The code phase data from those satellites is more difficult to decode and therefore has more noise.

PDOP Mask and Switch

The PDOP mask is the maximum PDOP limit for which any 2-D or 3-D position solution will be made. The PDOP 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 effect on either manual mode. Raising the PDOP mask generally increases the fix density during obscuration, but the fixes with the higher PDOP are less accurate (especially with Selective Availability present). Lowering the mask improves the average accuracy at the risk of lowering the fix density.

The data format is shown in Table A-21. The GPS receiver returns packet 4C hex.

Table A-21 Command Packet 2C

Byte	Item	Type/Units	Default	Byte 0 Value/Ve
0	Dynamics	BYTE/---	1-Land	(0) 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/---	0	
9-12	PDOP mask	SINGLE/---	8	
13-16	PDOP switch (3-D or 2-D)	SINGLE/---	6	

A negative value in a SINGLE field leaves that current setting unchanged.

Selection of mode 4 informs the GPS receiver that it is stationary. Any position fix computed or provided through 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 22 hex), the GPS receiver enters 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 54 hex 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 1 PPS (Pulse Per Second) output even if a full position fix cannot be accomplished.

Packet 2C defines the extreme conditions under which the receiver will operate, and the set of usable satellites based on the satellite geometry at the user's position.

*

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.

A.14.17 Command Packet 2D – Request Oscillator Offset

This packet requests the calculated offset of the GPS receiver master oscillator. This packet contains no data. The GPS receiver returns packet 4D hex. This packet is used mainly for service. The permissible oscillator offset varies with the particular GPS receiver.

A.14.18 Command Packet 2E – 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 4E hex. The data format is shown below. The GPS week number reference is Week # 0 starting January 6, 1980. The seconds count begins at the midnight which begins each Sunday morning.

Table A-22 Command Packet 2E

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

This packet is ignored if the receiver has already calculated the time from tracking a GPS satellite.

A.14.19 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 4F.

A.14.20 Command Packet 31 – Accurate Initial Position (XYZ Cartesian ECEF)

This packet is identical in content to packet 23 hex. 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.

A.14.21 Command Packet 32 – Accurate Initial Position (Latitude, Longitude, Altitude)

This packet is identical in content to packet 2B hex. This packet provides the GPS receiver with an 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.

A.14.22 Command Packet 34 – Satellite Number For One-Satellite Mode

This packet allows the user to control the choice of the satellite to be used for the 1D Timing mode. This packet contains one byte. If the byte value is 0, the GPS receiver automatically 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. A subsequent value of 0 will return the receiver to automatic 1-SV mode.

A.14.23 Command Packet 35 – Set/Request I/O Options

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

To request the option states without changing them, the user sends the packet with no data bytes included. To change any option states, the user includes 4 data bytes with the values 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 non-volatile memory. The GPS receiver returns packet 55 hex.

These 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

UTC - coordinated universal time.

Table A-23 Command Packet 35

Byte	Parameter Name	Bit Position	Default Bit Value	Option	Associated Packets
0	position	0 (LSB)	0	XYZ ECEF Output 0: off 1: on	42 or 83
		1	1	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	1	Precision-of-position output 0: single-precision packet 42 and/or 4A. 1: double-precision packet 83 and/or 84	
		5	0	0: output no Super Packets 1: output all enabled Super Packets	
		6-7	0	unused	
1	velocity	0	0	XYZ ECEF Output 0: off 1: on	43
		1	1	ENU output 0: off 1: on	56
		2-7	0	unused	
2	Timing	0	1	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	37

Table A-23 Command Packet 35 (Continued)

Byte	Parameter Name	Bit Position	Default Bit Value	Option	Associated Packets
2	Timing	3	0	Synchronized measurements 0: off 1: on	N/A
		4	0	Minimize Projection 0: off 1: on	N/A
		5-7	0	unused	
3	Auxiliary	0	0	raw measurements 0: off 1: on	5A
		1	1	Doppler smoothed codephase 0: raw 1: smoothed	5A
		2-7		unused	

Packet 35 is used to control the format and timing of the position and velocity output.

Bytes 0-1

Bytes 0 and 1 control the message output format.

Byte 2

Byte 2 contains the five time parameters described below:

- Time Type - This bit defines whether the time tags associated with a position fix are in GPS time or UTC time. The default is UTC time.
- Fix Computation Time - This bit controls the time and frequency of position fixes. The default is ASAP.

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.

- Output Time - This bit defines whether fixes are automatically output when computed or only sent in response to a packet 37 request. The default is automatic output.
- 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 obscurations make it impossible to obtain exactly concurrent measurements from each satellite.

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, obscurations may reduce the fix density when there are limited satellites. Use this mode cautiously.

- 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. This option is only available in version 1.14 and higher.

Byte 3

Byte 3, the auxiliary byte, controls the output of additional fix data. It contains two control bits:

- Bit 0 controls the output of raw measurements (Packet 5A).
- Bit 1 controls whether the raw measurements output in packet 5A are doppler smoothed.

A.14.24 Command Packet 37 – 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 57 and the appropriate position packet 42 or 4A, or 83 or 84, and the appropriate velocity packet 43 or 56, based on the I/O options in effect.

A.14.25 Command Packet 38 – 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 58.

*

Note – The GPS receiver can initialize itself without any data from the user; it just requires more time.

To request data without loading data, use only bytes 0 through 2; to load data, use all bytes. Before loading data, read the caution below.

Caution – Proper structure of satellite data is critical to receiver 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.

Table A-24 Command Packet 38

Byte	Item	Type	Value	Meaning
0	Operation	Byte	1 2	Request data from receiver Load data into receiver
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	

A.14.26 Command Packet 39 – Set/Request Satellite Disable or Ignore Health

Normally the GPS receiver selects only healthy satellites (based on transmitted values in the ephemeris and almanac) that 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 59 for operation modes 3 and 6 only.

Table A-25 Command Packet 39

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

At power-on and after a reset the default values are set for all satellites.

Caution – Ignoring health can cause the GPS receiver software to fail, as an unhealthy satellite may contain defective data. Use extreme caution in ignoring satellite health.

A.14.27 Command Packet 3A – Request Last Raw Measurement

This packet requests the most recent raw measurement data for one specified satellite. The GPS receiver returns packet 5A hex if data is available.

Table A-26 Command Packet 3A

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

A.14.28 Command Packet 3B – Request Current Status Of Satellite Ephemeris Data

This packet requests the current status of satellite ephemeris data. The GPS receiver returns packet 5B hex if data is available.

Table A-27 Command Packet 3B

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

A.14.29 Command Packet 3C – Request Current Satellite Tracking Status

This packet requests the current satellite tracking status. The GPS receiver returns packet 5C hex if data is available.

Table A-28 Command Packet 3C

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

A.14.30 Command Packet 3D – Request or Set Timing Port Configuration

This packet requests and optionally sets the timing port (port A) configuration. This configuration includes the baud rate, number of bits, parity, 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 3D is both an input and an output packet. A 3D input packet, with or without data, is responded to with a 3D output packet. The language mode is defined as follows. For transmission, the language mode specifies whether TSIP packets or NMEA are output on the timing port. For reception, the language mode specifies whether packets or RTCM data are received on the primary port.

*

Note – The timing port can be used for input only. This port will not accept input of TSIP packets.

The baud rate for the transmitter and the receiver can be set independently; but the number of bits, parity, and number of 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.

Table A-29 Command Packet 3D

Byte	Item	Type	Units	
0	XMT Baud Rate code	Byte	0: 50 baud 1: 110 4: 300 5: 600	6: 1200 8: 2400 9: 4800 11: 9600
1	RCV Baud Rate code	Byte	0: 50 1: 110 4: 300 5:600	6: 1200 8: 2400 9: 4800 11: 9600

2	Parity and # bits/char code: Xxxpppbb
	X = Don't care
		Byte	ppp:
			
			bb:
				0: even parity
				1: odd parity
				4: no parity
				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	
5	Language mode for Reception	Byte	0: Packets	

This information is held in non-volatile memory.

A.14.31 Report Packet 40 – Almanac Data Page

This packet provides almanac data for a single satellite. The GPS receiver sends this packet on request (packet 20 hex) and optionally, when the data is received from a satellite. The data format is shown below.

Table A-30 Report Packet 40

Byte	Item	Type	Units
0	satellite	BYTE	(identification number)
1-4	T_zc	SINGLE	seconds
5-6	week number	INTEGER	weeks
7-10	eccentricity	SINGLE	(dimensionless)
11-14	T_oa	SINGLE	seconds
15-18	i_o	SINGLE	radians
19-22	OMEGA_dot	SINGLE	radians/second
23-26	square root A	SINGLE	$(\text{meters})^{1/2}$
27-30	OMEGA 0	SINGLE	radians
31-34	omega	SINGLE	radians
35-38	M o	SINGLE	radians

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

A.14.32 Report Packet 41 – 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 21 hex 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.

Table A-31 Report Packet 41

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 – GPS week numbers run from 0 to 1023 and then cycles back to week #0. Week #0 began January 6, 1980. There will be another week #0 beginning August 22, 1999. The receiver automatically adds 1024 to the GPS week number after August 21, 1999, and reports the cumulative week number.

The seconds count begins with "0" each Sunday morning at midnight GPS time. A negative indicated time-of-week indicates that time is not yet known; in that case, the packet is sent only on request. The following table shows the relationship between the information in packet 41, and the packet 46 status code.

Table A-32 Relationship Between Packet 41 and Packet 46

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

*

Note – Before using the GPS time, verify that the packet 46 status code is 00 hex ("Doing position fixes"). This ensures the most accurate GPS time.

A.14.33 Report Packet 42 – Single-precision Position Fix, XYZ ECEF

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

Table A-33 Report Packet 42

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 83 is also sent with a negative time-of-fix to report the current known position. Packet 83 provides a double-precision version of this information.

A.14.34 Report Packet 43 – 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.

Table A-34 Report Packet 43

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

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

A.14.35 Report Packet 45 – 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 1F hex.

Table A-35 Report Packet 45

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.

A.14.36 Report Packet 46 – 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 26 hex, during an update cycle, when a new satellite selection is attempted, and when the receiver detects a change in its health. Packet 4B hex is always sent with this packet. The data format is given in the following table.

Table A-36 Report Packet 46

Byte	Item	Type	Value	Meaning
0	Status code	Byte		
			00 hex	Doing position fixes
			01 hex	Don’t have GPS time yet
			02 hex	Not used
			03 hex	PSOP is too high
			08 hex	No usable satellites
			09 hex	Only 1 usable satellite
			0A hex	Only 2 usable satellite
			0B hex	Only 3 usable satellite
			0C hex	The chosen satellite is unusable
1	Error codes	Byte		

The error codes in Byte 1 of packet 46 are encoded into individual bits within the byte. The bit positions and their meanings are shown below.

Table A-37 Report Packet 46 - Error Code Bit Positions

Error Code Bit Position	**Meaning if bit value = 1**
0 (LSB)	Battery back-up failed (note 3)
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 ref freq. error (note 2)
6	(Unused)
7 (MSB)	(Unused)

Note 1: After this error is detected, the bit remains set until the receiver is reset.

Note 2: This bit is "1" if the last computed reference frequency error indicated that the reference oscillator is out of tolerance. (Packet 2D requests the oscillator offset and packet 4D returns the oscillator offset to the user.)

Note 3: This bit is always set; Palisade does not have battery backup.

A.14.37 Report Packet 47 – Signal Levels for all Satellites

This packet provides received signal levels for all satellites currently being tracked or on which tracking is being attempted (that is, above the elevation mask and healthy according to the almanac). The receiver sends this packet only in response to packet 27 hex. The data format is shown below.

Table A-38 Report Packet 47

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

The signal level provided in this packet is a linear measure of the signal strength after correlation or de-spreading.

A.14.38 Report Packet 48 – 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 28 hex 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.

A.14.39 Report Packet 49 – 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 29 hex and when this data is received from a satellite.

Table A-39 Report Packet 49

Byte	Item
0	health of satellite #1
1	health of satellite #2
- - -	- - -
- - -	- - -
- - -	- - -
31	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.

A.14.40 Report Packet 4A – Reference Altitude

This packet is returned in response to a set or request reference altitude packet 0x2A.

Table A-40 Report Packet 4A - Reference Altitude

Byte	Item	Type	Units
0-3	Altitude	SINGLE	Meters above WGS-84 or MSL
4-7	Reserved	SINGLE	Reserved
8	Flag	BYTE	Reserved

A.14.41 Report Packet 4A – 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.

Table A-41 Report Packet 4A - Single-Precision LLA Position Fix

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
6-19	Time-of-Fix	SINGLE	Seconds

The LLA conversion is done according to the datum selected using packet 8E-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 current known position. Packet 84 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.

A.14.42 Report Packet 4B – Machine/Code ID and Additional Status

The receiver transmits this packet in response to packets 25 and 26 and following a change in state. In conjunction with packet 46, "health of receiver," this packet identifies the receiver and may present error messages. The machine ID can be used by equipment communicating with the receiver to determine the type of receiver to which the equipment is connected. Then the interpretation and use of packets can be adjusted accordingly.

Table A-42 Report Packet 4B

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

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

Table A-43 Report Packet 4B - Error Code Bit Positions

Status 1 Bit Position	Meaning if bit value = 1
0 (LSB)	Synthesizer Fault
1	Battery Powered Time Clock Fault
2	A-to-D Converter Fault (Not Used)
3	The Almanac stored in the receiver is not complete and current
4-7	Not used

A.14.43 Report Packet 4C – Report Operating Parameters

This packet provides several operating parameter values of the receiver. The receiver sends this packet in response to packet 2C hex. 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 receiver tries to track a satellite. The signal level mask sets the required signal level for a satellite to be used for position fixes.

The PDOP mask sets the maximum PDOP with which position fixes are calculated. The PDOP switch sets the threshold for automatic 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. This information is stored in non-volatile memory.

Table A-44 Report Packet 4C

Byte	Item	Type/Units	Default	Byte 0 Value/ Velocity
0	Dynamics code	BYTE	Land	(0) 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°	

Table A-44 Report Packet 4C (Continued)

Byte	Item	Type/Units	Default	Byte 0 Value/ Velocity
5-8	Signal level mask	SINGLE/---	0	
9-12	PDOP mask	SINGLE/---	8	
13-16	PDOP switch (3-D or 2-D)	SINGLE/---	8	

A.14.44 Report Packet 4D – Oscillator Offset

This packet provides the current value of the receiver master oscillator offset in Hertz at carrier. This packet contains one SINGLE number (4 Bytes). The receiver sends this packet in response to packet 2D hex. The permissible offset varies with the receiver unit.

A.14.45 Report Packet 4E – 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 2E hex. This packet contains one byte.

Table A-45 Report Packet 4E

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

A.14.46 Report Packet 4F – UTC Parameters

This packet is sent in response to command packet 2F and contains 26 bytes. It reports the UTC information broadcast by the GPS system. For details on the meanings of the following parameters, consult ICD-200, Sections 20.3.3.5.2.4, 20.3.3.5.1.8, and Table 20-IX. On the simplest level, to get UTC time from GPS time, subtract ΔT_{LS} seconds. The other information contained in this packet indicates when the next leap second is scheduled to occur.

Table A-46 Report Packet 4F

Byte	Value	Type
0-7	A0	DOUBLE
8-11	A1	SINGLE
12-13	ΔT_{LS}	INTEGER
14-17	T_{OT}	SINGLE
18-19	WN_T	INTEGER
20-21	WN_{LSF}	INTEGER
22-23	DN	INTEGER
24-25	ΔT_{LSF}	INTEGER

A.14.47 Report Packet 54 – Bias and Bias Rate

The receiver sends this packet to provide the computed clock-only solution when the receiver is in the manual or automatic overdetermined timing mode.

Table A-47 Report Packet 54

Byte	Item	Type	Units
0-3	Bias	SINGLE	meters
4-7	Bias rate	SINGLE	meters/second
8-11	Time of fix	SINGLE	seconds

The bias is the offset of the receiver internal time clock from GPS time. Bias is expressed as meters of apparent range from the satellites. It is used to correct the one PPS output. Bias rate is the frequency error of the receiver internal oscillator. It is expressed as apparent range rate.

Caution – For accurate interpretation of the propagation delay, the precise constant for the speed of light must be used. The ICD-200 value for the speed of light is 299,792,458 meters per second.

A.14.48 Report Packet 55 – I/O Options

This packet provides current I/O options in effect in response to packet 35 request. The data format is the same as for packet 35 hex 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).

Table A-48 Report Packet 55

Byte	Parameter Name	Bit Position	Default Bit Value	Option	Associated packet
0	position	0(LSB)	0	XYZ ECEF Output 0: off 1: on	42 or 83
		1	1	LLA Output 0: off 1: on	4A or 84
		2	0	LLA ALT Output 0: HAE 1: MSL geoid	4A or 84
		3	0	ALT input 0: HAE 1: MSL geoid	2A
		4	1	Precision-of-position output 0: single-precision packet 42 and/or 4A. 1: double-precision packet 83 and/or 84	
		5	0	Superpacket output 0: off 1: on	
		6	0	Superpacket format 0: binary 1: ASCII	
		7	0	unused	

Table A-48 Report Packet 55 (Continued)

Byte	Parameter Name	Bit Position	Default Bit Value	Option	Associated packet
1	velocity	0	0	XYZ ECEF Output 0: off 1: on	43
		1	1	ENU Output 0: off 1: on	56
		2-7	0	Unused	
2	Timing	0	1	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	

Table A-48 Report Packet 55 (Continued)

Byte	Parameter Name	Bit Position	Default Bit Value	Option	Associated packet
3	auxiliary	0	0	Raw measurements 0: off 1: on	5A
		1	0	Doppler smoothed codephase 0: raw 1: smoothed	5A
		2-7		Unused	

A.14.49 Report Packet 56 – 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 37 hex (last known fix). The data format is shown below.

Table A-49 Report Packet 56

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.

A.14.50 Report Packet 57 – 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 37 hex.

The data format is shown below.

Table A-50 Report Packet 57

Byte	Item	Type/Units	Byte 0 Value/Velocity
0	Source of information	BYTE/- - -	00/hex/none 01/regular fix
1	Mfg. diagnostic	BYTE/- - -	
2-5	Time of last fix	SINGLE/ seconds, GPS time	
6-7	Week of last fix	INTEGER/ weeks, GPS time	

A.14.51 Report Packet 58 – 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 38 hex (acknowledges the loading of data). The data format is shown below.

Table A-51 Report Packet 58

Byte	Item	Type	Value	Meaning
0	Operation	BYTE	1	Acknowledge
			2	Data Out
1	Type of data	BYTE	1	not used
			2	Almanac
			3	Health page, T_oa, WN_oa
			4	Ionosphere
			5	UTC
			6	Ephemeris
2	Sat PRN #	BYTE	0	Data that is not satellite ID-specific
			1 to 32	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 40, 49, and 4F respectively, and those reports are preferred. To get ionosphere or ephemeris, this report must be used.

Table A-52 Packet 58 ALMANAC Data

Byte	Item	Type	
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.

Table A-53 Packet 58 ALMANAC HEALTH Data

Byte	Item	Type	
4	week # for health	BYTE	(cf. ICD-200, Sec 20.3.3.5.1.3)
5-36	SV_health	32 BYTES	(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	

Table A-54 Packet 58 IONOSPHERE Data

Byte	Item	Type	
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)

Table A-55 Packet 58 UTC Data

Byte	Item	Type	
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	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.8)
37-38	WN_LSF	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.8)
39-40	DN	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.8)
41-42	delta_t_LSF	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.8)

Table A-56 Packet 58 EPHEMERIS Data

Byte	Item	Type	
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)

Table A-56 Packet 58 EPHEMERIS Data (Continued)

Byte	Item	Type	
103-110	i_o	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, OMEGADOT
163-170	ODOT_n	DOUBLE	derived from OMEGADOT

Note: All angles are in radians.

A.14.52 Report Packet 59 – 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. The data format is shown below.

*

Note – When viewing the satellite disabled list, the satellites are not numbered but are in numerical order. The disabled satellites are signified by a 1 and enabled satellites are signified by a 0.

Table A-57 Report Packet 59

Byte	Item	Type	Value	Meaning
0	Operation	BYTE	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)		(Depends on byte 0 value.)
			0	Enable satellite selection or heed satellite's health. Default value.
			1	Disable satellite selection or ignore satellite's health.

A.14.53 Report Packet 5A – Raw Measurement Data

This packet provides raw GPS measurement data. If the I/O auxiliary option for "raw data" has been selected, the receiver also sends this packet in response to packet 3A hex. The data format is shown below.

Table A-58 Report Packet 5A

Byte	Item	Type	Units
0	Satellite PRN number	BYTE	----
1-4	reserved	SINGLE	
5-8	Signal level	SINGLE	
9-12	Code phase	SINGLE	1/16th chip
13-16	Doppler	SINGLE	Hertz
17-24	Time of Measurement	DOUBLE	seconds

APPLICATION NOTE:

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

Table A-59 Correlation of AMU levels to C/N0

AMU level	C/N0
5	-20 dB SNR
16	-10 dB SNR
26	-5 dB SNR

*

Note – SNR $_{(\pm 3)}$ = 20log((signal counts/noise counts)*(BW/2)) where: signal counts = 64 * AMU; noise counts = 90, and BW = 1000Hz.

The C/N0 is affected by five basic parameters:

- signal strength from the GPS satellite
- receiver/antenna gain
- pre-amplifier noise figure
- receiver noise bandwidth
- accumulator sample rate and statistics

The approximation is very accurate from 0 to 25 AMUs.

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:

1/16 x C/A code chip =	977.517ns/16 = 61.0948 ns
	61.0948 x speed of light (m/s)
	18.3158 meters

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

Each mS integer corresponds to:

C/A code epoch x speed of light =	1 ms x speed of light (m/s)
	300 km (approximate)
	299.792458 km (precise)

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

A.14.54 Report Packet 5B – Satellite Ephemeris Status

This packet is sent in response to packet 3B and optionally, 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 5B is as follows.

Table A-60 Report Packet 5B

Byte	Item	Type	Units
0	Satellite 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.

A.14.55 Report Packet 5C – 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 3C hex. The data format is shown below.

Table A-61 Report Packet 5C

Byte/Item	Type/Units	Value/Meaning
Byte 0 / Satellite PRN number	BYTE/ number 1-32	
Byte 1 / Channel and slot code	BYTE	
		Bit position within byte 1 7(MSB) 3 (channel number beginning with 0) (MSB) 0 0 0 0 0 channel 1: used by all receivers 0 0 0 0 1 channel 2: 8-channel receivers 0 0 0 1 0 channel 3: 8-channel receivers 0 0 0 1 1 channel 4: 8-channel receivers 0 0 1 0 0 channel 5: 8-channel receivers 0 0 1 0 1 channel 6: 8-channel receivers 0 0 1 1 0 channel 7: 8-channel receivers 0 0 1 1 1 channel 8: 8-channel receivers
Byte 2 / Acquisition flag		0 never acquired 1 acquired 2 re-opened search
Byte 3 / Ephemeris flag		0 flag not set ≠0 good ephemeris for this satellite (<4 hours old, good health)
Byte 4-7 / Signal level	SINGLE	same as in packet 47 hex
Byte 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

Table A-61 Report Packet 5C (Continued)

Byte/Item	Type/Units	Value/Meaning
Byte 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.
Byte 16-19 / Azimuth	SINGLE/ radians	Approximate azimuth from true north to this satellite. Usually updated about every 3 to 5 minutes. Used for computing measurement correction factors.
Byte 20 / old measurement flag	BYTE	N/A
Byte 21 / Integer msec flag	BYTE	N/A
Byte 22 / bad data flag	BYTE	N/A
Byte 23 / Data collection flag	BYTE	N/A

A.14.56 Report Packet 6D – 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 24 hex or whenever a new satellite selection is attempted. The GPS receiver attempts a new selection every 30 seconds and whenever satellite availability and tracking status change. The data format is shown below.

Table A-62 Report Packet 6D

Byte	Item	Type	Units
0	Mode	BYTE	Bit / Value / Meaning 0-2 / 3 / 2D 0-2 / 4 / 3D 3 / 0 / Auto 3 / 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	

PDOP values of zero indicate 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.

A.14.57 Report Packet 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 62 and whenever a satellite selection is made and the mode is Auto GPS/GPD (modes 2 and 3).

*

Note – Palisade does not support Differential Position Fix Mode. This packet is provided for compatibility reasons only.

A.14.58 Report Packet 83 – 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-precision option is selected, the receiver sends this packet each time a fix is computed. The data format is shown below.

Table A-63 Report Packet 83

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 42 provides a single-precision version of this information.

A.14.59 Report Packet 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-precision option is selected, the receiver sends this packet each time a fix is computed. The data format is shown below.

Table A-64 Report Packet 84

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 4A provides a single-precision version of this information.

Caution – When converting from radians to degrees, using an insufficiently precise approximation for the constant π (Pi) introduces significant and readily visible errors. The value of π as specified in ICD-GPS-200 is 3.1415926535898.

A.14.60 Command Packet BB – Set Primary Receiver Configuration

TSIP command packet BB contains the primary Palisade configuration parameters. To leave any parameter unchanged when issuing a set, enter command 0 x FF or -1.0 as the value. The table below lists the individual fields within the BB packet.

To query for the primary receiver configuration, send packet BB with subcode 0 as the only data byte. The table below lists the individual fields within the BB packet.

*

Note – The receiver may require an initial position fix before switching to some modes.

Table A-65 Command Packet BB

Byte #	Item	Type	Value	Meaning	Default
0	Subcode	BYTE	0	Primary receiver configuration block	
1	Operating Dimension	BYTE	0 1 3 4 5 6 7	Automatic Time only (1-SV) Horizontal (2D) Full position (3D) DGPS reference 2D clock hold Overdetermined clock	Full Position
2	DGPS Mode	BYTE	0 1 3	DGPS off DGPS only DGPS auto	DGPS Auto
3	Dynamics Code	BYTE	1 2 3 4	Land/<120 knots Sea/<50 knots Air/<800 knots static/stationary	Land

Table A-65 Command Packet BB (Continued)

Byte #	Item	Type	Value	Meaning	Default
4	Solution Mode	BYTE	1 2	Overdetermined fix Weighted Overdetermined fix	Weighted Over-determined fix
5-8	Elevation Mask	SINGLE	0-π/2	Lowest satellite elevation for fixes	10°
9-12	AMU Mask	SINGLE		Minimum signal level for fixes	0
13-16	PDOP Mask	SINGLE		Maximum GDOP for fixes	8
17-20	PDOP Switch	SINGLE		Selects 2D/3D mode	6
21	DGPS Age	BYTE		Maximum time to use a DGPS correction (seconds)	30 seconds
22	Foliage Mode	BYTE	0 1 2	Never Sometimes Always	Sometimes
23	Low Power Mode	BYTE	N/A	N/A	Disabled
24	Clock Hold Mode	BYTE	N/A	N/A	Off
25	Measurement Rate	BYTE	0 1 2	1 Hertz 5 Hertz 10 Hertz	1 Hz
26	Position Fix Rate	BYTE	0 1 2 3	1 Hertz 5 Hertz 10 Hertz Position at measurement rate	1 Hz
27-42	Reserved	BYTE	-1	Reserved for future use	

A.14.61 Report Packet BB – Report Receiver Configuration

TSIP report packet BB is used to report the GPS Processing options.

Table A-66 Report Packet BB

Byte #	Item	Type	Value	Meaning	Default
0	Subcode	BYTE	0	Primary receiver configuration block	
1	Operating Dimension	BYTE	0 1 3 4 5 6 7	Automatic Time only (1-SV) Horizontal (2D) Full position (3D) DGPS reference 2D clock hold Over-determined clock	Full Position
2	DGPS Mode	BYTE	0 1 3	DGPS off DGPS only DDGPS auto	DGPS auto
3	Dynamics Code	BYTE	1 2 3 4	Land/<120 knots Sea/<50 knots Air/<800 knots Static/Stationary	Land
4	Solution Mode	BYTE	1 2	Overdetermined fix Weighted O/D fix	
5-8	Elevation Mask	SINGLE	0-π/2	Lowest satellite elevation for fixes (radians)	
9-12	AMU Mask	SINGLE		Minimum signal level for fixes	
13-16	PDOP Mask	SINGLE		Maximum GDOP for fixes	8
17-20	PDOP Switch	SINGLE		Selects 2D/3D mode	6

Table A-66 Report Packet BB (Continued)

Byte #	Item	Type	Value	Meaning	Default
21	DGPS Age	BYTE		Maximum time to use a DGPS correction (seconds)	30 seconds
22	Foliage Mode	BYTE	0 1 2	Never Sometimes Always	Sometimes
23	Low Power Mode	BYTE	N/A	N/A	Disabled
24	Clock Hold Mode	BYTE	N/A	N/A	Off
25	Measurement Rate	BYTE	0 1 2	1 Hertz 5 Hertz 10 Hertz	1 Hz
26	Position Fix Rate	BYTE	0 1 2 3	1 Hertz 5 Hertz 10 Hertz Position at measurement rate	1 Hz
27-43	Reserved	BYTE	-1	Reserved for future use	

A.14.62 Command Packet BC – Set Port Configuration Parameters

TSIP command packet BC is used to set the communication parameters on Port A and Port B. The table below lists the individual fields within the BC packet.

Palisade supports only Ports 0 (A) and 1 (B) and the TSIP and NMEA protocols. Port B supports only the 8 bit TSIP protocol. Flow control is not supported.

Table A-67 Command Packet BC

Byte #	Item	Type	Value	Meaning	Default
0	Port Number	BYTE	0 1 0xFF	Port A Port B current port	
1	Input Baud Rate	BYTE	0 1 2 3 4 5 6 7 8 9	None 110 baud 300 baud 600 baud 1200 baud 2400 baud 4800 baud 9600 baud 19200 baud 38400 baud	9600
2	Output Baud Rate	BYTE	0 1-9	Same as input baud rate As above	9600
3	# Data Bits	BYTE	2 3	7 bits 8 bits	8 bits
4	Parity	BYTE	0 1 2	None Odd Even	Odd
5	# Stop Bits	BYTE	0 2	1 bit 2 bits	1 bit
6	reserved	BYTE	0-15	0 = none	0

Table A-67 Command Packet BC (Continued)

Byte #	Item	Type	Value	Meaning	Default
7	Input Protocols	BYTE	0 2	none TSIP	TSIP
8	Output Protocols	BYTE	0 2 4	none TSIP NMEA	TSIP
9	Reserved	BYTE	0	None	

A.14.63 Report Packet BC – Request Port Configuration Parameters

TSIP packet BC is used to request the communication parameters on Port A and Port B. To query a port's configuration parameters, send packet BC with the requested port number. Table A-68, above, lists the individual fields within the BC report packet.

A.15 Custom OEM Packets

Several packets have been added to the core TSIP protocol to provide additional capability for OEM receivers. In OEM packets 8E and their 8F responses, the first data byte is a subcode that indicates the superpacket type. For example, in packet 8E-14, 14 is the subcode that indicates the superpacket type. Therefore the ID code for OEM packets is 2 bytes long, followed by the data.

A.16 TSIP Superpackets

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

A.16.1 Command Packet 8E-14 - Set New Datum

This packet allows the user to change the default datum from WG-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 4A and 84. The receiver responds with packet 8F-14.

The user may want 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 want to use a datum that is more optimized for the local shape of the earth in that area. However, these optimized datums 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.

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

Table A-68 Command Packet 8E-14

Byte #	Type	Value
0	Superpacket ID	0 x 14
1-2	INTEGER	Datum index

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.

Table A-69 Command Packet 8E-14

Byte #	Type	Value	Units
0	Superpacket ID	0x14	
1-8	DOUBLE	DX	M
9-16	DOUBLE	DY	M
17-24	DOUBLE	DZ	M
25-32	DOUBLE	A-axis	M
33-40	DOUBLE	Eccentricity Squared	None

A.16.2 Command Packet 8E-15 – Request Current Datum Values

This packet contains only the subpacket ID, 0x15. The response to this packet is 8F-15.

A.16.3 Command Packet 8E-20 – Request Last Fix with Extra Information

This packet requests packet 8F-20 or marks it for automatic output. If only the first byte (20) is sent, an 8F-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.

Table A-70 Command Packet 8E-20

Byte #	Item	Type	Meaning
0	Sub-packet ID	BYTE	ID for this sub-packet (always 0 x 20)
1	Mark for Auto-report (cf. bit 5 of packet 35)	BYTE	0 = do not auto-report 1 = auto-report

*

Note – Auto-report requires that superpacket output is enabled. Refer to command packet 35.

A.16.4 Command Packet 8E-41 – Manufacturing Operating Parameters

This packet is used to request the manufacturing parameters stored in nonvolatile memory. The packet contains only a single byte, the subpacket ID. The receiver returns packet 8F-41.

A.16.5 Command Packet 8E-42 – Production Parameters

This packet is used to request the production parameters stored in nonvolatile memory. This packet contains only a single byte, the subpacket ID. The receiver returns packet 8F-42.

A.16.6 Command Packet 8E-45 – Revert to Default Settings

This packet is used to clear the serial E^2 PROM segments or revert the stored parameters to their factory settings.

Table A-71 Command Packet 8E-45

Byte #	Item	Type	Meaning
0	Subcode	BYTE	ID for this sub-packet is always 0 x 45
1	Production options prefix	BYTE	3 CNFG 5 PORT 6 PPS 7 ACCU 8 DECORR 9 TIMING

*

Note – There are six nonvolatile memory segments that contain parameters that are programmable: CNFG, PORT, PPS, ACCU, DECORR and TIMING. The CNFG segment stores the receiver configuration parameters that are programmable with the command packets 0xBB and 0x2A. The PORT segment stores the port configuration parameters that are programmable with command packet 0xBC. The PPS segment stores the timing pulse characteristics defined by the command packet 0x8E-0x4A. The ACCU segment stores the accurate initial position supplied by the command packets 0x31 and 0x32. The DECORR segment stores the maximum number of position fix averages in the auto-survey before the switch to overdetermined clock mode (packet 8E-4B). The TIMING segment stores UTC offset information that is automatically collected by the receiver.

This packet generates an 8F-45 response.

A.16.7 Command Packet 8E-4A - Set PPS Characteristics

This packet allows the user to query and control Palisade's PPS characteristics. Palisade responds to a query or control command with packet 8F-4A. The packet contains 16 bytes in the following order:

Table A-72 Command Packet 8E-4A

Byte #	Item	Type	Meaning
0	Sub-packet ID	BYTE	Always 0 x 4A
1	PPS Driver Switch	BYTE	0 = off 1 = on
2	Time Base	BYTE	0: GPS 1: UTC (default)
3	PPS Polarity	BYTE	0: positive (default) 1: negative
4-11	PPS Offset or Cable Delay	DOUBLE	seconds 0.0
12-15	Bias Uncertainty Threshold	FLOAT	meters 300

Send a two byte 8E-4A packet without any parameters to request 8F-4A. Send the entire 16-byte message to update parameters.

The default setting for byte 3 is positive. This configures Palisade for the same pulse polarity as the AcutimeII smart antenna. Bytes 4 to 11 define the PPS cable delay offset. The default offset is 0, which corresponds to a 100-foot (30 meter) cable. These bytes allow the application to adjust the cable delay offset for longer or shorter cable lengths. Use a cable delay of ± 1.25 ns/foot to adjust PPS offset for cable lengths different than 100 feet. Palisade estimates the bias uncertainty as part of a PPS validity monitor. If the bias uncertainty exceeds the threshold, then Palisade disables the PPS output. The default bias uncertainty threshold is 300 meters, but this parameter may be programmed by the application. Palisade limits the threshold to $3x10^8$ meters. Each time the application adjusts the packet 8E-4A settings, the new settings are stored in nonvolatile memory.

A.16.8 Command Packet 8E-4B – Programming the Survey Limit

This packet allows the user to override the factory survey limit of 2000 position fix averages. Sending 8E-4B without parameters allows querying the current setting. The receiver returns packet 8F-4B.

Table A-73 Command Packet 8E-4B

Byte #	Item	Type	Meaning
0	Subcode	BYTE	ID for this sub-packet is always 0 x 4B
1-4	Auto-survey limit	LONG	Indicates the maximum number of position fixes to average in Auto 2D/3D before switching to over-determined timing mode

A.16.9 Command Packet 8E-4D – Automatic Packet Output Mask

Automatic output of packets on port B can be throttled using this command packet. The current mask can be requested by sending this packet with no data bytes except the subcode byte.

Table A-74 Command Packet 8E-4D - Current Mask

Byte #	Item	Type	Meaning
0	Subcode	BYTE	ID for this subpacket is always 0 x 4D

The automatic packet output mask can be set by sending this packet with 4 data bytes. This mask only disables automatic packet output. Packets generated in response to TSIP set or query commands will always be output by the receiver.

Table A-75 Command Packet 8E-4D - Automatic Packet Output Mask

Byte #	Item	Type	Meaning
0	Subcode	BYTE	ID for this subpacket is always 0 x 4D
1-4	Auto-output mask	LONG	32-bit packet enable bitmap

The bits are numbered in descending order of receipt, starting with bit 32 as the MSB of Byte 1, down to bit 0 as the LSB of Byte 4. The following table describes the packets affected by each bit.

Table A-76 Command Packet 8E-4D - Packets Affected By Bits

Bit #	Packets Output	Default	When Output	Meaning
0 (LSB)	40	0	After Decode	Almanac data collected from satellite.
1	58, 5B	0	After Decode	Ephemeris data collected from satellite.
2	4F	0	After Decode	UTC data collected from satellite.
3	58	0	After Decode	Ionospheric data collected from satellite.
4	48	0	After Decode	GPS Message.
5	49	0	After Decode	Almanac health page collected from satellite.
6		1		Reserved
7		1		Reserved
8	41	1	New Fix	Partial and full fix complete and packet output timer has expired.
9		1		Reserved
10		1		Reserved
11 (Note 1)	6D, 46, 4B, 82	1	Constellation Change, New Fix	New satellite selection
12		1	External Event	Reserved
13-29		1		Reserved
30	42, 43, 4A, 54, 56, 83, 84, 8F-20,	1	New Fix Update	Kinetic and Timing information. Output must be enabled using I/O options.
31	5A	1	New Fix	Output must be enabled using I/O options.

Note 1: A *1* in the bit mask turns on the associated packets and a *0* turns off the output of the associated packets.

A.16.10 Command Packet 8E-A5 – Super Packet Output Mask

This packet allows the user to query the enabled super packets. Selected super packets are output if they are enabled and the configured protocol is TSIP.

Table A-77 Command Packet 8E-A5

Byte #	Item	Type	Meaning
0	Subcode	BYTE	ID for this subpacket is always 0 x A5

The receiver returns the super packet enable mask, packet 8F-A5. Super packet output is configured using the output protocol options available in packet BC and 3D, and by sending the 8E-20, 8E-0B and 8E-AD auto-output configuration commands described in each packet's respective section.

A.16.11 Command Packet 8E-AD – Request or Configure Super Packet Output

The 8E-AD packet is a dual-purpose packet. If the 8E-AD byte sequence is sent with no data, the receiver will generate an 8F-AD packet on port B. The time reported by the 8F-AD packet on port B is always the beginning of the current second.

Output of the 8F-AD Primary UTC timing packet on Port A is configured by sending a 3 byte message 8E-AD n, where n ranges from 0 to 3, as defined below. The receiver returns the 8F-A5 Super Packet Output Mask. The packet structure for the 8E-AD n configuration command is:

Table A-78 Command Packet 8E-AD

Byte #	Item	Type	Value	Default	Meaning
0	Subcode	Byte	AD	Required	Super-packet ID
1	Flag	Byte	0 1 2 3	3	disable packet output on port A output packet on port A only at PPS output packet on port A only at event input output at both event input and PPS

A.16.12 Command Packet 8E-0B – Request or Configure Super Packet Output

The 8E-0B packet is identical in function to the 8E-AD packet. If the 8E-0B byte sequence is sent with no data, the receiver will return an 8F-0B packet on port B. The time reported by the 8F-AD packet on port B is always the beginning of the current second.

Output of the 8F-0B Comprehensive timing packet on Port A is configured by sending a 3-byte message 8E-0B n, where n ranges from 0 to 3. The receiver returns the 8F-A5 Super Packet Output Mask. The packet structure for the 8E-0B n configuration command is:

Table A-79 Command Packet 8E-0B

Byte #	Item	Type	Value	Default	Meaning
0	Subcode	Byte	OB	Required	Super-packet ID
1	Flag	Byte	0 1 2 3	2	disable packet output on port A output packet on port A only at PPS output packet on port A only at event input output at both event input and PPS

A.16.13 Report Packet 8F-14 – Current Datum Values

This packet contains 41 data bytes with the values for the datum currently in use and is sent in response to packet 8E-14. These five values describe an ellipsoid to convert ECEF XYZ coordinate system into LLA.

Table A-80 Report Packet 8F-14

Byte #	Type	Value	Units
0	Super packet ID	14	
1-2	Datum index (-1 for custom)	0	
3-10	DOUBLE	DX	M
11-18	DOUBLE	DY	M
19-26	DOUBLE	DZ	M
27-34	DOUBLE	A-axis	M
35-42	DOUBLE	Eccentricity squared	none

A.16.14 Report Packet 8F-15 – Current Datum Values

This packet contains 43 data bytes with the values for the datum currently in use and is sent in response to packet 8E-15. If a built-in datum is being used, both the datum index and the five 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 five values will be displayed. These five values describe an ellipsoid to convert ECEF XYZ coordinate system into LLA.

Table A-81 Report Packet 8F-15

Byte #	Type	Value
0	BYTE	ID for this sub-packet (always 0 x 15)
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.

A.16.15 Report Packet 8F-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. Automatic output of 8F-20 must also be enabled by setting bit 5 of byte 0 in command packet 0x35.

The data format is shown below.

Table A-82 Report Packet 8F-20

Byte #	Item/Type	Meaning
0	Subpacket ID / BYTE	ID for this subpacket (always 0 x 20)
1	KeyByte/BYTE	Reserved for Trimble DGPS postprocessing
2-3	east velocity / INTEGER	units 0.005 m/s or 0.020 m/s (see Byte 24). Overflow = 0 x 8000
4-5	north velocity / INTEGER	units 0.005 m/s or 0.020 m/s (see Byte 24). Overflow = 0 x 8000
6-7	up velocity /INTEGER	units 0.005 m/s or 0.020 m/s (see Byte 24). Overflow = 0 x 8000
8-11	Time of Week / UNSIGNED LONG	GPS Time in milliseconds
12-15	Latitude / LONG INTEGER	WGS-84 latitude, units = 2^{-31} semicircle. Range = -2^{30} to 2^{32}
16-19	Longitude / UNSIGNED LONG	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 2-7 have been scaled by 4.
25	Reserved	0
26	Datum	Datum index + 1

Table A-82 Report Packet 8F-20 (Continued)

Byte #	Item/Type	Meaning
27	Fix Type / BYTE	Type of fix. This is a set of 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-circulated altitude 1: 2D fix used entered altitude 4 0: unfiltered 1: position or altitude filter on 5-7 unused (always 0)
28	NumSVs/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 SVs	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.
48-55	Iono Param / 8 CHARS	The broadcast ionospheric parameters.

Table A-83 Report Packet 8F-20

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

Thus the total length of data in packet is 41 + 2n bytes, where n is the number of satellites.

A.16.16 Report Packet 8F-41 – Manufacturing Operating Parameters

This packet provides information on the manufacturing parameters stored in nonvolatile memory.

Table A-84 Report Packet 8F-41

Byte #	Item	Type	Meaning
0	Subcode	BYTE	ID for this subpacket is always 0 x 41
1-2	Board serial number prefix	INTEGER	
3-6	Board serial number	ULONG	
7	Year of build	BYTE	
8	Month of build	BYTE	
9	Day of build	BYTE	
10	Hour of build	BYTE	
11-14	Oscillator offset	SINGLE	
15-16	Test code identification number	INTEGER	

A.16.17 Report Packet 8F-42 - Production Parameters

This packet provides information on the production parameters stored in nonvolatile memory.

Table A-85 Report Packet 8F-42

Byte #	Item	Type	Meaning
0	Subcode	BYTE	ID for this subpacket is always 0 x 42
1	Production options prefix	BYTE	
2	Production number extension	BYTE	
3-4	Case serial number prefix	INTEGER	
5-8	Case serial number	ULONG	
9-12	Production number	ULONG	
13-14	Reserved	INTEGER	
15-16	Machine identification number	INTEGER	
17-18	Reserved	INTEGER	

A.16.18 Report Packet 8F-45 – Revert to Default Settings

This packet is sent in response to packet 8E-45 and indicates that the E^2 PROM segment indicated in Byte 1 has been cleared back to factory settings successfully. If packet 45 appears unrequested, then either the GPS receiver power was cycled or the GPS receiver was reset.

Table A-86 Report Packet 8F-45

Byte #	Item	Type	Meaning
0	Subcode	BYTE	ID for this subpacket is always 0 x 45
1	Production options	BYTE	3 CNFG 5 PORT 6 PPS 7 ACCU 8 DECORR 9 TIMING

A.16.19 Report Packet 8F-4A – PPS Characteristics

This packet reports Palisade's PPS characteristics. This packet is sent in response to a query command with packet 8E-4A. The packet contains 16 bytes in the following order:

Table A-87 Report Packet 8F-4A

Byte #	Item	Type	Units
0	Subpacket ID	BYTE	Always 0 x 4A
1	PPS Driver Switch	BYTE	0: off 1: on
2	Time Base	BYTE	0: GPS 1: UTC (default)
3	PPS Polarity	BYTE	0: positive (default) 1: negative
4-11	PPS Offset or Cable Delay	DOUBLE	seconds
12-15	Bias Uncertainty Threshold	SINGLE	meters

A.16.20 Report Packet 8F-4B – Programming the Survey Limit

This packet provides information on user overrides of the factory survey limit of 2000 position fix averages. It is sent in response to a query or set command 8E-4B.

Table A-88 Report Packet 8F-4B

Byte #	Item	Type	Meaning
0	Subcode	BYTE	ID for this sub-packet is always 0 x 4B
1-4	Maximum	ULONG	Indicates the maximum number of position fixes to average in Auto 2D/3D before the switch to overdetermined clock (static mode)

A.16.21 Report Packet 8F-4D – Automatic Packet Output Mask

This packet provides information on the automatic packets that may be output by the receiver. Sent in response to 8E-4D query or set.

Table A-89 Report Packet 8F-4D

Byte #	Item	Type	Meaning
0	Subcode	BYTE	ID for this sub-packet is always 0 x 4D
1-4	Bit Mask	ULONG	Bits in the mask enable output packets

The following table describes the meaning and packets output by each set bit.

Table A-90 Report Packet 8F-4D

Bit #	Packets Output	When Output	Meaning
0(LSB)	40 Alm	After Decode	Almanac data collected from satellite
1	58, 5B	After Decode	Ephemeris data collected from satellite.
2	4F	After Decode	UTC data collected from satellite
3	58	After Decode	Ionospheric data collected from satellite
4	48	After Decode	GPS Message.
5	49	After Decode	Almanac health page collected from satellite.
6			Reserved
7			Reserved
8	41	New Fix	Partial and full fix complete and packet output timer has expired.
9			Reserved
10			Reserved
11	6D, 82	Constellation Change	New satellite selection
12		External Event	Reserved
13-29			Reserved
30	4A, 8F-20, 42, 43, 54, 56, 82, 83, 84	New Fix Update	Kinetic and Timing information. Output must be enabled with I/O options.
31 (Note 1)	5A	New Fix	Output must be enabled with I/O options.

Note 1: A *1* in the bit mask indicates that output for the associated packets is ON and a *0* indicates that the output is turned OFF.

A.16.22 Report Packet 8F-A5 – Super Packet Output Mask

This packet reports the 32-bit Super Packet Output Mask. Mask bits set to 1 indicate that output of the corresponding packet is enabled. Enabled super packets are output only if the configured port output protocol on port A is TSIP.

Table A-91 Report Packet 8F-A5

Byte #	Item	Type	Meaning
0	Subcode	BYTE	ID for this subpacket is always 0 x A5
1-4	Bit Mask	BYTES	bits in the mask enable super packets

The receiver bit mask is defined as follows: Bytes are numbered as above, and bit 0 is LSB within the byte.

Table A-92 Report Packet 8F-A5

Byte	Bit #	Item	Default	Meaning if set to 1
1	0	8F-0B	0	Synchronous 8F-0B (1 Hertz)
	1	8F-0B	1	Event output of 8F-0B
	2-3	Reserved	1	
	4	8F-AD	1	Synchronous 8F-AD (1 Hertz)
	5	8F-AD	1	Event output of 8F-AD
	6-7	Reserved	1	Future use
2	0	8F-20	1	Enable 8F-20 output
	1-7	Reserved	1	
3	0-7	Reserved	0	Always 0
4	0-7	Reserved	0	Always 0

A.16.23 Synchronous Packets Output on Port A

The following packets are output immediately after transition of the PPS pulse, to allow identification and qualification of the PPS pulse. These packets may also be requested on port B. See the associated 8E-AD and 8E-0B packets for more information.

Report Packet 8F-AD - Primary UTC Time

The output of the 8F-AD packet is synchronized with the PPS, and may also be generated in response to external events. This packet provides accurate time and date information for time stamping and time transfer. The leap flag provides complete UTC event information, allowing implementation of sophisticated distributed systems intended to operate synchronously with UTC time. This packet is always output first in a possible sequence of up to 3 synchronous packets available on port A. Output of this packet can be disabled and configured using the 8E-AD packet on port B.

Table A-93 Report Packet 8F-AD

Byte #	Item	Type	Meaning
0	Subpacket ID	BYTE	Subcode 0 x AD
1-2	Event Count	INTEGER	External event counter. Zero for PPS.
3-10	Fractional Second	DOUBLE	Time elapsed in current second (seconds)
11	Hour	BYTE	UTC Hour
12	Minute	BYTE	UTC Minute
13	Second	BYTE	Second (0-59; 60 = leap)
14	Day	BYTE	Date (1-31)
15	Month	BYTE	Month (1-12)
16-17	Year	INTEGER	Year (4 digit)
18	Receiver Status	BYTE	Tracking Status (see definition below)
19	UTC Flags	BYTE	Leap Second Flags (see definition below)
20	Reserved	BYTE	Contains 0 x FF
21	Reserved	BYTE	Contains 0 x FF

The tracking status flag allows precise monitoring of receiver tracking status and allows a host system to determine whether the time output by the receiver is valid. After self survey has completed, the receiver only needs to track one satellite to maintain precise synchronization with UTC.

Table A-94 Tracking Status Flag Definitions

Flag	Status	Meaning
0	DOING_FIXES	Receiver is navigating.
1	GOOD_1SV	Receiver is timing using one satellite
2	APPX_1SV	Approximate time
3	NEED_TIME	Start-up
4	NEED_INITALIZATION	Start-up
5	PDOP_HIGH	Dilution of Precision too High
6	BAD_1SV	Satellite is unusable
7	0SVs	No satellites usable
8	1SV	Only 1 satellite usable
9	2SVs	Only 2 satellites usable
10	3SVs	Only 3 satellites usable
11	NO_INTEGRITY	Invalid solution
12	DCORR_GEN	Differential corrections
13	OVERDET_CLK	Overfetermined fixes

Leap Second Flag

Leap seconds are inserted into the UTC timescale to counter the effect of gradual slowing of the earth's rotation due to friction. The 8F-AD packet provides extensive UTC leap second information to the user application. The **Leap Scheduled** bit is set by the receiver, when the leap second has been scheduled by the GPS control segment. The Control segment may schedule the leap second several weeks before the leap second takes place. The **Leap Pending** bit indicates that the leap second will be inserted at the end of the current day. The **GPS Leap Warning** bit is set while GPS is operating in the leap exception mode specified in ICD-200. The **Leap in Progress** bit is set to 1 at the beginning of the leap second, and cleared at the beginning of the second following the leap event. The date rollover is delayed by one second on the day the leap second is inserted. The date will not increment until the beginning of the first second following the leap second.

Table A-95 Leap Second Flag Definitions

Bit #	Name	Meaning if set to 1
0	UTC Flag	UTC Time is available
1-3	Reserved	N/A
4	Leap Scheduled	GPS Almanac's leap second date is not in the past.
5	Leap Pending	24-hour warning. Cleared before leap second.
6	GPS Leap Warning	Set +/- 6 hours before/after leap event.
7	Leap in Progress	Leap second is now being inserted.

Report Packet 8F-0B - Comprehensive Time

Palisade outputs this packet port A. The output of the packet is synchronized with the PPS, and may also be generated in response to external events. Report packet 8F-0B provides easy identification of each timing pulse and contains all the information required for most timing and synchronization applications. Output of this packet can be disabled and configured using the 8E-0B packet on port B. If output of the 8F-AD packet is also enabled, the 8F-0B packet will always be output after the 8F-AD packet. If the NMEA protocol is also enabled, 8F-0B will always be output before the NMEA ZDA packet. The packet contains 74 bytes in the following order:

Table A-96 Report Packet 8F-0B

Byte #	Item	Type	Meaning
0	Subpacket ID	BYTE	Subcode 0 x 0B
1-2	Event Count	INTEGER	External event counter. Zero for PPS.
3-10	UTC/GPS TOW	DOUBLE	UTC/GPS time of week (seconds)
11	Date	BYTE	Date of event or PPS
12	Month	BYTE	Month of event or PPS
13-14	Year	INTEGER	Year of event or PPS
15	Receiver Mode	BYTE	Receiver operating dimensions 0 Horizontal (2D) 1 Full position (3D) (Survey) 2 Single satellite (0D) 3 Automatic (2D/3D) 4 DGPS reference 4 Clock hold (2D) 6 Overdetermined clock (default)
16-17	UTC Offset	INTEGER	UTC offset value (seconds)
18-25	Oscillator Bias	DOUBLE	Oscillator bias (meters)
26-33	Oscillator Drift Rate	DOUBLE	Oscillator drift (meters/second)
34-37	Oscillator Bias Uncertainty	SINGLE	Oscillator bias uncertainty (meters)

Table A-96 Report Packet 8F-0B (Continued)

Byte #	Item	Type	Meaning
38-41	Oscillator Drift Uncertainty	SINGLE	Oscillator bias rate uncertainty (meters/second)
42-49	Latitude	DOUBLE	Latitude in radians
50-57	Longitude	DOUBLE	Longitude in radians
58-65	Altitude	DOUBLE	Altitude above mean sea level, meters
66-73	Satellite ID	8 BYTES	Identification numbers of tracking and usable satellites

Bytes 66 through 73 identify the tracking and usable satellites. A tracked satellite is distinguished from a usable satellite by a negative sign (−) appended to its PRN number.

In this superpacket, time is referenced to UTC to correspond to the default PPS timebase. To configure Palisade to output time relative to GPS, the PPS must be characterized accordingly. Command packet 8E-4A enables the PPS to be re-defined at run-time and stores the new settings in nonvolatile memory.

*

Note – Leap seconds can not be predicted in advance using only the 8F-0B packet. A leap second can be identified by observing that the date does not increment after 86400 seconds have elapsed in the current day. The date rollover is delayed for the duration of the leap second, and the day/month/year count reported does not increment to the next day until the beginning of the second following the leap event. Decoding of the 8F-AD packet provides complete leap status information.

The UTC offset is incremented at the beginning of the first second following the leap second.

A.17 Datums

The table on the following pages lists datums.

Table A-97 Datums

Index	DX	DY	DZ	A-axis	Eccentricity	Description
0	0	0	0	6378137.000	0.00669437999014	/*WGS-84*/
1	-128	481	664	637797.155	0.00667437311265	/*Tokyo from old J6 values*/
2	-8	160	176	6378206.400	0.0067865799761	/*NAD-27*/
3	-9	151	185	6378206.400	0.00676865799761	/*Alaska/Canada*/
4	-87	-98	-121	6378388.000	0.00672267002233	/*European*/
5	-133	-48	148	6378160.000	0.00669454185459	/*Australian*/
6	0	0	4	6378135.000	0.00669431777827	/*WGS-72*/
7	0	0	0	6378137.000	0.00669438002290	/*NAD-83*/
8	0	0	0	6378137.000	0.00669437999014	/*NAD-02*/
9	0	0	0	6378137.000	0.00669437999014	/*Mexican*/
10	0	0	0	6378137.000	0.00669437999014	/*Hawaiian*/
11	0	0	0	6378137.000	0.00669437999014	/*Astronomic*/
12	0	0	0	6378137.000	0.00669437999014	/*U S Navy*/
13	-87	-98	-121	6378388.000	0.00672267002233	/*European*/
14	-134	-48	149	6378160.000	0.00669454185459	/*Australian 1984*/
15	-166	-15	204	6378249.145	0.00680351128285	/*Adindan-Mean*/
16	-165	-11	206	6378249.145	0.00680351128285	/*Adindan-Ethiopia*/
17	-123	-20	220	6378249.145	0.00680351128285	/*Adindan-Mali*/
18	-128	-18	224	6378249.145	0.00680351128285	/*Adindan-Senegal*/
19	-161	-14	205	6378249.145	0.00680351128285	/*Adindan-Sudan*/
20	-43	-163	45	6378245.000	0.00669342162297	/*Afgooye-Somalia*/
21	-150	-250	-1	6378388.000	0.00672267002233	/*Ain El Abd-Bahrain*/
22	-491	-22	435	6378160.000	0.00669454185459	/*Anna 1 Astr 1965*/
23	-143	-90	-294	6378249.145	0.00680351128285	/*Arc 1950-Mean*/
24	-138	-105	-289	6378249.145	0.00680351128285	/*Arc 1950-Botswana*/

Table A-97 Datums (Continued)

Index	DX	DY	DZ	A-axis	Eccentricity	Description
25	-125	-108	-295	6378249.145	0.00680351128285	/*Arc 1950-Lesotho*/
26	-161	-73	-317	6378249.145	0.00680351128285	/*Arc 1950-Malawi*/
27	-134	-105	-295	6378249.145	0.00680351128285	/*Arc 1950-Swaziland*/
28	-169	-19	-278	6378249.145	0.00680351128285	/*Arc 1950-Zaire*/
29	-147	-74	-283	6378249.145	0.00680351128285	/*Arc 1950-Zambia*/
30	-142	-96	-293	6378249.145	0.00680351128285	/*Arc 1950-Zimbabwe*/
31	-160	-6	-302	6378249.145	0.00680351128285	/*Arc 1960-Mean*/
32	-160	-6	-302	6378249.145	0.00680351128285	/*Arc 1960-Kenya*/
33	-160	-6	-302	6378249.145	0.00680351128285	/*Arc 1960-Tanzania*/
34	-205	107	53	6378388.000	0.00672267002233	/*Ascension Isl 1958*/
35	145	75	272	6378388.000	0.00672267002233	/*Astro Beacon E 1945*/
36	114	-116	-333	6378388.000	0.00672267002233	/*Astro B4 Sorol Atoll*/
37	-320	550	-494	6378388.000	0.00672267002233	/*Astro Dos 71/4*/
38	124	-234	-25	6378388.000	0.00672267002233	/*Astro Station 1952*/
39	-133	-48	148	6378160.000	0.00669454185459	/*Australian Geo 1966*/
40	-127	-769	472	6378388.000	0.00672267002233	/*Bellevue (IGN)*/
41	-73	213	296	6378206.400	0.00676865799761	/*Bermuda 1957*/
42	307	304	-318	6378388.000	0.00672267002233	/*Bogota Observatory*/
43	-148	136	90	6378388.000	0.00672267002233	/*Compo Inchauspe*/
44	298	-304	-375	6378388.000	0.00672267002233	/*Canton Island 1966*/
45	-136	-108	-292	6378249.145	0.00680351128285	/*Cape*/

Table A-97 Datums (Continued)

Index	DX	DY	DZ	A-axis	Eccentricity	Description
46	-2	151	181	6378206.400	0.00676865799761	/*Cape Canaveral mean*/
47	-263	6	431	6378249.145	0.00680351128285	/*Carthage*/
48	175	-38	113	6378388.000	0.00672267002233	/*Chatham 1971*/
49	-134	229	-29	6378388.000	0.00672267002233	/*Chua Astro*/
50	-206	172	-6	6378388.000	0.00672267002233	/*Corrego Alegre*/
51	-377	681	-50	6377397.155	0.00667437223180	/*Djakarta (Batavia)*/
52	230	-199	-752	6378388.000	0.00672267002233	/*DOS 1968*/
53	211	147	111	6378388.000	0.00672267002233	/*Easter Island 1967*/
54	-87	-98	-121	6378388.000	0.00672267002233	/*Euro 1950-Mean*/
55	-104	-101	-140	6378388.000	0.00672267002233	/*Euro 1950-Cyprus*/
56	-130	-117	-151	6378388.000	0.00672267002233	/*Euro 1950-Egypt*/
57	-86	-96	-120	6378388.000	0.00672267002233	/*Euro 1950-Eng/ Scot*/
58	-86	-96	-120	6378388.000	0.00672267002233	/*Euro 1950-Eng/Ire*/
59	-84	-95	-130	6378388.000	0.00672267002233	/*Euro 1950-Greece*/
60	-117	-132	-164	6378388.000	0.00672267002233	/*Euro 1950-Iran*/
61	-97	-103	-120	6378388.000	0.00672267002233	/*Euro 1950-Sardinia*/
62	-97	-88	-135	6378388.000	0.00672267002233	/*Euro 1950-Sicily*/
63	-87	-95	-120	6378388.000	0.00672267002233	/*Euro 1950-Norway*/
64	-87	-107	-120	6378388.000	0.00672267002233	/*Euro 1950-Port/ Spain*/
65	-86	-98	-119	6378388.000	0.00672267002233	/*European 1979*/
66	-133	-321	50	6378388.000	0.00672267002233	/*Gandajika Base*/
67	84	-22	209	6378388.000	0.00672267002233	/*Geodetic Datum 1949*/
68	-100	-248	259	6378206.400	0.00676865799761	/*Guam 1963*/
69	252	-209	-751	6378388.000	0.00672267002233	/*GUX 1 Astro*/

Table A-97 Datums (Continued)

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

Table A-97 Datums (Continued)

Index	DX	DY	DZ	A-axis	Eccentricity	Description
97	-9	161	179	6378206.400	0.00676865799761	/*NAD 27-Eastern US*/
98	-5	135	172	6378206.400	0.00676865799761	/*NAD 27-Alaska*/
99	-4	154	178	6378206.400	0.00676865799761	/*NAD 27-Bahamas*/
100	1	140	165	6378206.400	0.00676865799761	/*NAD 27-San Salvador*/
101	-10	158	187	6378206.400	0.00676865799761	/*NAD 27-Canada*/
102	-7	162	188	6378206.400	0.00676865799761	/*NAD 27-Alberta/ BC*/
103	-22	160	190	6378206.400	0.00676865799761	/*NAD 27-East Canada*/
104	-9	157	184	6378206.400	0.00676865799761	/*NAD 27-Manitoba/ Ont*/
105	4	159	188	6378206.400	0.00676865799761	/*NAD 27-NW Ter/ Sask*/
106	-7	139	181	6378206.400	0.00676865799761	/*NAD 27-Yukon*/
107	0	125	201	6378206.400	0.00676865799761	/*NAD 27-Canal Zone*/
108	-3	143	183	6378206.400	0.00676865799761	/*NAD 27-Caribbean*/
109	0	125	194	6378206.400	0.00676865799761	/*NAD 27-Central Amer*/
110	-9	152	178	6378206.400	0.00676865799761	/*NAD 27-Cuba*/
111	11	114	195	6378206.400	0.00676865799761	/*NAD 27-Greenland*/
112	-12	130	190	6378206.400	0.00676865799761	/*NAD 27-Mexico*/
113	0	0	0	6378137.0	0.00669438002290	/*NAD 83-Alaska*/
114	0	0	0	6378137.0	0.00669438002290	/*NAD 83-Canada*/
115	0	0	0	6378137.0	0.00669438002290	/*NAD 83-CONUS*/
116	0	0	0	6378137.0	0.00669438002290	/*NAD 83-Mex/Cent Am*/
117	-425	-169	81	6378388.0	0.00672267002233	/*Observatorio 1966*/

Table A-97 Datums (Continued)

Index	DX	DY	DZ	A-axis	Eccentricity	Description
118	-130	110	-13	6378200.0	0.00669342162297	/*Old Egyptian 1907*/
119	61	-285	-181	6378206.400	0.00676865799761	/*Old Hawaiian-mean*/
120	89	-279	-183	6378206.400	0.00676865799761	/*Old Hawaiian-Hawaii*/
121	45	-290	-172	6378206.400	0.00676865799761	/*Old Hawaiian*/
122	65	-290	-190	6378206.400	0.00676865799761	/*Old Hawaiian*/
123	58	-283	-182	6378206.400	0.00676865799761	/*Old Hawaiian*/
124	-346	-1	224	6378249.15	0.00680351128285	/*Oman*/
125	375	-111	431	6377563.4	0.00667053999999	/*Ord Sur Brit '36-Mean*/
126	375	-111	431	6377563.4	0.00667053999999	/*OSB-England*/
127	375	-111	431	6377563.4	0.00667053999999	/*OSB-Isle of Man*/
128	375	-111	431	6377563.4	0.00667053999999	/*OSB-Scotland/Shetland*/
129	375	-111	431	6377563.4	0.00667053999999	/*OSB-Wales*/
130	-307	-92	127	6378388.0	0.00672267002233	/*Pico De Las Nieves*/
131	-185	165	42	6378388.0	0.00672267002233	/*Pitcairn Astro 1967*/
132	16	196	93	6378388.0	0.00672267002233	/*Prov So Chilean1963*/
133	-288	175	-376	6378388.0	0.00672267002233	/*Prov S. American 1956-Mean*/
134	-270	188	-388	6378388.0	0.00672267002233	/*Prov S. American 1956-Bolivia*/
135	-270	183	-390	6378388.0	0.00672267002233	/*Prov S. American 1956-N Chile*/
136	-305	243	-442	6378388.0	0.00672267002233	/*Prov S. American 1956-S Chile*/
137	-282	169	-371	6378388.0	0.00672267002233	/*Prov S. American 1956-Colom*/

Table A-97 Datums (Continued)

Index	DX	DY	DZ	A-axis	Eccentricity	Description
138	-278	171	-367	6378388.0	0.00672267002233	/*Prov S. American 1956-Equador*/
139	-298	159	-369	6378388.0	0.00672267002233	/*Prov S. American 1956-Guyana*/
140	-279	175	-379	6378388.0	0.00672267002233	/*Prov S. American 1956-Peru*/
141	-295	173	-371	6378388.0	0.00672267002233	/*Prov S. American 1956-Venez*/
142	11	72	-101	6378206.4	0.00676865799761	/*Puerto Rico*/
143	-128	-283	22	6378388.0	0.00672267002233	/*Quatar National*/
144	164	138	-189	6378388.0	0.00672267002233	/*Qornoq*/
145	-225	-65	9	6378388.0	0.00672267002233	/*Rome 1940*/
146	-203	141	53	6378388.0	0.00672267002233	/*Santa Braz*/
147	170	42	84	6378388.0	0.00672267002233	/*Santo (DOS)*/
148	-355	21	72	6378388.0	0.00672267002233	/*Sapper Hill 1943*/
149	-57	1	-41	6378160.0	0.00669454185459	/*S. American 1969-Mean*/
150	-62	-1	-37	6378160.0	0.00669454185459	/*S. American 1969-Argentina*/
151	-61	2	-48	6378160.0	0.00669454185459	/*S. American 1969-Bolivia*/
152	-60	-2	-41	6378160.0	0.00669454185459	/*S. American 1969-Brazil*/
153	-75	-1	-44	6378160.0	0.00669454185459	/*S. American 1969-Chile*/
154	-44	6	-36	6378160.0	0.00669454185459	/*S. American 1969-Colombia*/
155	-48	3	-44	6378160.0	0.00669454185459	/*S. American 1969-Ecuador*/
156	-53	3	-47	6378160.0	0.00669454185459	/*S. American 1969-Guyana*/
157	-61	2	-33	6378160.0	0.00669454185459	/*S. American 1969-Paraguay*/

Table A-97 Datums (Continued)

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

A.18 Reference Documents

SS-GPS-300B
System Specification for the NAVSTAR Global Positioning System

ICD-GPS-200
NAVSTAR GPS Space Segment/Navigation User Interfaces

25334-10
Trimble Navigation Smart Antenna Developers Guide, Rev. B, June 1996

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 to the GPS system in non-mathematical terms .

Proceedings - Institute of Navigation Washington DC
A series of three abstracts published between 1980 & 1986 of papers from the Journal of the Institute of Navigation. Essential source material for any system designer.