Trimble

Force 11

GLOBAL POSITIONING SYSTEM (GPS)

VERSA MODULE EUROPA (VME)

RECEIVER CARD

(GVRC)

Installation, Operation, and Maintenance Manual

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1. INTRODUCTION

1.1 Purpose

The GPS Versa Module Europa (VME) Receiver Card (GVRC) is a Precise Positioning Service (PPS) receiver designed to collect and process the Global Positioning System (GPS) satellite signals to derive accurate 3-dimensional position, velocity, and time. The receiver can also be aided by an auxiliary sensor for increased performance in integrated applications.

1.2 Capabilities

1.2.1 Overview

The GVRC operates with signals broadcast from the NAVSTAR Global Positioning System satellites. As the satellites orbit the earth, the satellite availability changes continuously. The GVRC contains functions for determining the availability of satellites at any given time, and for determining the optimum times for usage. When the GVRC is operated with antenna line-of-sight visibility to the sky, the GVRC automatically searches for satellite signals and acquires the data necessary for a GPS solution. Using data derived from satellite signals, the GVRC calculates position, velocity, and time (PVT) solutions for output via the digital data ports.

The GVRC is capable of operating in a Precise Positioning Service (PPS) mode after an authorized operator has loaded the appropriate cryptovariables. Cryptovariables (CVs) can be entered through the key fill port by using a KOI-18, KYK-13, or AN/CYZ-10 data loader. CVs can also be manually entered via the digital data ports. Operation in the PPS mode mitigates the effects of Selective Availability (SA), and the Anti-Spoofing (A-S) feature allows access to the encrypted Y-code. The GVRC is capable of processing both the P(Y)-code and C/A-code on the L1/L2 GPS frequencies. When not authorized for PPS operation, the GVRC is capable of operating in the Standard Positioning Service (SPS) mode. Hardware and software zeroize functions allow cryptovariable information and all volatile memory data to be immediately and irreversibly deleted from GVRC memory components.

The remainder of this section briefly outlines the various capabilities of the GVRC.

1.2.2 Position, Velocity, and Time (PVT) GPS Solutions

The GVRC calculates position, velocity and time solutions at a maximum rate of one solution per second. The accuracy of the solution depends on the operating mode and other conditions as described in section 1.3.2. Each solution is time-tag referenced to GPS and/or Universal Coordinated Time (UTC).

The GVRC provides Precise Time and Time Interval (PTTI) data in several formats. Time rollover pulses are provided at each UTC second and minute. Binary Coded Decimal (BCD) time-of-day data is also provided in accordance with ICD-GPS-156 and ICD-GPS-060. HaveQuick-compliant time-of-day signals are provided in Manchester code.

1.2.3 External Interfaces

The GVRC is designed to be installed in a VMEbus system. The antenna interface is a SMA connector to support a coaxial cable connection to a remote antenna.

The GVRC incorporates three distinct input/output interfaces. The primary control, power, and data interface is the VMEbus which complies with the IEEE STD-1014-1987 VMEbus Specification and ICD-GPS-156. An Instrumentation Port (IP) which complies with ICD-GPS-150 is provided on the GVRC face plate (see figure 2-1). The IP is an RS-232 communications port incorporating a DB9 style connector. The third interface option is the Maintenance Port (MP) which is also implemented as an RS-232 port on the face plate, and is configured for the Precision Lightweight GPS Receiver (PLGR) interface standard mode (see section 1.3.6).

The KOI-18/KYK-13/CYZ-10 interface is a single function port for insertion of encryption keys. The key loading port complies with ICD-GPS-225 and CZE-93-105. Proper use of the key loading port is required for PPS operation. This interface also includes a discrete to zeroize CVs.

1.2.4 Dynamics

The GVRC is capable of providing outputs with the specified accuracy throughout the dynamic environment expected for naval vessels and water craft. The default velocity, acceleration, and jerk limits are summarized in Table 1-1.

Table 1-1. GVRC Dynamic Limits

Characteristic	*Limit*
Velocity	40 m/s
Acceleration	15 m/s/s
Jerk	7.5 m/s/s/s

1.2.5 Environment

The GVRC will operate to specified performance levels at temperatures from 0° C to +60° C. It can be stored at temperatures from –40° C to +85° C with no degradation.

The GVRC is designed to operate in conditions of relative humidity up to 98 percent including condensation in the form of water and frost.

The GVRC satisfies EMI/C requirements of MIL-STD-461C (Class A1a), and is resistant to jamming and spoofing when properly keyed.

1.3 Characteristics

1.3.1 GPS Signals

The GVRC operates on the L1/L2 GPS frequencies and has the capability to demodulate both the C/A-code and the P(Y)-code. When an authorized user has keyed the GVRC with the appropriate cryptovariables, the GVRC can remove SA accuracy degradation and operate with the encrypted Y-code.

1.3.2 Accuracy

Table 1-2 compares PPS enabled GVRC performance with SPS accuracy.

Table 1-2. Accuracy

Scenario	*Accuracy*
POSITION ACCURACY (Authorized User)	16 meters SEP (steady state) 18 meters SEP (maximum dynamics)
POSITION ACCURACY (Unauthorized User)	76 meters SEP
VELOCITY ACCURACY (Authorized User)	0.1 meter/sec RMS (no jerk, unaided) 0.03 meters/sec RMS (aided)
PULSE-PER-SECOND TIMING ACCURACY	100 nanoseconds (1 sigma)
HAVE QUICK TIMING ACCURACY	10 microseconds (1 sigma)

The listed position accuracies are in terms of meters, spherical error probable (SEP).

The listed accuracies apply assuming a user range error (URE) (Space/Control) of less than 4.0 meters under the following conditions:

a. Position Dilution of Precision (PDOP) less than 2.57

b. Horizontal Dilution of Precision (HDOP) less than 1.6

c. Vertical Dilution of Precision (VDOP) of less than 2.0

d. Unmodelled ionospheric error of less than 5 meters (one sigma)

SPS Mode (unauthorized user) values assume that Selective Availability is active.

The GVRC computes a Figure of Merit (FOM) value which equates to an Expected Position Error (EPE) as shown in Table 1-3.

1.3.3 Satellite Acquisition and Selection

1.3.3.1 Signal Acquisition Process

When power is applied, the GVRC enters the INITIALIZATION mode in which it does not attempt to acquire and track satellites. Upon being commanded to the NAVIGATION mode, the GVRC uses information stored in memory to determine which satellites are above the horizon and the approximate Doppler frequencies of the signals. Typically, this information would include the satellite constellation almanac, the last GVRC position fix, and an estimate of current time. If any of this information is not resident in GVRC memory when power is applied, the time to acquisition will be lengthened unless the user provides this initialization data to the unit. Position and time estimates, plus almanac information can be inputted through any one of the digital data ports.

1.3.3.2 Time-to-First-Fix (TTFF)

Time-to-first fix is the elapsed time from the user demand on the GVRC to the first display of accurate PVT data. The probability is 0.95 that the TTFF will be less than 90 seconds, provided the GVRC position uncertainty does not exceed 100 km, the GVRC has a time uncertainty of less than 2 minutes, current almanac is available, and the cryptovariables for that day are loaded and validated (if SA/A-S operation is required).

Table 1-3. FOM and Definition

FOM	*Expected Position Error (EPE)* *(in meters)*
1	less than or equal to 25
2	greater than 25, less than or equal to 50
3	greater than 50, less than or equal to 75
4	greater than 75, less than or equal to 100
5	greater than 100, less than or equal to 200
6	greater than 200, less than or equal to 500
7	greater than 500, less than or equal to 1000
8	greater than 1000, less than or equal to 5000
9	greater than 5000

1.3.3.3 Satellite Selection

The GVRC will consider all satellite vehicles (SVs) currently being tracked for use in calculating a GPS solution. The satellites must satisfy line-of-sight masking criteria (minimum signal level, minimum elevation angle, maximum GDOP, and the 4SV/3SV switch GDOP) to be used in calculating a solution.

The GVRC will track the eight highest satellites in view and calculate a PVT solution. The GVRC will automatically select fewer satellites if eight are not available. If four satellites are not available or there is no four-satellite combination which provides GDOP lower than the GDOP switch mask, the GVRC will augment available satellites with external sensor data when available. In this condition, the GVRC will use altitude hold (when enabled), employing the last known GPS altitude, or a value input from the host system.

As time passes and the satellite availability changes, the GVRC will automatically acquire rising satellites and adjust the selected constellation for the solution.

1.3.4 Anti-Spoofing (A-S)

The GVRC can provide the navigation accuracy presented in section 1.3.2 in a spoofing environment. A spoofing environment is considered to be present when at least one deceptive pseudolite signal is being received which has the same C/A- and P-codes associated with a valid Pseudo Random Noise (PRN) code number. Deceptive signals are typically broadcast at signal levels of up to 10 dB greater than received satellite signal levels. The deceptive signal attempts to force the GPS receiver to calculate erroneous PVT data by shifting to the higher power pseudolite carrier and code Doppler rates away from the actual satellite carrier and code Doppler rates.

The GVRC can protect against deception and denial of GPS service. Protection is provided during initial satellite signal acquisition, satellite signal re-acquisition during normal operation, and while incorporating a new satellite into the PVT solution set. Rejection of the deception signals is based on use of the encrypted Y-code.

1.3.4.1 *Anti-Spoofing ON and Anti-Spoofing OFF*

The GVRC operates in either an ANTI-SPOOFING ON or an ANTI-SPOOFING OFF condition. In the ON condition, it is optimized for use against spoofers. While in the OFF condition, it is optimized for ease of use and improved TTFF.

When powered on, the GVRC defaults to the ANTI-SPOOFING ON condition. If the database is complete and the GVRC is keyed, the GVRC will proceed to acquire and track satellites in this mode when commanded to NAVIGATE by the user.

1.3.4.2 *Anti-Spoofing Operation*

The GVRC must be correctly initialized to enable ANTI-SPOOFING ON operation. If not resident within the GVRC memory, user insertion of initialization data via any of the available data ports must include the following data:

a. Current SV almanac

b. Current position; accurate within 100 km

c. Current time; accurate within two (2) minutes

d. Valid cryptovariables

If the initialization data is not available, the GVRC will remain in the WAITING FOR INITIALIZATION state when commanded to the NAVIGATION mode. Otherwise it will commence search and acquisition of satellites.

1.3.4.3 *Anti-Spoofing OFF Operation*

If operational conditions permit, or if initialization data insertion cannot be completed, the GVRC can be operated in the ANTI-SPOOF OFF (mixed mode) condition. The following types of operation are possible with ANTI-SPOOFING OFF:

a. PPS receiver operation (tracking P-code corrected for SA),

b. C/A-code differential GPS operation (keyed or unkeyed) and connected via any of the digital data ports to a source of differential corrections,

c. SPS receiver operation using C/A-code,

d. Blind search (no knowledge of initial position, time, or satellite visibility),

e. “Anywhere” searches (poor or unreliable knowledge of position, but having approximate time and almanac).

In the ANTI-SPOOFING OFF mode, the GVRC will, upon being commanded to NAVIGATION, search for and acquire satellites regardless of the initial status of its database. To prevent inadvertent corruption of a database in a spoofing environment, GVRC always powers on in the ANTI-SPOOFING ON condition (unless exiting from a power-interrupt condition of less than 30 seconds). The GVRC must be deliberately switched to ANTI-SPOOFING OFF before it will attempt to acquire satellites when not fully initialized.

The GVRC database may be initialized from an external source while in INITIALIZE mode.

1.3.4.4 *Summary of Primary Operating Modes*

<u>INITIALIZE</u>. The GVRC does not attempt to search, acquire or track satellites. The GVRC defaults to this mode following power-up or reset. An exception is following a short (less than 30

second) power interruption, in which case the GVRC returns to the mode present prior to interruption. The GVRC must be in this mode to accept the following initialization data:

a. Time of day

b. Initial position

c. Almanac

d. Ephemeris

e. Lever arms

f. L1/L2 equipment delay

The GVRC will accept aiding data in the INITIALIZE mode.

NAVIGATE. In this mode the GVRC searches for, acquires, and tracks satellites to calculate a navigation solution. It accepts aiding data and utilizes a blending filter to calibrate system accuracy. In the Y-CODE ONLY mode, the GVRC will remain in the INITIALIZE mode after being commanded to NAVIGATE, unless it has initial position, time, almanac, and cryptovariables, as discussed in section 1.3.4.3. Once this data is supplied, the GVRC will transition to NAVIGATE mode if it was formerly commanded to do so.

TEST Mode. The GVRC enters this mode to perform commanded or initial built-in-test.

STANDBY Mode. This is similar to INITIALIZE mode with the exception that the GVRC will attempt Y-code re-acquisition after having been in this mode for a period of up to 20 minutes, upon being commanded back to NAVIGATE.

1.3.5 Selective Availability (SA)

1.3.5.1 General

In the early days of GPS, the DoD directed that GPS include the capability to deny military utility to unauthorized users. Selective Availability and Anti-Spoofing (SA and A-S) are the results of that directive.

SA is the deliberate introduction of errors into the GPS measurements. This denial of accuracy is implemented in two ways. First, predetermined errors are introduced into the navigation data transmitted by the satellites. The result is that unauthorized users (users without receivers that can neutralize the error) compute erroneous positions and clock offsets. Second, the satellite clock itself is altered. Whereas errors in the navigation data create slowly varying errors in the position solutions, the clock dither produces a much faster error behavior. Clock dither is quite obvious in velocity computations.

SA results in errors in position, velocity, and time. With SA off, and without differentially correcting the data, horizontal accuracy using single-frequency code-phase receivers has been demonstrated to be about 12 meters Circular Error Probable (CEP) (30 meters 95% of the time). With SA in effect, the U.S. government promised 40 meters horizontally CPE , and less than 173 meters 95% of the time.

1.3.5.2 GVRC Selective Availability and Key Loading

When operating with current cryptovariables loaded, GVRC automatically removes SA error. Cryptovariables are loaded into the GVRC using the front panel J10 connector. While the keyloading device is attached and operated, the GVRC front panel ORANGE LED blinks at a rate of 2.5 Hz. When the keyloader is removed or inactivated, the ORANGE LED blinks at 1 Hz until keys are validated, whereupon the ORANGE LED is continuously illuminated.

Once CVs have been loaded, the user has the option to specify a mission duration to the GVRC. This is a period, in days, after which the GVRC security module will automatically zeroize the CVs. Once CVs are loaded, the mission duration defaults to one (1) day. The user may modify the value once, and only once, as follows:

Step 1: Enter a mission duration via one of the digital interfaces within one (1) hour of the loading of the CVs. Maximum value is 244 days.

Step 2: Operate the GVRC through or during a period of greater than one (1) hour, but less than one (1) day, following loading of the CVs. In this case the GVRC will set a default mission duration of 240 days.

If the user does not perform either of Step 1 or Step 2 above, the GVRC will zeroize CVs upon subsequent power-up (default of one day exceeded). Note in the above that the period of one (1) day commences at midnight (UTC) on the day in which CVs were loaded. Once set, mission duration cannot be reset prior to expiration without first zeroizing the keys and re-keying.

1.3.6 GVRC Initialization Using PLGR

The maintenance port defaults to the PLGR interface standard mode (9600 baud, 8 data bits, no parity and 1 stop bit) regardless of jumper settings. This port can be connected to a PLGR which can be commanded to transfer initialization data to the GVRC. Refer to the PLGR operating manual for details. Once a transfer is commenced, GVRC will enter the INITIALIZATION mode. Following successful transfer, the GVRC will enter the STANDBY mode.

2. INSTALLATION

2.1 Installation Configuration

Figure 2-1 illustrates the GVRC board connectors and general configuration. Figure 2-2 presents the pin-to-signal assignments (pin-outs) for the VME connectors and the face-plate connectors. Figure 2-3 identifies the locations of the various DIP switches and jumpers that can be set to provide the desired configuration for the GVRC. The pre-set configuration installed at the factory prior to delivery is defined in section 2.1.5.

The GVRC requires the following operator settings before installation into a double-height, single-width slot of a VMEbus rack:

- Set the VME address (refer to section 2.1.1)
- Select the controlling interface (refer to section 2.1.2)
- If required, select the 5-VDC bias for the GPS antenna and low-noise amplifier (LNA) (refer to section 2.1.3)
- Configure proper RF input attenuation (refer to section 2.1.4)

2.1.1 Set VME Address

The GVRC must be configured to interface on the VME bus. Setting the individual DIP switches of S100 establishes the address of the GVRC. Figure 2-3 depicts the location of switch S100. Data or instructions passed over the VME bus to or from the GVRC are coded with a unique device address. The device address determined by the settings of S100 must match the address used by the VME bus controller. At initial installation the GVRC S100 switches should be set to the values required by the bus-controller software. Table 2-1 identifies the VME address bit for each of the 10 switches of S100. Turn a switch on to assert its address line, and turn the switch off to negate the address line.

Table 2-1. S100 Switches and VME Address Relationships

Switch #	*VME Address Bit #*	*Switch #*	*VME Address Bit #*
10	23	5	18
9	22	4	17
8	21	3	16
7	20	2	15
6	19	1	Not used

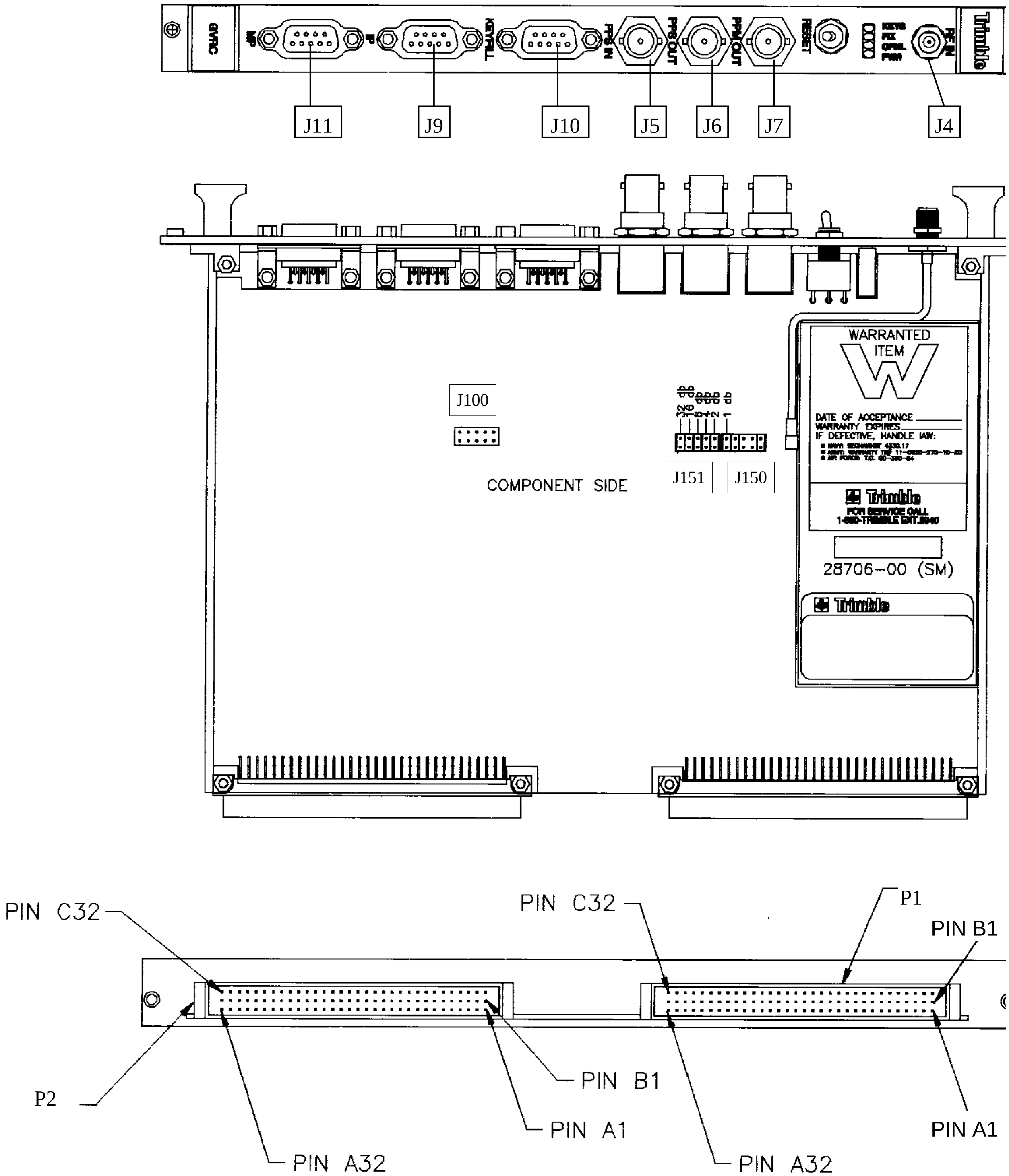

Figure 2-1. GVRC Connectors and Pin Arrangement

Pin #	*Signal Name*	*Pin #*	*Signal Name*	*Pin #*	*Signal Name*
VME P1 CONNECTOR					
A1	D00	B1	BBSY	C1	D08
A2	D01	B2	BCLR	C2	D09
A3	D02	B3	ACFAIL	C3	D10
A4	D03	B4	BGO IN	C4	D11
A5	D04	B5	BGO OUT	C5	D12
A6	D05	B6	BG1 IN	C6	D13
A7	D06	B7	BG1 OUT	C7	D14
A8	D07	B8	BG2 IN	C8	D15
A9	GND	B9	BG2 OUT	C9	GND
A10	SYSCLK	B10	BG3 IN	C10	SYSFAIL
A11	GND	B11	BG3 OUT	C11	BERR
A12	DS1	B12	BR0	C12	SYSRESET
A13	DS0	B13	BR1	C13	LWORD
A14	WRITE	B14	BR2	C14	AM5
A15	GND	B15	BR3	C15	A23
A16	DTACK	B16	AM0	C16	A22
A17	GND	B17	AM1	C17	A21
A18	AS	B18	AM2	C18	A20
A19	GND	B19	AM3	C19	A19
A20	ACK	B20	GND	C20	A18
A21	ACKIN	B21	SERCLK	C21	A17
A22	ACKOUT	B22	SERDAT	C22	A16
A23	AM4	B23	GND	C23	A15
A24	A07	B24	IRQ7	C24	A14
A25	A06	B25	IRQ6	C25	A13
A26	A05	B26	IRQ5	C26	A12
A27	A04	B27	IRQ4	C27	A11
A28	A03	B28	IRQ3	C28	A10
A29	A02	B29	IRQ2	C29	A09
A30	A01	B30	IRQ1	C30	A08
A31	–12V	B31	+5VSTDBY	C31	+12V
A32	+5V	B32	+5V	C32	+5V
VME P2 CONNECTOR					
A1	TM CODE IN +	B1	+5V	C1	TM CODE IN –
A2	TM FAULT IN (ACTIVE LOW)	B2	GND	C2	TBD
A3	TM FAULT IN A	B3	RESERVED	C3	TM FAULT IN B
A4	TM CODE OUT A	B4	A24	C4	TM CODE OUT B
A5	TM FAULT OUT (ACTIVE LOW)	B5	A25	C5	TBD
A6	TM FAULT OUT A	B6	A26	C6	TM FAULT OUT B
A7	HAVEQUICK OUT	B7	A27	C7	HAVEQUICK OUT RTN
A8	RS-422 OUT A	B8	A28	C8	RS-422 OUT B
A9	RS-422 IN A	B9	A29	C9	RS-422 IN B
A10	TIME MARK PULSE	B10	A30	C10	NC
A11	BAUD RATE SELECT	B11	A31	C11	NC
A12	D RESET	B12	GND	C12	NC
A13	GVRC RDY	B13	+5V	C13	NC
A14	NC	B14	D16	C14	NC
A15	NC	B15	D17	C15	NC
A16	NC	B16	D18	C16	NC
A17	NC	B17	D19	C17	NC
A18	NC	B18	D20	C18	NC
A19	NC	B19	D21	C19	NC
A20	NC	B20	D22	C20	NC
A21	NC	B21	D23	C21	NC
A22	NC	B22	GND	C22	NC
A23	NC	B23	D24	C23	NC
A24	NC	B24	D25	C24	NC
A25	NC	B25	D26	C25	NC
A26	NC	B26	D27	C26	NC
A27	NC	B27	D28	C27	NC
A28	NC	B28	D29	C28	NC
A29	NC	B29	D30	C29	NC
A30	NC	B30	D31	C30	NC
A31	NC	B31	GND	C31	NC
A32	NC	B32	+5V	C32	NC
J9 CONNECTOR (IP)		**J11 CONNECTOR (MP)**		**J10 CONNECTOR (KEYFILL)**	
1	N/C	1	N/C	1	SA/AS RETURN
2	RS-232 TX	2	RS-232 TX	2	N/C
3	RS-232 RX	3	RS-232 RX	3	KYK E
4	N/C	4	N/C	4	KYK C
5	GND	5	GND	5	KYK A
6	PPS IN	6	PPS IN	6	ZEROIZE -- ALL
7	N/C	7	N/C	7	LOAD STATUS
8	N/C	8	N/C	8	KYK D
9	N/C	9	N/C	9	KYK B

Figure 2-2. GVRC Pin-to-Signal Assignments (Pin-outs)

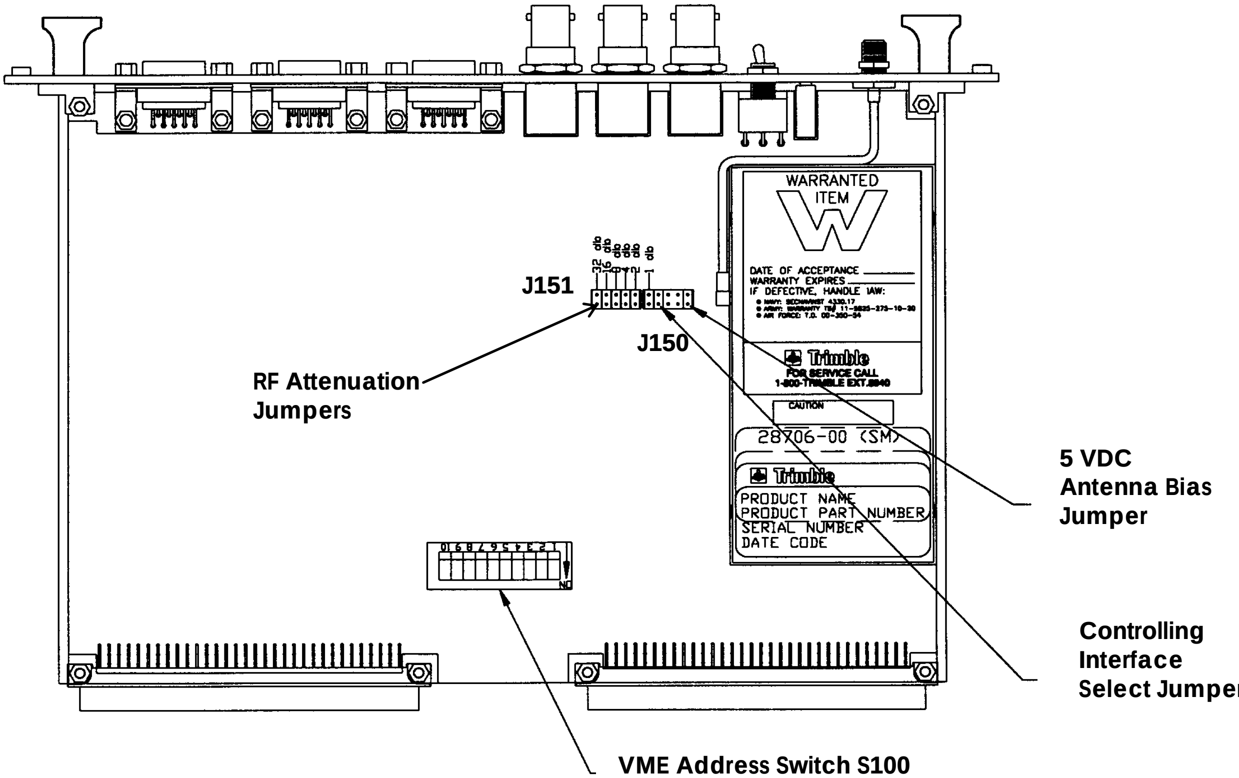

Figure 2-3. GVRC Jumper and DIP Switch Locations

2.1.2 Select Controlling Interface

The GVRC can be configured to have either the VME interface or the Instrument Port as the controlling interface, as specified in ICD-GPS-156. Select the desired controlling interface as indicated in Table 2-2. Note that only commands described in ICD-GPS-156 are influenced by this setting. The Interface Control jumper is located on the jumper block labeled J150 as shown in Figure 2-3.

Table 2-2. Configure Controlling Interface

Controlling Interface	***Jumper***
Instrument port	Inserted
VME interface	Removed

2.1.3 Configure Antenna Bias Voltage

The GVRC can be configured to have a 5-VDC bias voltage on the center pin of the RF input connector by inserting a jumper where indicated in Figure 2-3. The antenna bias voltage jumper is located on jumper block J150.

Table 2-3. Configure Antenna Bias Voltage

Bias Voltage Status	***Jumper***
+5 VDC Present	Inserted
No Bias Voltage	Removed

2.1.4 Configure RF Input Attenuation

The GVRC can be configured with jumpers to attenuate the RF input. Proper installation of the jumper(s) is required for optimal performance. Too much attenuation of the RF input can cause low or inconsistent SNR readings when tracking satellites. Too little attenuation of the RF input can cause degraded anti-jamming performance.

The GVRC has six jumper settings ranging from 1 dB to 32 dB which will allow the RF input to be attenuated from 1 dB up to 63 dB. See Figure 2-3 for the location of the six jumpers on the GVRC. The attenuation jumpers are located on jumper block J151 (2, 4, 8, 16, and 32 dB) and block J150 (1 dB).

The jumpers provide a range of attenuation to account for installation-dependent variations in the antenna LNA and signal losses in the RF cable connecting the LNA to the GVRC.

The configuration of the jumper(s) is dependent on the LNA that provides amplification to the satellite signals received at the antenna and the signal loss due to the RF cable connecting the LNA to the GVRC. The initial attenuation setting is calculated by taking the base value of –21 dB, adding the gain of the LNA, and then subtracting the loss of the RF cable. (The base value of –21 dB is the difference between the P(Y)-code signal level of –163 dB at the antenna (as specified in ICD-GPS-200), and the minimum required signal level of –142 dB at the RF input of the GVRC (as specified in CI-GVRC-300).)

Examples:

Pre-amplifier Gain minus Cable Loss	Recommended Attenuation Setting
21 dB	0 dB
35 dB	14 dB (8 + 4 + 2)
50 dB	29 dB (16 + 8 + 4 + 1)

2.1.5 Pre-Set Jumper and Switch Configuration

The pre-set configuration of the GVRC upon delivery from the manufacturer is presented in Table 2-4.

Table 2-4. Pre-Set Jumper and Switch Configuration

VME Address Bits	S100	All Switches OFF (All Bits Negated)
Controlling Interface	J150	Jumper Not Installed (VME Interface Controls)
Antenna Bias Voltage	J150	Jumper Not Installed (No Bias Voltage)
RF Attenuation	J151 and J150	Jumper Installed on J151 at the 8 dB position. Other positions have no jumpers installed
Factory Testing Options	J100	The Jumpers on block J100 are not for user-selectable options. No jumpers installed for operational service.

2.1.6 Instrumentation Port (IP) Baud Rate Selection

The GVRC can be commanded into either of two instrumentation port (IP) baud rates. The standard rate is 9600 baud which is compatible with the PLGR standard. The high data rate is 19,200 baud for receive and 76,800 baud for transmit. The IP baud rate is selectable by the user via the A11 pin on connector P2. If the A11 pin is connected to chassis ground, the IP operates in the high data rate mode. If the A11 pin is not connected (open circuit), the IP operates in the PLGR standard data rate.

2.2 Controls, Indicators and Connectors

In addition to the configuration switches and jumpers, the GVRC provides controls and indicators on its front panel that can be used during operation. Six connectors (four on the front panel, two on the plug-in edge) provide convenient interface with various system functions.

2.2.1 Front-Panel Control and Indicators

The RESET switch on the front panel causes a reset when operated, and the receiver is reset to the INITIALIZE mode. Host equipment will need to re-initialize the VME interface and re-establish IP/MP connectivity following activation of this reset. Refer to ICD-GPS-156 for further details.

There are four LED indicators on the front panel of the GVRC. Collectively, they indicate the current status of the GVRC, as shown in Table 2-5.

Table 2-5. LED Indications

LED	*Condition*	*Indicates*
PWR (red)	Constantly lit	Power is applied to GVRC
OPNL (yellow)	Constantly lit	GVRC is operational
	Blinking	Fatal error detected by boot program (e.g., corrupted/invalid main program)
FIX (green)	Constantly lit	Position fix in process
KEYS (orange)	Constantly lit	Keys are valid
	Rapidly blinking	Key loader is detected
	Slowly blinking	Keys accepted but not yet verified
Yellow, green, and orange	Blinking in unison	Built-in test (BIT) in process

2.2.2 Interface Connectors

The GVRC interface connectors are listed in Table 2-6.

Table 2-6. GVRC Interface Connectors

Interface	***Connector***	***Location***
VMEbus	VME P1	Back edge
ICD-GPS-150/156 (using RS-422)	VME P2	Back edge
PTTI timing signals (per ICD-GPS-060)	VME P2	Back edge
L1/L2 RF signals	J4 SMA (RF IN) and 50-ohm cable	Front panel
ICD-GPS-150/156 (using RS-232)	DB9 J9 IP (Instrument Port) J11 MP (Maintenance Port)	Front panel
KOI-18/KYK-13/AN-CYZ-10 keyfill	DB9 J10 (KEYFILL)	Front panel
Pulse-Per-Second Out	BNC J6 (PPS OUT)	Front panel
Pulse Per Minute Out	BNC J7 (PPM OUT)	Front panel
Pulse Per Second In	BNC J5 (PPS IN)	Front panel

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2.3 GVRC Interface Cabling

Standard off-the-shelf commercial cables can be used to interface the RS-232 digital data ports to an IBM-compatible PC.

3. MAINTENANCE AND SERVICE

The GVRC is designed to require very little operator maintenance or service. It has a built-in test (BIT) capability for self-diagnostic check of operations.

3.1 Troubleshooting

The GVRC is designed with a BIT feature that performs a power-up self test. The self test can detect 95% of all failures. If a significant failure has occurred, which is indicated by the orange LED on the front panel, status can by obtained via any one of the digital data ports.

None of the BIT failures can be repaired by the operator. Repair of the GVRC is completed above the organizational level. Refer to approved maintenance instructions for disposition of retrograde units.

3.1.1 Power

The GVRC indicates power is present by a lighted red LED on the front panel.

- If the GVRC fails to power-up, verify that proper external input power is supplied to the GVRC.
- If it is determined that proper power is supplied to the GVRC, the unit must be returned for repair.

3.1.2 Signal

If the GVRC will not track satellites, be sure that the antenna is free from obstruction and has an unrestricted view of the sky.

If tracking does not begin within a reasonable time, zeroizing the GVRC will clear all memory and return the unit to default settings.

CAUTION

EMERGENCY ZEROIZE is to be used with caution. All GVRC random access memory, including position, cryptovariables, almanac, time, and ephemeris data will be erased if this method of zeroize is used.

Memory data lost during EMERGENCY ZEROIZE may be manually restored through one of the digital data ports.

3.1.3 Built-In Test Protocols

The GVRC performs three types of built-in test (BIT). On initial application of power, the GVRC completes a self-test and reports a GO or NO GO status to the NAVSSI host. The GVRC will respond to a host command to complete a self-test at any time during normal operation. The

GVRC also performs a background BIT during normal operation as a method of performance monitoring. The GO and NO GO status discrete is a dedicated pin on the VME P2 connector. The commanded and background BIT results are provided via shared memory in the O-GVRC21 output message which is defined in ICD-GPS-156. As a means of maintenance support, or whenever implemented by the NAVSSI host, the GVRC provides extended status and health communications over the IP or MP via the serial communications ports on the front panel or VME P2 connector. The IP/MP status and health communications are defined in the TIPY protocol ICD (P/N 27028-01).

3.1.3.1 Initial Self-Test

The POWER ON SELF-TEST is initiated on first application of power to the GVRC or in response to a system reset command. The reset can be implemented in any of three ways. The reset toggle switch on the front panel may be placed momentarily to RESET. The Discrete Reset (DRESET) signal may be asserted on pin A12 of VME connector P2. The reset may also be commanded by software from the NAVSSI host. When the self-test is in progress, the GVRC stops all processing and indicates "not ready" or NO GO by outputting a logic 0 (less than 0.6 VDC) on pin A13 of VME connector P2. Upon successful completion of the self-test (less than 8 seconds), the GVRC enters the INITIALIZATION mode and asserts "ready" or GO on pin A13 of VME connector P2.

3.1.3.2 Commanded BIT

The results of the commanded BIT are reported in shared memory output message 0-GVRC21 Word 9, Initial/Commanded BIT Log. The Word 9 log provides status on 8 receiver functions as follows:

EEPROM/RAM/A-D Converter/DPRAM
Auxiliary Power Low or Absent
Security Module
Reference Clock
Low Power Time Source
A-D Converter BIT
Channel BIT
Task Status

Further definition of the faults identified in Word 9 is provided in Words 11 through 19 of message 0-GVRC21.

3.1.3.3 Background BIT

The results of the performance monitoring tests (background BIT) are reported to the NAVSSI host in message 0-GVRC21 Word 8. The faults which can be reported in Word 8 are as follows:

AGC Level Low
Security Module Fault
Auxiliary Power Low
ICD-225 CV Erase Fault
L2 Tracking Fault
Software Zeroize Failed
Hardware Zeroize Failed
Shorted Antenna Fault
Open Antenna Fault
High Antenna Current

Clock Reference Fault
Task/OS Fault

Further definition of the faults identified in Word 8 is provided in Words 11 through 19 of message 0-GVRC21.

3.2 Software Upgrades

Software upgrades will be made available, as necessary, to update the operational program, the MAGVAR table, and the Datum tables in the GVRC. These upgrades will be IBM PC compatible and can be downloaded via the RS-232 or RS-422 data ports.

MAGVAR and Datum Tables which are stored in read-only memory (ROM) are individually field upgradeable. PC-based software is used to re-program the ROM. Refer to approved maintenance instructions. The GVRC employs dual sets of MAGVAR and datum information. One set is part of the main program, and the second is the field loaded file. The GVRC will test for a field-loaded file and will then select for use either its internal or the down-loaded data depending on which has the later date code. Software version numbers and date code information for the active MAGVAR and Datum information is stored within the Card ID area of the GVRC shared memory. Refer to ICD-GPS-156 for details.

4. TESTING

4.1 RS-232 and RS-422 Interface

Application software is provided to run on an IBM-compatible personal computer to allow a PC operator to fully test the GVRC.

The program includes:

FLASH.EXE	Reads the current software image file and downloads into the GVRC. Also used for MAGVAR and Datum upgrades.
TPMON.EXE	Monitor program to exercise the GVRC via the TIPY digital data port.
DATAMON.EXE	Monitor program to exercise the GVRC via the ICD-GPS-153 digital data port. Note that if the PC operator has the GVRC transmitting data at 76.8K Baud, the PC must have a special serial I/O board.

4.2 VMEbus Interface

Testing of the VMEbus interface requires a special diagnostic analyzer installed in the VMEbus rack which is interfaced to an IBM-compatible personal computer.

Appendix A
GLOSSARY

Acronyms and Abbreviations

2D	Two Dimensional
2dRMS	RMS error
3D	Three Dimensional
ALM	Almanac
A-S	Anti-Spoofing
AVG	Average
AZ	Azimuth
BCD	Binary Coded Decimal
BIT	Built-In Test
C	Celsius
CA	Climb Angle
CEP	Circular Error Probable
CMD	Command
CR	Climb Rate
CRS	Course
CV	Cryptovariable
CVW	Crypto Variable Weekly
DA	Department of the Army
DAE	Departure Angle Error
dB/Hz	Decibels per Hertz
dBW	Decibels referenced to 1 Watt
deg	Degrees
desel	Deselect
dm	Degrees, Decimal Minutes
DMA	Defense Mapping Agency
dms	Degrees, Minutes, Seconds
DoD	Department of Defense
DOP	Dilution of Precision
DPORT	Data Port
DTM	Datum
E	East
EAE	Entry Angle Error
ECEF	Earth-Centered Earth-Fixed
ECM	Electronic Counter Measures
ECCM	Electronic Counter-Counter Measures
EFM	Ephemeris
EHE	Estimated Horizontal Error
EIA	Electronic Industries Association
EIR	Equipment Improvement Report
EL	Elevation
ELA	Elevation Angle
ELD	Elevation Distance
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EMP	Electromagnetic Pulse
EPE	Estimated Position Error
EPLRS	Enhanced Position Location Reporting System
ETA	Estimated Time of Arrival
EVE	Estimated Verticle Error
F	Fahrenheit
fix	Position Fix
FOM	Figure of Merit
FRZ	Freeze
ft	Foot
ft/sec	Foot Per Second
GDOP	Geometric Dilution of Precision
G	Grid
GPA	Glide Path Angle
GPE	Glide Path Error
GPS	Global Positioning System
GPU	General Purpose User
GS	Ground Speed
GUV	Group Unique Variable
GVAR	Grid Variation
GVRC	Global Positioning System (GPS) Versa Module Europa (VME) Receiver Card
HA	Helmet Antenna
HAE	Height Above Ellipsoid
HAHO	High Altitude, High Opening
HDG	Heading
HDOP	Horizontal Dilution of Precision
HMMWV	High Mobility Muti-purpose Wheeled Vehicle
HPA	Horizontal Position Accuracy
IAW	In Accordance With
ICD	Interface Control Document
IM	Installation Mount
INIT	Initialize
I/O	Input/Output

JTIDS	Joint Tactical Information Distribution System
km	Kilometer
km/h	Kilometers Per Hour
kts	Knots
L	Local Time
lat	Latitude
LCD	Liquid Crystal Display
lcl	Local
L/L	Latitude/Longitude
LLA	Latitude/Longitude/Altitude
lon	Longitude
LRU	Line Replaceable Unit
M	Magnetic North
m	Meter
MK	Mark
m/s	Meters per second
m/s/s	Meters per second per second
MAG	Magnetic
MAGVAR	Magnetic Variation
MCSP	Mission Complete Success Probability
MGRS	Military Grid Reference System
MI	Statute Miles
MIL	Angualr Measure for 1/6400th of a Circle
MMD	Minimum Miss Distance
MPH	Miles Per Hour
MSL	Mean Sea Level
mvar	Magnetic Variation
M/V	Manpack/Vehicle
N	North
N/A	Not Applicable
NAV	Navigation
NBC	Nuclear, Biological & Chemical
NM	Nautical Mile
NTISSI	National Telecommunications & Information
O&M	Operations & Maintenance
OPA	Overall Position Accuracy
OPS	Operations
P	Page
PDOP	Position Dilution of Precision
POS	Position
posfix	Position Fix
PP	Present Position
pps	Pulse Per Second
PPS	Precise Positioning Service
PPS-SM	Precise Positioning Service-Security Module
PRN	PseudoRandom Noise
PTTI	Precise Time & Time Interval
PVT	Position, Velocity & Time
RA	Remote Antenna
RAM	Random Access Memory
REAC	Reaction Time
RNG	Range
ROM	Read Only Memory
S	South
SA	Selective Availability
SA/A-S	Selective Availability/ Anti-Spoofing
SAIP	Spares Acquisition Integrated with Production
SEP	Spherical Error Probable
SM	Security Module
sq	Square
SR	Slant Range
SS	System Specification
SSI	Systems Security Instruction
STBY	Standby
STR	Steering Angle
STR-3D	Up/Down Steering Angle
STS	Status
SV(s)	Satellite Vehicles(s)
T	True
TFOM	Time Figure of Merit
TGT	Target
TM	Technical Manual
TNG	Training
TR	Technical Report
TRK	Track
TTFF	Time To First Fix
TTG	Time To Go
TTSF	Time To Subsequent Fix
UPS	Universal Polar Stereo-graphic
URA	User Range Accuracy
URE	User Range Error
USRA	User-Supplied Remote Antenna
UTC	Universal Time, Coordinated
UTM	Universal Transverse Mercator
VA	Vehicle Antenna
VDOP	Vertical Dilution of Precision
VEL	Velocity
VEP	Vertical Error Probable

W	West		
WGS	World Grid System	YD	Yards
WMM	World Magnetic Model		
WP	Waypoint	Z	Zulu Time
XTE	Crosstrack Error		

Glossary Of Terms

2dRMS	Twice the distance root mean squared. As used by the operators of the GPS when specifying SA levels, it is the error distance within which 95% of the position solutions will fall.
2D	Two-dimensional positions. A 2D position fix provides latitude and longitude. Elevation is assumed to be fixed. Only three satellites are required to provide a 2D position with a user-supplied elevation.
3D	3D position provides the elevation in addition to Lat/Lon and requires four satellites.
Almanac	A reduced-precision subset of the ephemeris parameters. Used by the GVRC to compute the elevation and azimuth angles of the satellites. Each satellite broadcasts the almanac for all the satellites.
C/A-code	Coarse/Acquisition code. This is the "civilian" code made available by the Department of Defense (DoD). It is subject to SA. The authorized user can correct the degradation effects of SA.
Channel	Refers to the GVRC hardware that is required to lock to a satellite, make the range measurements and collect data from the satellite.
Cryptovariable	The coded information transferred to the GVRC manually or via key loaders which allow the GVRC to begin SA correction and/or P(Y)-code demodulation.
Differential Navigation	A technique similar to relative positioning except that one or both of the points may be moving. The pilot of a ship or aircraft may need to know his position relative to a harbor or runway. A data link is used to relay the error terms to the moving vessel to allow real-time navigation.
ENU	A topocentric spherical coordinate system, "East-North-Up".
Elevation Difference	Vertical distance from current position to waypoint.
Elevation Angle	The angle between the line of sight vector and the horizontal plane.
Elevation Mask	Refers to the elevation angle below which a satellite is considered unusable. It is used to prevent the GVRC from searching for satellites which are obscured by buildings or mountains.
Ephemeris	A set of parameters that describe a satellite's orbit very accurately. It is used by the GVRC to compute the position of the satellite. This information is broadcast by the satellites.
GDOP	Geometric Dilution of Precision describes how much an uncertainty in range affects the uncertainty in position. It depends on where the satellites are relative to the user.
Ground Speed	Velocity over the ground.
Geoid	Actual physical shape of the earth which is difficult to describe mathematically because of the local surface irregularities and sea-land variations.
GPD	Global positioning with differential corrections applied.

GPS Time	The length of the second is fixed and is determined by primary atomic frequency standards. Leap-seconds are not used as they are in Universal Time Coordinated.
HDOP	Horizontal Dilution of Precision describes how an uncertainty in range affects the horizontal position (latitude and longitude).
IODE	Issue Of Data, Ephemeris. Part of the navigation data. It is the issue number of the ephemeris information. A new ephemeris is available usually on the hour.
L1	The primary L-band signal radiated by each NAVSTAR satellite at 1575.42 Mhz. The L1 beacon is modulated with the NAV message. L2 is centered at 1227.60 MHz.
L2	The secondary L-band signal radiated by each NAVSTAR satellite at 1227.6 MHz.
Key Loader	Cryptokey loading device KYK-13, KOI-18, or AN/CYZ-10.
Mapping Datum	Refers to a mathematical model of the earth. Many local datums model the earth for a small region: e.g., Tokyo datum, Alaska, NAD-27 (North American). Others, WGS-84, for example, model the whole earth.
NAV Data	The 1500 bit navigation message broadcast by each satellite at 50 bps on both L1 and L2 beacons. This message contains system time, clock correction parameters, ionospheric delay model parameters, and the vehicle's ephemeris and health. This information is used to process GPS signals to obtain user position and velocity.
P-code	The "Precise" code sent on both L1 and L2 GPS beacons. When encrypted, it is resistant to SA and spoofing.
Pseudo-random noise (PRN)	Each GPS satellite generates its own distinctive PRN code which serves as identification of the satellite, as a timing signal, and as a subcarrier for the navigation data.
Pseudorange	A measure of the range from the GVRC's antenna to the satellite. Pseudo-range is obtained by multiplying the speed of light by the apparent transit time of the signal from the satellite.
PDOP	Position Dilution of Precision is the determination of position uncertainty in range affecting both the horizontal position (latitude and longitude) and the vertical position (elevation).
Range	Horizontal distance from current position to waypoint.
Relative Positioning	The process of determining the vector distance between two points and the coordinates of one spot relative to another. This technique yields GPS positions with greater precision than the single-point positioning mode.
Rise/Set Time	The period during which a satellite is visible; i.e., has an elevation angle that is above the elevation mask. A satellite is said to "Rise" when its elevation angle exceeds the mask and "Set" when the elevation drops below the mask.
TDOP	Time Dilution of Precision, the uncertainty of clock bias, affects the horizontal position (latitude and longitude).
Time To Go	Estimated time to go until arrival at a waypoint.
VDOP	Vertical Dilution of Precision describes how an uncertainty in range affects the vertical position (elevation).
Velocity	Three-dimensional velocity.