



**GPSG-1000
GPS/Galileo
Positional Simulator**

Operation Manual



GPSG-1000

GPS/Galileo Positional Simulator

Operation Manual

PUBLISHED BY
VIAVI Solutions, Inc.

COPYRIGHT © VIAVI Solutions, Inc. 2022

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise without the prior permission of the publisher.

Original Issue	Jun 2011
Re-Issued	July 2022

ELECTROMAGNETIC COMPATIBILITY

Double shielded and properly terminated external interface cables must be used with this equipment when interfacing with the RS-232 and Ethernet.

For continued EMC compliance, all external cables must be shielded and 3 meters or less in length.

NOMENCLATURE STATEMENT

In this manual, GPSG-1000, Test Set or Unit refers to the GPSG-1000 GPS/Galileo Positional Simulator.

THIS PAGE INTENTIONALLY LEFT BLANK.

Declaration of Conformity

The Declaration of Conformity Certificate included with the Unit should remain with the Unit.

VIAVI Solutions recommends the operator reproduce a copy of the Declaration of Conformity Certificate to be stored with the Operation Manual for future reference.

THIS PAGE INTENTIONALLY LEFT BLANK.

Precautions

SAFETY FIRST - TO ALL OPERATIONS PERSONNEL

GENERAL CONDITIONS OF USE

This product is designed and tested to comply with the requirements of IEC/EN61010-1 'Safety requirements for electrical equipment for measurement, control and laboratory use' for Class I portable equipment and is for use in a pollution degree 2 environment. The equipment is designed to operate from installation supply Category II.

Equipment should be protected from liquids such as spills, leaks, etc. and precipitation such as rain, snow, etc. When moving the equipment from a cold to hot environment, allow the temperature of the equipment to stabilize before the equipment is connected to the supply to avoid condensation forming.

The equipment must only be operated within the environmental conditions specified in the performance data.

CASE, COVER OR PANEL REMOVAL

Opening the Case Assembly exposes the operator to electrical hazards that may result in electrical shock or equipment damage. Do not operate this Test Set with the Case Assembly open.

SAFETY IDENTIFICATION IN TECHNICAL MANUAL

This manual uses the following terms to draw attention to possible safety hazards that may exist when operating or servicing this equipment:

	IDENTIFIES CONDITIONS OR ACTIVITIES THAT, IF IGNORED, CAN RESULT IN EQUIPMENT OR PROPERTY DAMAGE, E.G., FIRE.
	IDENTIFIES CONDITIONS OR ACTIVITIES THAT, IF IGNORED, CAN RESULT IN PERSONAL INJURY OR DEATH.

SAFETY SYMBOLS IN MANUALS AND ON UNITS

	CAUTION: Refer to accompanying documents. (This symbol refers to specific CAUTIONS represented on the unit and clarified in the text.)
	Indicates a Toxic hazard.
	Indicates item is static sensitive.
	AC TERMINAL: Terminal that may supply or be supplied with AC or alternating voltage.

SAFETY FIRST - TO ALL OPERATIONS PERSONNEL (cont)

EQUIPMENT GROUNDING PROTECTION

Improper grounding of equipment can result in electrical shock.

USE OF PROBES

Refer to Performance Specifications for the maximum voltage, current and power ratings of any connector on the Test Set before connecting a probe from a terminal device. Be sure the terminal device performs within these specifications before using the probe for measurement, to prevent electrical shock or damage to the equipment.

POWER CORDS

Power cords must not be frayed or broken, nor expose bare wiring when operating this equipment.

USE RECOMMENDED FUSES ONLY

Use only fuses specifically recommended for the equipment at the specified current and voltage ratings. Refer to Performance Specifications for fuse requirements and specifications.

INTERNAL BATTERY

This unit contains a Lithium Ion Battery, serviceable only by a qualified technician.

EMI (ELECTROMAGNETIC INTERFERENCE)

CAUTION	SIGNAL GENERATORS CAN BE A SOURCE OF ELECTROMAGNETIC INTERFERENCE (EMI) TO COMMUNICATION RECEIVERS. SOME TRANSMITTED SIGNALS CAN CAUSE DISRUPTION AND INTERFERENCE TO COMMUNICATION SERVICE OUT TO A DISTANCE OF SEVERAL MILES. USER OF THIS EQUIPMENT SHOULD SCRUTINIZE ANY OPERATION THAT RESULTS IN RADIATION OF A SIGNAL (DIRECTLY OR INDIRECTLY) AND SHOULD TAKE NECESSARY PRECAUTIONS TO AVOID POTENTIAL COMMUNICATION INTERFERENCE PROBLEMS.
----------------	--

SAFETY FIRST - TO ALL OPERATIONS PERSONNEL (cont)

TOXIC HAZARDS

WARNING	SOME OF THE COMPONENTS USED IN THIS EQUIPMENT MAY INCLUDE RESINS AND OTHER MATERIALS WHICH GIVE OFF TOXIC FUMES IF INCINERATED. TAKE APPROPRIATE PRECAUTIONS IN THE DISPOSAL OF THESE ITEMS.
----------------	--

	BERYLLIA
WARNING	<p>BERYLLIA (BERYLLIUM OXIDE) IS USED IN THE CONSTRUCTION OF SOME OF THE COMPONENTS IN THIS EQUIPMENT.</p> <p>THIS MATERIAL, WHEN IN THE FORM OF FINE DUST OR VAPOR AND INHALED INTO THE LUNGS, CAN CAUSE A RESPIRATORY DISEASE. IN ITS SOLID FORM, AS USED HERE, IT CAN BE HANDLED SAFELY, HOWEVER, AVOID HANDLING CONDITIONS WHICH PROMOTE DUST FORMATION BY SURFACE ABRASION.</p> <p>USE CARE WHEN REMOVING AND DISPOSING OF THESE COMPONENTS. DO NOT PUT THEM IN THE GENERAL INDUSTRIAL OR DOMESTIC WASTE OR DISPATCH THEM BY POST. THEY SHOULD BE SEPARATELY AND SECURELY PACKED AND CLEARLY IDENTIFIED TO SHOW THE NATURE OF THE HAZARD AND THEN DISPOSED OF IN A SAFE MANNER BY AN AUTHORIZED TOXIC WASTE CONTRACTOR.</p>

	BERYLLIUM COPPER
WARNING	<p>SOME MECHANICAL COMPONENTS WITHIN THIS INSTRUMENT ARE MANUFACTURED FROM BERYLLIUM COPPER. THIS IS AN ALLOY WITH A BERYLLIUM CONTENT OF APPROXIMATELY 5%. IT REPRESENTS NO RISK IN NORMAL USE.</p> <p>THE MATERIAL SHOULD NOT BE MACHINED, WELDED OR SUBJECTED TO ANY PROCESS WHERE HEAT IS INVOLVED.</p> <p>IT MUST BE DISPOSED OF AS "SPECIAL WASTE."</p> <p>IT MUST NOT BE DISPOSED OF BY INCINERATION.</p>

	LITHIUM
WARNING	<p>A LITHIUM BATTERY IS USED IN THIS EQUIPMENT.</p> <p>LITHIUM IS A TOXIC SUBSTANCE SO THE BATTERY SHOULD IN NO CIRCUMSTANCES BE CRUSHED, INCINERATED OR DISPOSED OF IN NORMAL WASTE.</p> <p>DO NOT SHORT CIRCUIT OR FORCE DISCHARGE SINCE THIS MIGHT CAUSE THE BATTERY TO VENT, OVERHEAT OR EXPLODE.</p>

SAFETY FIRST - TO ALL OPERATIONS PERSONNEL (cont)

FIRE HAZARD

WARNING

MAKE SURE THAT ONLY FUSES OF THE CORRECT RATING AND TYPE ARE USED FOR REPLACEMENT. IF AN INTEGRALLY FUSED PLUG IS USED ON THE SUPPLY LEAD, ENSURE THAT THE FUSE RATING IS COMMENSURATE WITH THE CURRENT REQUIREMENTS OF THIS EQUIPMENT.

INPUT OVERLOAD

CAUTION

TX PORT MAXIMUM REVERSE POWER
100 mW

CAUTION

RX LEVEL MUST NOT EXCEED -20 dBm

STATIC SENSITIVE COMPONENTS



This equipment contains components sensitive to damage by Electrostatic Discharge (ESD). All personnel performing maintenance or calibration procedures should have knowledge of accepted ESD practices and/or be ESD certified.

Preface

SCOPE

This Manual contains instructions for operating the GPSG-1000. It is strongly recommended that the Operator become thoroughly familiar with this manual before attempting to operate the equipment.

ORGANIZATION

This manual is composed of the following chapters:

CHAPTER 1 - INTRODUCTION

Provides an introduction and a brief overview of Test Set functions and features.

CHAPTER 2 - TEST SET OPERATION

Identifies Test Set Controls, Connectors and Indicators.

Provides Power On and Power Off procedures.

Provides functional description of Graphic User Interface (GUI) components.

Provides instructions for defining Test Set parameters.

CHAPTER 3 - TEST SET FUNCTIONS

Provides functional description of Test Set functions.

CHAPTER 4 - TESTING

Provides GPS and Galileo Receiver test guidelines.

CHAPTER 5 - MAINTENANCE

Identifies Maintenance and Software Update procedures.

CHAPTER 6 - PRINCIPLES OF OPERATION

Provides information regarding Test Set principles of operation.

CHAPTER 7 - SPECIFICATIONS

Identifies Test Set specifications.

APPENDIX A - PIN-OUT TABLES

Identifies connector pin locations.

APPENDIX B - ABBREVIATIONS

Lists terms and abbreviations used in this manual.

THIS PAGE INTENTIONALLY LEFT BLANK.

Service Upon Receipt of Material

UNPACKING TEST SET

Special design packing material inside this shipping container provide maximum protection for the Test Set. Avoid damaging the shipping container and packaging material when unpacking equipment; if necessary the shipping container and packaging material can be reused to ship the Test Set.

Use the following steps to unpack the Test Set:

STEP	PROCEDURE
1.	Cut and remove sealing tape on top of the shipping container. Open shipping container and remove top packing mold.
2.	Grasp the Test Set firmly while restraining the shipping container. Lift the equipment and packing material vertically out of the shipping container.
3.	Place Test Set and end cap packing on a flat, clean and dry surface.
4.	Remove protective plastic bag from the Test Set.
5.	Place protective plastic bag and end cap packing materials inside shipping container.
6.	Store shipping container for possible future use.

CHECKING UNPACKED EQUIPMENT

Inspect equipment for possible damage incurred during shipment. If Test Set has been damaged, report the damage to VIAVI Solutions Customer Service.

Review packing slip to verify shipment is complete. Packing slip identifies the standard items as well as purchased options. Report all discrepancies to VIAVI Solutions.

Contact:

VIAVI Solutions	
	Customer Service Department
	10200 West York Street
	Wichita, Kansas 67215
Telephone:	800-835-2350
FAX:	316-524-2623
email:	AvComm.Service@viavisolutions.com

Standard Items

ITEM		PART NUMBER	QTY
GPS/Galileo Positional Simulator		87339	1
Power Supply		67374	1
Power Cord (U.S.)		62302	1
Power Cord (European)		64020	1
Operation Manual (CD)		88037	1
Getting Started Manual (paper)		88038	1

ITEM		PART NUMBER	QTY
Transit Case		88493	1
Coax Cable (50ft)		90114	1
GPSG Antenna Coupler		87636	1
Shot Bag		88753	1
RX Antenna		90113	1

Optional Items

ITEM		PART NUMBER	QTY
Battery Pack		86196	1
External Battery Charger		87040	1
Antenna Coupler Placement Pole Kit (Pole and D Ring)		90106	1
Kit, CPLR Dual GPS Antenna System		91136	1
Kit, CPLR Triple GPS Antenna System		91137	1
Maintenance Manual		89023	1
GPS Receiver Termination Kit, 190 Ohms		113108	1
GC-130 GPS Antenna Coupler Kit		141193	1

Table of Contents

Chapter 1 - Description 1 - 1

Introduction	1 - 1
Scope	1 - 1
Nomenclature Cross-Reference List	1 - 1
Equipment Capabilities and Features	1 - 2
Capabilities	1 - 2
Features	1 - 2
Utilities	1 - 2

Chapter 2 - Test Set Operation 2 - 1

Introduction	2 - 1
Power Requirements	2 - 1
Power	2 - 1
AC Power Requirements	2 - 1
Battery Recharging Using GPSG-1000	2 - 2
Battery Recharging Using Battery Cradle	2 - 2
Installation	2 - 3
Ventilation Requirements	2 - 3
Bench Top Installation	2 - 3
Controls and Connectors	2 - 4
Front Panel Controls	2 - 4
Rear Panel Controls and Connectors	2 - 6
Operating Procedures	2 - 7
Power ON Test Set	2 - 7
Power OFF Test Set	2 - 7
User Interface Components	2 - 8
Launch Bar	2 - 8
Launch Bar Navigation	2 - 9
Function Keys	2 - 9
Function Windows	2 - 9
Function Window Icons	2 - 10
Defining Parameters	2 - 11
Entering Numeric Values	2 - 11
Numeric Keypad and Slider Bar	2 - 11
Data Slew Bar	2 - 12
Drop-down Menus	2 - 12
Selectable Units	2 - 12
Locked Fields	2 - 13

Chapter 3 - Test Set Functions 3 - 1

Introduction	3 - 1
Test Set Functions	3 - 1
Simulation Function Window	3 - 1
Setup Simulation Window	3 - 5
Setup Motion Window	3 - 12
Setup Channels Window	3 - 13
Setup I/O Window	3 - 14
SV PRN Selection Function Window	3 - 15
SV PRN Edit Window	3 - 16
Route Function Window	3 - 18
Route Edit Stored Window	3 - 20
Route Edit Edit Window	3 - 21
Waypoint Function Window	3 - 23
Waypoint Edit Stored Window	3 - 25
Waypoint Edit Edit Window	3 - 26
GPS RX Function Window	3 - 27
Maintenance Function Window	3 - 29
Calibration Function Window	3 - 30
Diagnostics Function Window	3 - 31
File Almanacs Function Window	3 - 32
File Routes Function Window	3 - 34
File Settings Function Window	3 - 35
File Trajectory Function Window	3 - 36
Kml Function Window	3 - 37
Waypoint Window	3 - 39
System Function Window	3 - 40

Chapter 4 - Testing GPS/ Galileo Receivers 4 - 1

Introduction	4 - 1
Antenna Coupler Installation	4 - 1
Setup Basic Static Simulation	4 - 2
Setup Basic Dynamic Simulation	4 - 4
Setup Basic Trajectory Simulation	4 - 6
GPS Receiver Communication	4 - 8
Sensitivity	4 - 9
Measuring Time to First Fix (TTFF) and Position Accuracy	4 - 12
RAIM Testing and SV Geometry	4 - 18

Chapter 5 - Maintenance 5 - 1

Introduction	5 - 1
Visual Inspections	5 - 1
External Cleaning	5 - 1
Maintenance Procedures	5 - 1
Battery Replacement	5 - 1
GPSG-1000 Software Update Procedure	5 - 2
GPSG-1000 Debug Files	5 - 4
Identifying Installed Software Version	5 - 5
GPSG-1000 Almanac Update	5 - 6
Maintenance Function Windows	5 - 7
System Function Windows	5 - 10

Chapter 6 - Principles of Operation 6 - 1

Principles of Operation	6 - 1
GPSG-1000	6 - 1
GPS System	6 - 2
SPS Standard Positioning Service	6 - 6
Position Calculation	6 - 6
GPS Timekeeping	6 - 18
GNSS Accuracy	6 - 19
GNSS Augmentation	6 - 20
GPS Modernization Signals	6 - 24
The Galileo System	6 - 28

Chapter 7 - Product Specifications 7 - 1

Generator	7 - 1
Master Oscillator	7 - 3
Coupler	7 - 3
Battery	7 - 4
DC INPUT	7 - 4
Physical Characteristics	7 - 4
Environmental	7 - 4
Accessories	7 - 5

Appendix A - Pin-Out TablesA - 1

Ethernet Connector A - 1
USB Host 1 Connector A - 1
USB Host 2 Connector A - 2
USB OTG Connector A - 2
DC power Connector A - 2
AUX Connector A - 3

Appendix B - TerminologyB - 1

Appendix C - Exporting, Editing and Importing Waypoints C - 1

Appendix D - Exported and Imported File FormatsD - 1

Appendix E - Recording and Playing Trajectory Routes .E - 1

Appendix F - GPST-1000 USB Memory Device Format CompatibilityF - 1

Appendix G - Connecting Dual Antenna Coupler Kit . . . G - 1

Appendix H - Connecting Triple Antenna Coupler Kit . . .H - 1

Appendix I - Direct Connecting to GPS Receivers I - 1

List of Figures

GPSG-1000 GPS/Galileo Positional Simulator	1 - 1
GPSG-1000 Screen Cover/Stand	2 - 3
Front Panel Controls	2 - 4
Test Set Rear Panel Controls and Connectors	2 - 6
Launch Bar - Open/Close Tab	2 - 8
Launch Bar and Simulation Function Window	2 - 8
Function Keys	2 - 9
Function Window	2 - 9
Numeric Keypad	2 - 11
Data Slew Bar	2 - 12
Drop-down Menu	2 - 12
Selectable Units	2 - 12
Locked Field	2 - 13
Simulation Function Window (GPS Static)	3 - 1
Simulation Function Window (Galileo Static)	3 - 2
Simulation Function Window (SBAS Static)	3 - 2
Setup Simulation Window	3 - 5
Setup Motion Window	3 - 12
Setup Channels Window	3 - 13
Setup I/O Window	3 - 14
SV PRN Selection Function Window	3 - 15
SV PRN Edit Window	3 - 16
Route Function Window	3 - 18
Route Edit Stored Window	3 - 20
Route Edit Edit Window	3 - 21
Waypoint Function Window	3 - 23
Waypoint Edit Window	3 - 25
Waypoint Edit Edit Window	3 - 26
GPS Receiver Window	3 - 27
Maintenance Menu	3 - 29
Calibration Password Window	3 - 30
Diagnostics Function Window	3 - 31
File Almanacs Function Window	3 - 32
File Routes Function Window	3 - 34
File Settings Function Window	3 - 35
File Trajectory Function Window	3 - 36

Kml Window	3 - 37
Waypoint Window	3 - 39
System Menu	3 - 40
GPSG-1000 RF Connection	4 - 1
SV PRN Single SV Selection	4 - 9
Simulation Function Window	4 - 10
TTFF vs. Signal Strength	4 - 12
Global SV Tracks	4 - 18
Battery Replacement	5 - 2
USB Ports	5 - 3
Maintenance Menu	5 - 7
Calibration Password Window	5 - 8
Diagnostics Function Window	5 - 9
System Menu	5 - 10
Options Function Window	5 - 11
System Configuration - Status	5 - 12
System Configuration - Hardware	5 - 14
System Configuration – UI Options	5 - 15
System Configuration – Network	5 - 16
System Configuration – Date/Time	5 - 17
GPS System Segments	6 - 2
GPS Satellite	6 - 3
GPS Satellite Orbital Planes	6 - 3
GPS SV Block Schematic	6 - 4
GPS SV Signal Data Structure	6 - 4
GPS Monitor Stations	6 - 5
GPS Navigation Data	6 - 6
GPS Almanac	6 - 7
Satellite Relative Position	6 - 8
GPS Received Signal	6 - 8
GPS Received Signal	6 - 9
GPS Code Correlation Process	6 - 10
GPS Nav Data Recover by Modulo 2 Addition	6 - 10
GPS Signal After De-spreading	6 - 11
GPS Subframe Hand-Over Word	6 - 12
GPS Pseudo Range	6 - 13
GPS Pseudo Range	6 - 14
Triangulation using one known point	6 - 15
Triangulation using two known point	6 - 15
Triangulation using three known point	6 - 15
Triangulation using two known points in 3D space	6 - 15
Triangulation using three known points in 3D space	6 - 16

Multi-path Delays	6 - 16
Atmospheric Delays	6 - 17
GPS v. UTC Time Format	6 - 19
SBAS Coverage	6 - 21
GPS Modernization Signals	6 - 24
Galileo Satellite (GIOVE Test SV)	6 - 28
Ethernet Pin-Out Diagram	A - 1
USB Host 1 Pin-Out Diagram	A - 1
USB Host 2 Pin-Out Diagram	A - 2
USB OTG Pin-Out Diagram	A - 2
DC Power Connector Pin-Out Diagram	A - 2
AUX Connector Pin-Out Diagram	A - 3
Waypoint Screen	C - 1
Waypoint Edit Screen	C - 2
Waypoint Edit, Waypoint Data Screen	C - 2
New Waypoint List	C - 3
File Waypoints Screen	C - 3
Waypoint Export Successful	C - 4
File Waypoints Screen	C - 5
USB Import Warning Pop-up	C - 6
Waypoint Import Successful	C - 6
File Locations	D - 1
Route Page	D - 5
Main Menu	E - 1
Main Menus, Lower Section	E - 2
GPS RX Page	E - 2
GPS RX Page with 3d Fix	E - 3
GPS RX Page, Recording Trajectory	E - 3
File Page, Trajectory File Saved	E - 4
File Page, Trajectory Loaded	E - 4
Setup Page, Trajectory Setup	E - 5
Simulation Page, Trajectory File Running	E - 5
Trajectory Simulation Complete	E - 6
File Locations	F - 1

THIS PAGE INTENTIONALLY LEFT BLANK.

List of Tables

Basic NMEA-183 Sentences	4 - 8
Typical Receiver C/N0 as a Function of RF Level	4 - 11
TTFV Values for Four Simulations at Different UTC	4 - 16
Horizontal Accuracy for Various UTC Simulations	4 - 17
PS Positional Error Sources	6 - 18
RAIM Alarms	6 - 23
Galileo Signals	6 - 30
SNC, SNR and C/N0	6 - 32
C/N0 as a Function of Noise Figure	6 - 33
Correlation of RF Power Level and Receiver C/N0	6 - 34

THIS PAGE INTENTIONALLY LEFT BLANK.

Chapter 1 - Description

1.1 INTRODUCTION



Fig. 1-1 GPSG-1000 GPS/Galileo Positional Simulator

1.1.1 Scope

Type of Manual: Operation Manual

Equipment Name/ Model Number: GPSG-1000 GPS/Galileo Positional Simulator

Equipment use: Satellite constellation simulator for testing GPS and Galileo receivers.

1.1.2 Nomenclature Cross-Reference List

Common Name Official Nomenclature

GPSG-1000, Test Set or Unit GPSG-1000 GPS/Galileo Positional Simulator

1.2 EQUIPMENT CAPABILITIES AND FEATURES

The GPSG-1000 is a single carrier simulator, designed to be used for portable or bench testing in the GPS/Galileo Receiver testing environment. The GPSG-1000 has a twelve channel configuration with upgradeable software. The simulator provides GPS legacy and modernization signals as well as Galileo signals. Simultaneous GPS and Galileo operation is provided. The GPSG-1000 simulates static or dynamic 3D positions. The GPSG-1000 and supplied accessories are stored in a hard plastic transit case.

1.2.1 Capabilities

The GPSG-1000 provides users with the following standard capabilities:

- Selectable single carrier
- Twelve channel configuration
- GPS Signals Simulated - L1, L1C, L2C, L5
- Galileo Signals Simulated – E1, E5 (E5a, E5b)
- Simultaneous GPS/Galileo simulation
- SBAS Satellites Simulated – WAAS/EGNOS L1, L5
- RF Port DC isolation for direct connect to any receiver
- Antenna coupler
- Large 12" touch screen with simple user interface
- Remote control interface LAN
- Auto Almanac Load via built in GPS Receiver

1.2.2 Features

- System Screen
- SV Selection Table displays SV Geometry for RAIM testing
- Programmable SV Parametrics and Health
- Static or Multi-leg Dynamic Positional Simulation via Waypoint Entry System
- Receiver NMEA Bus Interface
- Receiver ARINC 429 Interface

1.2.3 Utilities

- Software Upgrade
- Waypoint Data Base
- Operational Status

Chapter 2 - Test Set Operation

2.1 INTRODUCTION

This chapter refers to local operation of a GPSG-1000 configured with factory default settings unless specified otherwise. New Test Sets are configured to start in the factory default setting. Review Installation and Power Requirements before using the Test Set.

2.2 POWER REQUIREMENTS

2.2.1 Power

The GPSG-1000 is powered by an internal Lithium Ion Battery. The battery charging circuit enables the operator to recharge the battery anytime the unit is connected to the DC power supply. The GPSG-1000 can operate continuously utilizing the DC power supply. The internal battery is equipped to power the GPSG-1000 for four hours of continuous use.

2.2.2 AC Power Requirements

The DC Power Supply supplied with the GPSG-1000 operates over a voltage range of 100 to 250 VAC at 47 to 63 Hz. The battery charger operates whenever DC Power (11 to 32 Vdc) is applied to the Test Set with the supplied DC Power Supply or a suitable DC power source.

NOTE: If the supply voltage is <11V, the unit will switch to internal battery. If the voltage is >32V, a 7 AMP resettable fuse on the DC input port will open, protecting the Test Set.

When charging, the battery reaches a 100% charge in approximately four hours. The Battery Charge temperature range is >-10° to <60°C, controlled by an internal battery charger.

2.2.3 Battery Recharging Using GPSG-1000

STEP	PROCEDURE
1.	Connect AC Line Cable to AC PWR Connector on the AC Adapter and an appropriate AC power source.
2.	Connect the AC Adapter DC output to the DC POWER Connector on the GPSG-1000.
3.	Verify the BATTERY indicator displays blinking green.
4.	Allow four hours for battery charge or until the BATTERY Indicator displays a steady green.

BATTERY LED INDICATORS

Battery Voltage Low (red)

The unit turns off within one minute w/o charger.

Battery Pre-Charging (flashing yellow)

Trickle charge during extremely low voltage on the battery.

Battery Charging (flashing green)

Charge in progress.

Battery Fully Charged (green)

Battery Temperature Extreme (blue)

Temperature <0°C or >45°C can't charge battery.

Battery Error (red)

The unit has a problem with the battery or charging system.

Battery Missing (off)

AC applied w/o battery in place.

Battery Suspended Charge (flashing red)

AC applied with battery charging suspended.

2.2.4 Battery Recharging Using Battery Cradle

STEP	PROCEDURE
1.	Connect AC Line Cable to AC PWR Connector on the AC Adapter and an appropriate AC power source.
2.	Connect the AC Adapter DC output to the DC POWER Connector on the Battery Cradle.
3.	Allow four hours for battery to charge.

2.3 INSTALLATION

2.3.1 Ventilation Requirements

The GPSG-1000 is convection cooled via the enclosure case. Avoid standing the instrument on or close to other equipment that is hot.

2.3.2 Bench Top Installation

The Test Set can be positioned in flat or tilted position by utilizing the built in screen cover/stand when used in a bench top environment (Fig. 2-1).

CAUTION

TO AVOID DAMAGE TO TOUCH SCREEN, DO NOT STACK OTHER EQUIPMENT ON TOP OF THE TEST SET.



Fig. 2-1 GPSG-1000 Screen Cover/Stand

2.4 CONTROLS AND CONNECTORS

2.4.1 Front Panel Controls

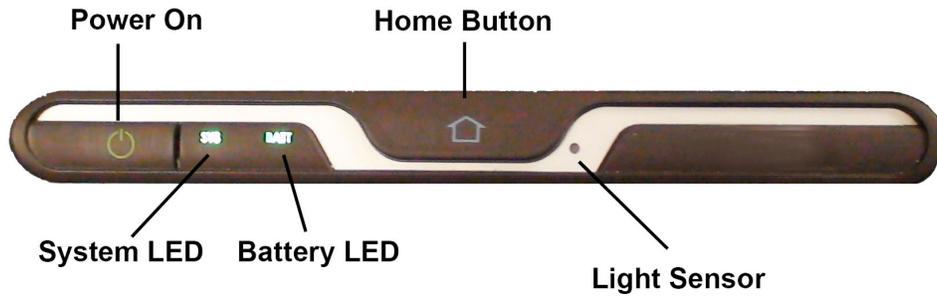


Fig. 2-2 Front Panel Controls

Control	Description
Power ON/OFF	The Power On/Off Button is used to power the Test Set on and off.
System LED	Powered On (green) Indicates the unit is in an operational status.
	Failure (red) Some form of failure has occurred which precludes using the display to indicate the problem (e.g. main processor failure, power supply fault, etc.).
	Boot (blinking blue) Unit is booting and is not yet able to indicate status on the display (during initial OS and application load).
	Off/Standby (orange) Unit is off, but power is supplied to the power supply from the AC power supply.
	Off w/o External Supply (off) Unit is off, no external power supplied.
Home Button	Pressing and holding the Home Button for 5 sec sets the backlight to maximum brightness.
Light Sensor	Monitors the ambient light and adjusts the display brightness. The light sensor is not operational at this time. Currently the display brightness must be set manually.
Magnetic Sensor	Detects if the display cover is open or closed and used to turn off the display as part of power management.

Test Set Functions

Control	Description
Battery LED	<p>Battery Voltage Low (red) The unit turns off within one minute without charger</p> <p>Battery Pre-Charge (flashing yellow) Trickle charge during extremely low voltage on the battery.</p> <p>Battery Charging (flashing green) Charge in progress</p> <p>Battery Fully Charged (green)</p> <p>Battery Temperature Extreme (blue) Temperature <0° C or >45° C can't charge battery</p> <p>Battery Error (red) Problem with the battery or charging system.</p> <p>Battery Missing (Off) AC applied without battery in place.</p> <p>Battery Suspended Charge (flashing Red) AC applied w/ battery charging suspended</p>

2.4.2 Rear Panel Controls and Connectors

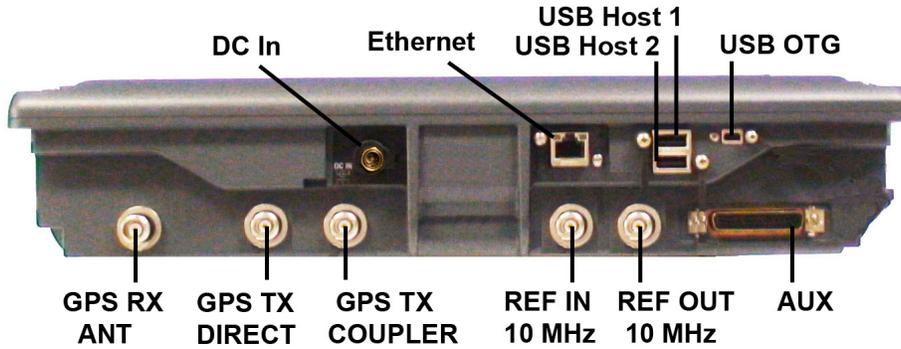


Fig. 2-3 Test Set Rear Panel Controls and Connectors

Connector	Description
USB Host 1	USB standard connection that allows connection of USB devices (e.g. a USB memory stick or Network connectors). Recommended USB memory device is VIAVI PN 67325.
USB Host 2	USB standard connection that allows connection of USB devices (e.g. a USB memory stick or Network connectors). Recommended USB memory device is VIAVI PN 67325.
USB OTG	USB On The Go, for future expansion.
GPS Rx Ant	External Antenna connection for Test Set internal GPS receiver.
GPS Tx Direct	RF output for direct connection to receiver under test. AC coupled, Maximum DC 50 V.
GPS Tx Coupler	RF output for connection to Antenna Coupler.
REF In 10MHz	The 10MHz In (5V p-p Max) Connector, is a BNC connection, used to connect the Test Set to an external frequency standard, providing a TTL signal.
REF Out 10MHz	The 10MHz Out (1.5V p-p Nom) Connector, is a BNC connection, providing an output of the internal 10MHz reference Oscillator.
Ethernet	Standard Base T RJ45 connection. This connection can be used for software upgrades and remote operation.
Aux	26 pin D type, providing a 3.3 VDC LVTTTL trigger input and 3.3 VDC LVTTTL trigger output, and a 1PPS TTL L1 C/A code frame sync output. RS-232 transmitter connection provides an NMEA sentence output, the content of which corresponds to the output of the TX Direct and Coupler output ports. The NMEA sentences outputted on the RS-232 port include GGA, RMC and GSV. ARINC 429 I/O provides expansion capability for the future.

2.5 OPERATING PROCEDURES

2.5.1 Power ON Test Set

After completing Initial Installation, perform the following steps to Turn On the Test Set:

STEP	PROCEDURE
1.	Press On/Off Button on Front Panel to power on Test Set.
2.	The Power Up window is displayed when the unit is first powered on or after Factory Defaults have been restored.

2.5.2 Power OFF Test Set

Perform the following steps to power off the Test Set:

STEP	PROCEDURE
1.	Press On/Off Button on Front Panel to power down the Test Set, then press OK to confirm.

2.6 USER INTERFACE COMPONENTS

The Test Set User Interface (UI) is a touch screen control panel that provides a flexible working environment for all users. The UI uses maximized Function Windows i.e. one function window occupies the entire screen area. The Test Set User Interface (UI) is navigated locally using the Front Panel Touch Screen

2.6.1 Launch Bar

The Launch Bar is a vertical scrolling menu located at the left side of the User Interface. The Launch Bar provides access to the Function Icons as shown in Fig. 2-4. The menu must be opened to access the Function Icons. The Launch Bar is opened and closed by touching or clicking on the light gray bar at the left side the menu.



Fig. 2-4 Launch Bar - Open/Close Tab

When the Launch Bar is opened, it appears in front of any Simulation Function Windows currently occupying that area of the display. The Launch Bar can be closed to view the complete Simulation Function Window.

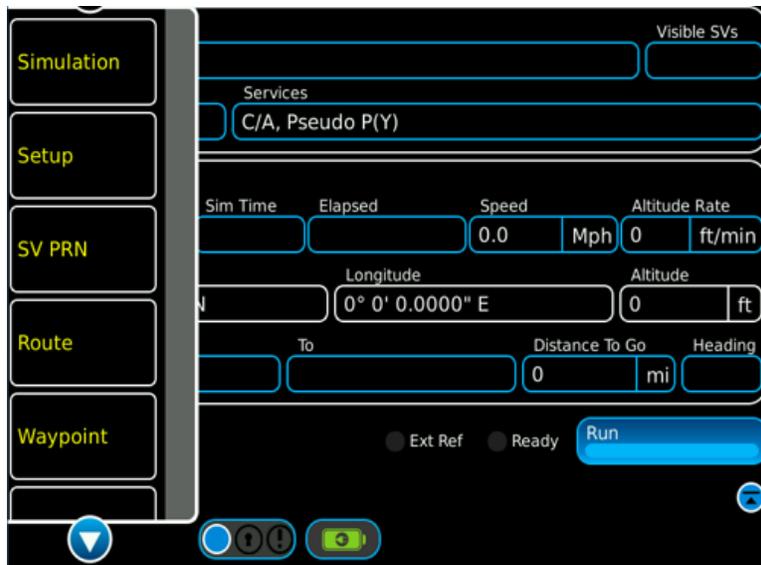


Fig. 2-5 Launch Bar and Simulation Function Window

2.6.2 Launch Bar Navigation

The arrows on the top and bottom of the Launch Bar are used to scroll the Function Icons Up and down.

2.6.3 Function Keys

The Launch Bar consists of keys that identify functions installed on the Test Set.



Fig. 2-6 Function Keys

2.6.4 Function Windows

Function Windows provide visual access to the Test Set's control parameters and displayed data.

Function	How to
Opening/Closing Function Windows	Function Windows are opened by selecting the Function Icon from the Launch Bar. Function Windows are closed by selecting the blue circle icon at the bottom of the window or by selecting the Function Icon on the Launch Bar.

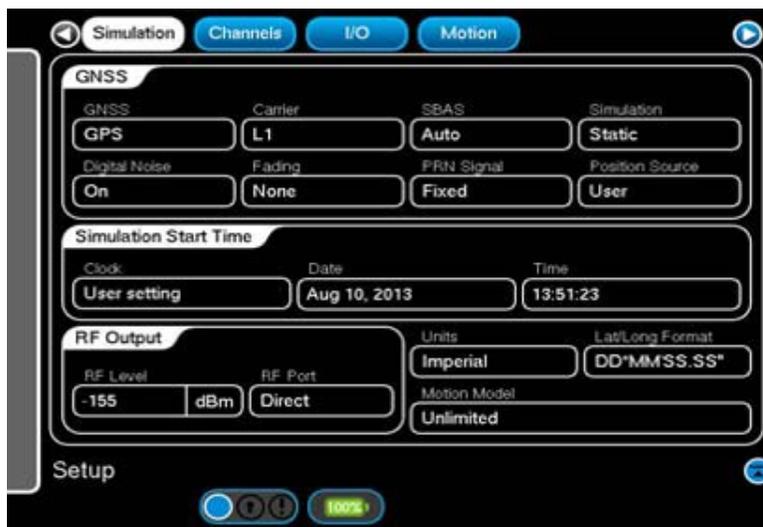
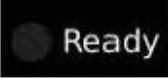
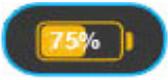


Fig. 2-7 Function Window

2.6.5 Function Window Icons

Function Windows use the following icons to indicate various functions or states:

ICON	DESCRIPTION
	<p>Closes the Function Window while leaving the function in the Active State.</p>
	<p>Maximizes Function Window and opens Status Bars.</p>
	<p>Minimizes Function Window and closes Status Bars.</p>
	<p>Selects the next tab left or right. Displays a gray background when no additional tabs are available to the left or to the right.</p>
	<p>Displays Running and a green circle when the simulation is running.</p>
	<p>Displays Ready and a gray circle when the simulation is stopped.</p>
	<p>Displays remaining battery capacity in %.</p>

2.7 DEFINING PARAMETERS

2.7.1 Entering Numeric Values

Numeric values are used to define a variety of test parameters such as frequency and level. When a numeric data field is selected for editing, a group of data entry pop-up windows is launched which provides the following methods for defining the value:

2.7.2 Numeric Keypad and Slider Bar

The Numeric Keypad allows the user to enter a specific numeric value. A value is entered by pressing the numbers on the keypad. The value is enabled pressing the unit of measurement on the Numeric Keypad.

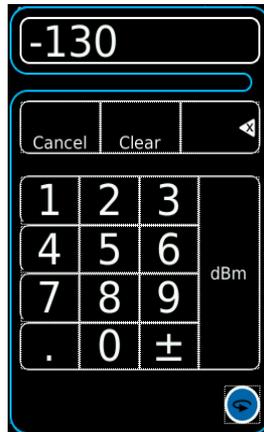


Fig. 2-8 Numeric Keypad

Icon	Description
	Pressing Cancel voids any entered changes and closes the group of data entry pop-up windows.
	Pressing Clear resets a numeric value to 0.
	Pressing Backspace deletes the last digit in the numeric value.
	Pressing Next Value Selection replaces the Numeric Keypad with the Slew Data Bar. Press again and the Numeric Keypad appears.

2.7.3 Data Slew Bar

The Data Slew Bar incrementally selects specific data values by spinning the wheel. Selecting x10 increases the step increment by a factor of 10. Selecting /10 decreases the step increment by a factor of 10.

Select UP arrow to increase data value. Select DOWN arrow to decrease data value. Select CANCEL to void data entry.

Selecting Enter closes the Data Slew Bar.



Fig. 2-9 Data Slew Bar

2.7.4 Drop-down Menus

Drop-down Menus are used to list pre-defined variables. Selecting a Drop-down Menu opens the list of variables available for that field. The variable currently selected is displayed on the menu as bold white label on a blue background. Drop-down Menus can be dragged up and down on the display in order to view long lists.



Fig. 2-10 Drop-down Menu

2.7.5 Selectable Units

Some fields may have selectable units. For those fields identified, select the units field and a drop-down menu will be displayed.

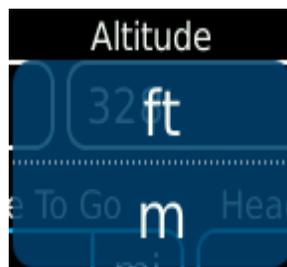


Fig. 2-11 Selectable Units

2.7.6 Locked Fields

A small padlock symbol may be displayed against certain fields indicating that the field is locked and may not be edited or accessed. The altitude field shown is locked due to the fact that a simulation is running, or the simulation mode has been set to dynamic mode. The field will become unlocked when the simulation is stopped or is in static mode.



Fig. 2-12 Locked Field

THIS PAGE INTENTIONALLY LEFT BLANK.

Chapter 3 - Test Set Functions

3.1 INTRODUCTION

This chapter provides an operational description of standard simulator functions.

3.2 TEST SET FUNCTIONS

3.2.1 Simulation Function Window

The Simulation Function Window is used to display the selected GPS Galileo and SBAS SV PRN's, Visible SV's, carrier, and PVT (position, velocity and time). The Simulation Function Window also controls static position and altitude.



Fig. 3-1 Simulation Function Window (GPS Static)

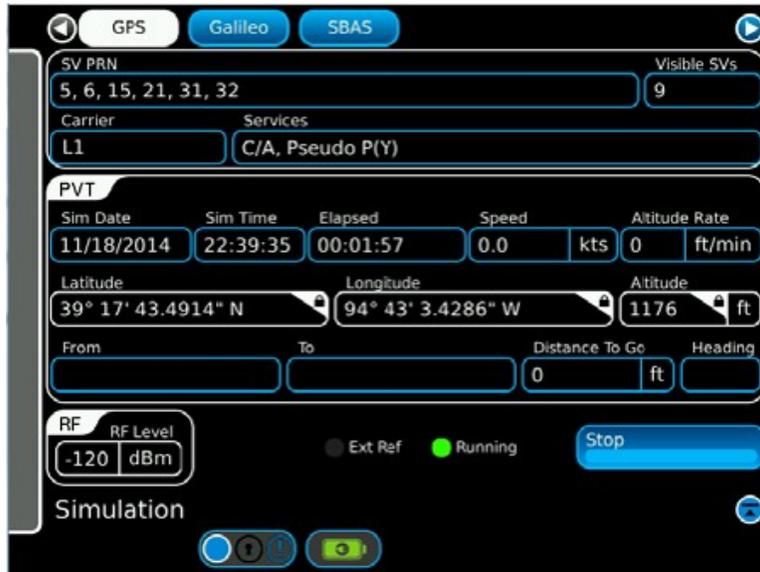


Fig. 3-2 Simulation Function Window (Galileo Static)



Fig. 3-3 Simulation Function Window (SBAS Static)

Control Component	Description
Latitude	Incremental Data Entry: Latitude entered in decimal format Example: 37o39.0000N (37 degrees, 39.0000 minutes North) Sign: N or S NOTE: This field is locked when SIMULATION = DYNAMIC or TRAJECTORY.
Longitude	Incremental Data Entry: Longitude entered in decimal format Example: 97o26.0000E (97 degrees, 26.0000 minutes East) Sign: E or W NOTE: This field is locked when SIMULATION = DYNAMIC or TRAJECTORY.

Test Set Functions

Altitude	Numeric Pad: Altitude: 0 to 100,000 ft in 1 ft steps or 0 to 18,288 M in 1 M steps NOTE: This field is locked when SIMULATION = DYNAMIC or TRAJECTORY.
RF Level	Numeric Pad: RF level entered as -68 to -130 dBm in Coupler mode or -93 to -155 dBm in Direct mode. NOTE: The listed RF Level settings are assuming 0 dBm settings for Coupler Loss, Coupler Cable and Direct Cable on the Setup I/O Window. The RF Level entry window will be reduced by the values entered for these settings.

Display Component	Description
GPS SV PRN	Displays selected GPS SV PRN's. Range: 1 to 32
GAL SV PRN	Displays selected Galileo SV PRN's Range: 1 to 36
SBAS	Displays SBAS SV PRN, status and System. Example: 133:INMARSAT 4F3, AMER
Visible SV's	Displays the total number of GPS, Galileo and SBAS SV's available in the current simulation scenario.
Carrier	Displays selected carrier, dependent on GNSS and Carrier selections in Setup. NOTE: The GPS Services and Galileo Services are displayed in the Services field. GNSS System: GPS Carrier: L1 GPS Services: C/A, Pseudo P(Y) Carrier: L1 no P(y) GPS Services: C/A Carrier: L2 GPS Services: L2C, Pseudo P(Y) Carrier: L5 GPS Services: SoL GNSS System: Galileo Carrier: E1 Galileo Services: I/NAV, Pseudo-G/NAV Carrier: E5 Galileo Services: I/NAV, F/NAV GNSS System: GPS/Galileo Carrier: L1/E1 GPS Services: C/A, Pseudo P(Y) Galileo Services: I/NAV, Pseudo-G/NAV Carrier: L5/E5 GPS Services: SoL Galileo Services: I/NAV, F/NAV
Services	Displays GNSS service generated.
Current Sim. Date	Displays Date in DD/MM/YYYY format.
Speed	Displays speed in MPH or Km/h when running a dynamic or trajectory simulation, dependent on Speed setting on the Route Edit page.
Current Sim. Time	Displays Time in 24 Hr format HH/MM/SS. NOTE: Displayed in uncorrected UTC time.
Elapsed Time	Displays elapsed time in 24 Hr format HH/MM/SS.
Altitude Rate	Displays Altitude Rate in ft/min or m/min when running a dynamic simulation, dependent on Altitude Rate setting on the Route Edit page.

Test Set Functions

From	Displays name of starting waypoint when running a dynamic simulation, dependent on Name entered on the Route Edit page.
To	Displays name of ending waypoint when running a dynamic simulation, dependent on Name entered on the Route Edit page.
Distance To Go	Displays the Distance To Go from the current simulated position to the ending waypoint when running a dynamic simulation.
Heading	Displays the simulated heading when running a dynamic or trajectory simulation.

3.2.2 Setup Simulation Window

The Setup Simulation Window is used to configure the test set operational parameters.

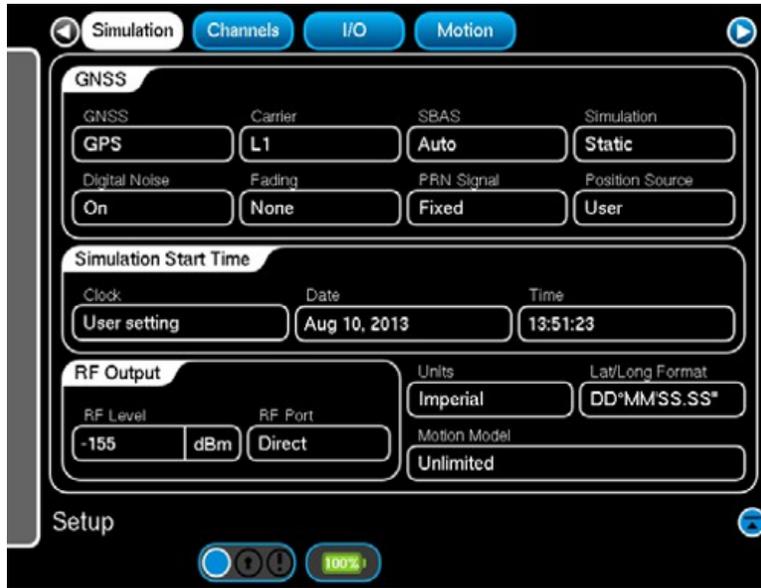


Fig. 3-4 Setup Simulation Window

Control Component	Description
GNSS	Drop Down Selections: GPS - Only GPS satellites simulated. Galileo - Only Galileo satellites simulated. GPS+Galileo - Both GPS and Galileo satellites simulated, the number of SV's per system is dependent on the GNSS Allocation (dual mode) settings on the Setup Channels Window.
Carrier	Drop down menu provides selection of carrier, carrier is dependent on GNSS selection in Setup. Drop Down Selections: GPS - L1, L1C, L2, L2C, L5, L1 no P(y) Galileo - E1, E5, E5A GPS + Galileo - L1/E1, L5/E5
Simulation	Drop Down Selections: Static - Single waypoint entry fixed position simulator. Dynamic - Position simulation is dynamically changing according to parameter entries in Route and Waypoint Windows. Trajectory - Position simulation is dynamically changing according to data read from an NMEA sentence file loaded through the File menu screen.

Control Component	Description
<p>SBAS</p>	<p>Drop Down Selections: AUTO - Automatic optimized selection of SBAS satellite (WAAS/EGNOS) according to simulated position. OFF - SBAS satellites are turned OFF.</p> <p>NOTE: With AUTO selected only 5 or 11 GPS/Galileo SV's are available. With OFF selected a full 6 or 12 GPS/Galileo SV's are available.</p> <p>NOTE: Actual Number of available SV's is dependent on user options.</p> <p>NOTE: Locations without SBAS satellite coverage will result in no SBAS signals being generated in some simulations, even though SBAS SV simulation has been enabled.</p> <p>NOTE: According to the NMEA specification, the numbers 33 to 64 are reserved for SBAS satellites. The offset from NMEA SBAS SV ID to SBAS PRN is 87. For example, an SBAS PRN number of 138 minus 87 results in an SV ID of 51. From the preceding example, some receivers will report the ID of the SV as 138, while some receivers may report the ID as 51.</p>
<p>Digital Noise</p>	<p>Drop Down Selections: Off - When coupling to the receiver antenna. On - When connecting directly to the receiver, bypassing the antenna/LNA.</p> <p>NOTE: Automatically set to OFF when RF PORT = COUPLER. Automatically set to ON when RF PORT = DIRECT.</p> <p>NOTE: Use of digital noise via antenna coupler will result in degraded SV Signal to Noise ratio and may cause receiver to loose track or not obtain a stable fix.</p>
<p>Fading</p>	<p>Drop Down Selections: None - SV signal amplitudes do not have fading applied. Static - SV signal amplitudes have amplitude fading applied. Pedestrian - SV signal amplitudes have amplitude fading applied. Land Vehicle - SV signal amplitudes have amplitude fading applied. Aircraft - SV signal amplitudes have amplitude fading applied.</p> <p>NOTE: None, Pedestrian, Land Vehicle and Aircraft amplitude fading are recommended for use in Dynamic mode. None and Static are recommended for use in Static mode.</p> <p>NOTE: See section 3.2.2.A for additional information on Fading and multi-path Implementation.</p>
<p>PRN Signal</p>	<p>Drop Down Selections: Fixed - All SV Levels are set to the amplitude selected in the RF Level control component. Variable - Ensures the relative SV signal levels are set proportional to the respective pseudo ranges.</p>

Test Set Functions

Control Component	Description
Position Source	Drop Down Selections: User - User entered position. GPS - On board GPS receiver derived position.
Clock	Drop down selections: GPSRX - simulation uses uncorrected GPS UTC time and date in conjunction with loaded almanac and ephemeris data. USER- simulation uses User entered Time and Date which sets SV parameters against loaded almanac and ephemeris. INTERNAL - simulation uses time and date that is available from the real time clock of the GPSG-1000.
Date	Incremental Data Entry: Date to be used during simulation.
Time	Incremental Data Entry: Time to be used during simulation. NOTE: The appropriate message content announcing a future leap second event is transmitted when simulation dates are within a period starting approximately 60 days before the leap second event. The appropriate message content is updated within two hours after the leap second event.
RF Level	Numeric Pad: RF level entered as -68 to -130 dBm in Coupler mode or -93 to -155 dBm in Direct mode. NOTE: The listed RF Level settings are assuming 0 dBm settings for Coupler Loss, Coupler Cable and Direct Cable on the Setup I/O Window. The RF Level entry window will be reduced by the values entered for these settings.
RF Port	Drop Down Selections: Direct - Generator uses GPS TX DIRECT port. Coupler - Generator uses GPS TX COUPLER port.
Units	Drop Down Selections: Imperial - Parameters displayed/entered in Imperial units. SI - Parameters displayed/entered in SI units. Aero/Imperial - Parameters displayed/entered in Imperial units, speed is display/entered in knots. Aero/SI - Parameters displayed/entered in SI units, speed is displayed/entered in knots.

Test Set Functions

Motion Model	<p>Drop Down Selections: Pedestrian Automobile Marine Low Performance Aircraft High Performance Aircraft Custom Unlimited</p> <p>The velocity and acceleration limits used during dynamic simulation mode will be based on the item chosen in the drop down selection menu. The values of the velocity and acceleration can be viewed using the Motion tab on the Setup Motion page.</p> <p>NOTE: During trajectory simulations the unlimited motion model velocity and acceleration limits are used.</p>
Lat/Long Format	<p>Drop Down Selections: DD.DD° DD°MM.MM' DD°MM' SS"</p>

3.2.2.A Fading and Multi-path Model Implementation

The GPSG-1000 firmware implements independent multi-path models for each satellite channel. Each channel supports a two-state (good/bad) Rician fading model with independently configurable fading and shadowing in each state. This underlying model can also be simplified to support a Rayleigh fading model.

In Rician fading the power of the received signal varies as the dominant line-of-sight component is partially canceled by delayed reflections of itself, particularly when the delays experienced by the reflected rays are time-varying.

In Rayleigh fading the power of the received signal varies according to the Rayleigh statistical distribution (i.e. as the radial component of the sum of two uncorrelated Gaussian random variables). This is generally considered as a good model for scenarios where the signal has been highly scattered and there is no dominant line-of-sight component. This situation typically occurs in urban environments, and during propagation through the atmosphere.

Shadowing simulates the effect of occasionally losing the line-of-sight signal due to obstruction of the signal by nearby objects. This can occur due to the motion of the satellite across the sky taking the apparent position of satellite behind buildings of other objects, but is typically caused by motion of the user. The effect is that the multi-path environment can be described as a two state system, with different behavior in the “good” or non-obstructed state and “bad” or obstructed state.

Fading is modeled as being uncorrelated between satellites and frequencies, whereas shadowing is uncorrelated between satellites, but correlated across frequencies.

There is no support for simulating multi-path ray delay in the current firmware, so the model is best considered as simulating a very complex multi-path environment with many multi-path rays and none dominant.

The GPSG-1000 firmware models the line-of-sight component as having 0 dB power, with the power of the multi-path components relative to this level.

The multi-path environments currently implemented in the GPSG-1000 are shown in the following table:

MULTI-PATH MODEL	DESCRIPTION
None	No Fading or multi-path effects are simulated.
Static	20 dB Rice factor. 0.025 Hz fading bandwidth. No Shadowing.
Pedestrian	Unblocked "good" state: 11.9 dB Rice factor. 40 s mean time in state. Blocked "bad" state: 5.9 dB Rice factor. 10 s mean time in state. 5 dB attenuation. Fading bandwidth 0.5 Hz. Shadowing bandwidth 1 Hz. Shadowing variation 2 dB (1σ).
Land	Unblocked "good" state: 13.2 dB Rice factor. 9 s mean time in state. Blocked "bad" state: 7.2 dB Rice factor. 1 s mean time in state. 10 dB attenuation. Fading bandwidth 7.3 Hz. Shadowing bandwidth 2 Hz. Shadowing variation 2 dB (1σ).
Aeronautical	20.2 dB Rice factor. Fading bandwidth 0.01 Hz. No Shadowing.

The GPSG-1000 software includes pre-defined configurations for several representative multi-path environments selectable in the Simulation Window's Fading field. These environments are:

- NONE - No fading or multi-path effects are simulated.
- STATIC - Representative of the environment for a static receiver with clear view of the sky.
- PEDESTRIAN - Representative of a pedestrian in an urban environment.
- LAND - Representative of a land vehicle in a rural environment.
- AERONAUTICAL - Representative of the environment experienced by a flying aircraft.

It should be noted that the real environments can change dramatically according to time-of-day satellite geometry, receiver location, and receiver motion. The pre-defined environments can therefore only be considered as representative of what might be experienced by a receiver in such an environment.

3.2.3 Setup Motion Window

The Setup Motion Window is used to select the motion model limits to be used in a dynamic simulation.

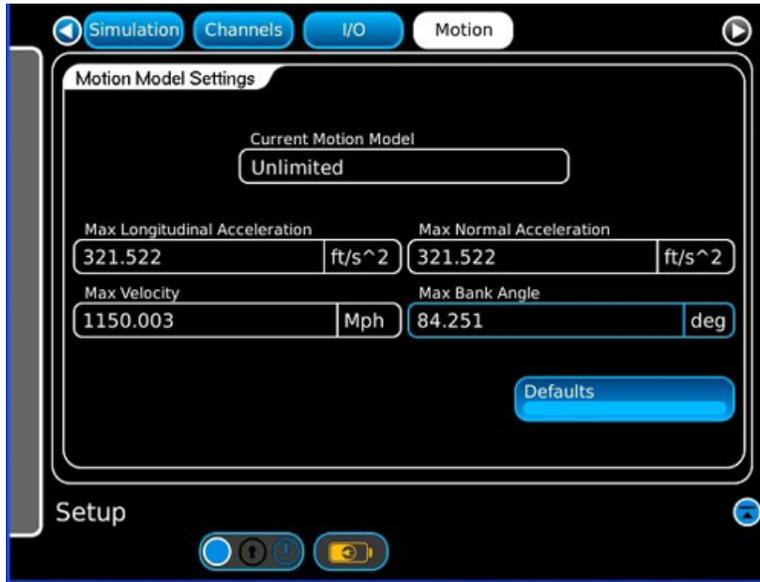


Fig. 3-5 Setup Motion Window

Control Component	Description
Current Motion Model	Drop down selections: Pedestrian Automobile Marine Low Performance Aircraft High Performance Aircraft Custom Unlimited
Maximum Longitudinal Acceleration	Numeric Pad: Longitudinal Acceleration entered in either feet/second ² with a maximum of 328.083 ft/s ² , or in meters/second ² with a maximum of 100 m/s ² .
Maximum Normal Acceleration	Numeric Pad: Normal Acceleration entered in either feet/second ² with a maximum of 328.083 ft/s ² , or in meters/second ² with a maximum of 100 m/s ² .
Maximum Velocity	Numeric Pad: Maximum Velocity entered in either miles per hour with a maximum of 1150.782 mph, kilometers per hour with a maximum of 1852 km/h, or knots with a maximum of 999 kts.
Defaults	Returns the edited values on the Setup Motion Window to their default values.
Display Component	Description
Maximum Bank Angle	Maximum bank angle calculated for the body in motion based on a coordinated turn. Note that a non-coordinated turn is assumed for pedestrian, automotive and marine bodies in motion, so no maximum bank angle is displayed.

3.2.4 Setup Channels Window

The Setup Channels Window is used to configure the total SV's available in a simulation and in a dual mode simulation to allocate the number of SV's used for GPS, Galileo and SBAS.

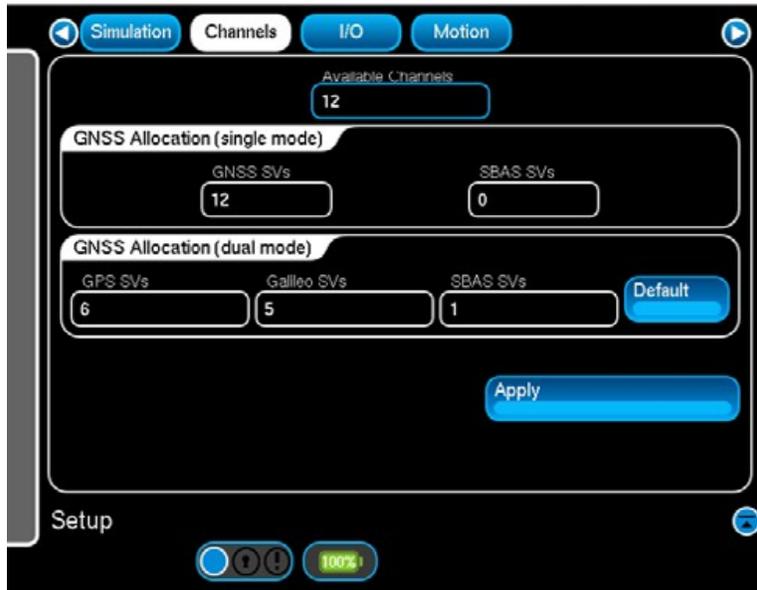


Fig. 3-6 Setup Channels Window

Control Component	Description
GNSS SVs	Numeric Pad: Sets the total number of GNSS system SV's. The total number of GNSS and SBAS SVs cannot exceed 6 on a 6 channel unit, or 12 on a 12 channel unit.
GPS SV's	Numeric Pad: Sets the total number of GPS SV's available for simulation. Range 1 - 6 (6 Ch) or 1 - 12 (12 Ch) SV's. Total GPS, Galileo and SBAS SV's can not exceed 6 (6 Ch) or 12 (12 Ch) SV's. Only used during GPS+Galileo dual mode simulation.
Galileo SV's	Numeric Pad: Sets the total number of Galileo SV's available for simulation. Range 1 - 6 (6 Ch) or 1 - 12 (12 Ch) SV's. Total GPS, Galileo and SBAS SV's can not exceed 6 (6 Ch) or 12 (12 Ch) SV's. Only used during GPS+Galileo dual mode simulation.
SBAS SV's	Numeric Pad: Sets the total number of SBAS SV's available for simulation. Range 0 - 4 SV's. Total GPS, Galileo and SBAS SV's can not exceed 6 (6 Ch) or 12 (12 Ch) SV's. Only used during GPS+Galileo dual mode simulation.
Default	Sets the allocated SV's to default values of GPS SV's = 3 (6 Ch) or 6 (12 Ch), Galileo SV's = 3 (6 Ch) or 6 (12 Ch) and SBAS SV's = 0.

Display Component	Description
Available Channels	Displays the total number of available channels. 6 channels for standard unit or 12 channels if option 1 is installed.

3.2.5 Setup I/O Window

The Setup I/O Window is used to configure the test set Loss and Input/Output operational parameters.

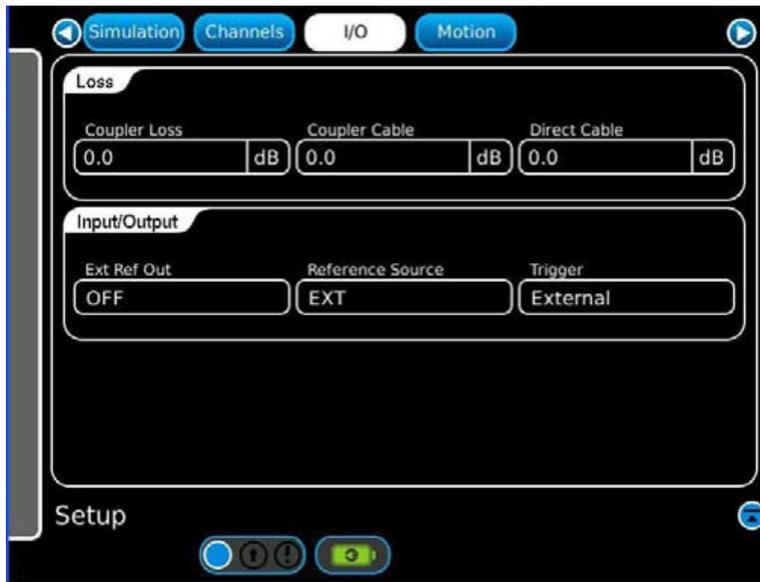


Fig. 3-7 Setup I/O Window

Control Component	Description
Coupler Loss	Numeric Pad: Antenna Coupler insertion loss in dB. Range: 0 to 40 dB
Coupler Cable	Numeric Pad: Antenna Coupler RF coax cable loss in dB. Range: 0 to 12 dB. NOTE: If using either the Dual, or Triple GPS Antenna Coupler Kits please see the instructions for the appropriate kit in either Appendix G or H to determine the loss value to enter in this control component.
Direct Cable	Numeric Pad: Direct RF coax cable loss in dB. Range: 0 to 12 dB. NOTE: If using the optional GPS Receiver Termination Kit see the instructions for entering the appropriate direct cable loss value for the components in Appendix I.
Ext Ref Out	Drop Down Selections: ON - External reference output ON. OFF - External reference output OFF.
Reference Source	Drop Down Selections: INT - Internal 10 MHz TCXO. EXT - External 10 MHz input.
Trigger	Drop Down Selections: Auto - Simulation will run immediately after the run button is pressed. External - Simulation will run once the external trigger line toggles from a 3.3 LVTTTL low level to a high level.

3.2.6 SV PRN Selection Function Window

The SV PRN Selection Function Window allows the user to select specific GPS/Galileo SV's for editing. The available SV's, according to the currently loaded almanac and UTC, are displayed in two tables. One table for GPS SV's and one table for Galileo SV's. The tables display the SV PRN number, satellite geometry and health. The satellites selected determine the accuracy of the positional simulation. SV's which are currently being use are displayed in green text and SV's which are available for use, but not currently being used are displayed in white text.

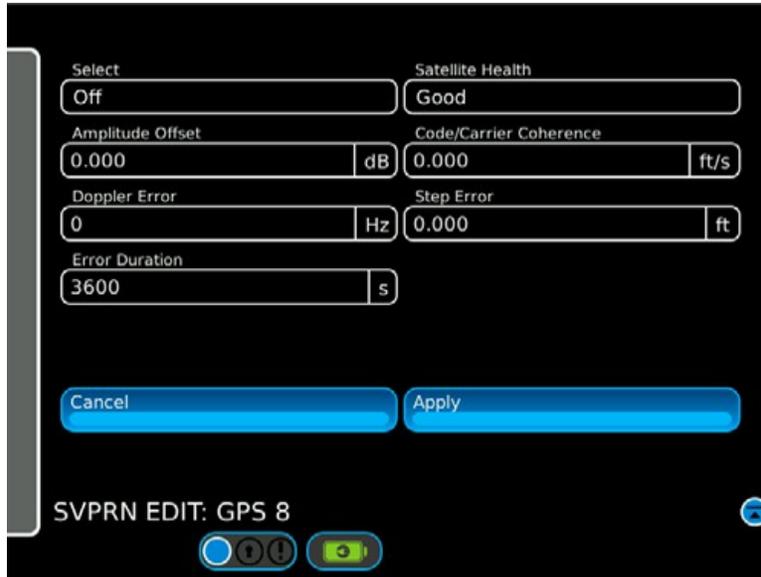


Fig. 3-8 SV PRN Selection Function Window

Display Component	Description
Select	Displays SV status On or Off.
SV	Displays SV number. Range GPS: 1 to 32, GAL: 1 to 36.
Elevation	Displays SV Elevation in degrees. Range: 0 to 90 deg.
Azimuth	Displays SV Azimuth in degrees. Range 0 to +/-180 deg.
Health	Displays SV Health GOOD or BAD.
Reset	Returns items edited on the SV PRN Edit Window to their default values.

3.2.7 SV PRN Edit Window

The SV PRN Edit Window opens when an SV line is selected in either the GPS or GAL tables, displayed in the SV PRN Selection Function Window. The SV PRN Edit Window allows the user to set parameters specific to the SV such as Doppler Step, Pseudo Range Step Error, Carrier Coherence, Satellite Health and Amplitude offset.

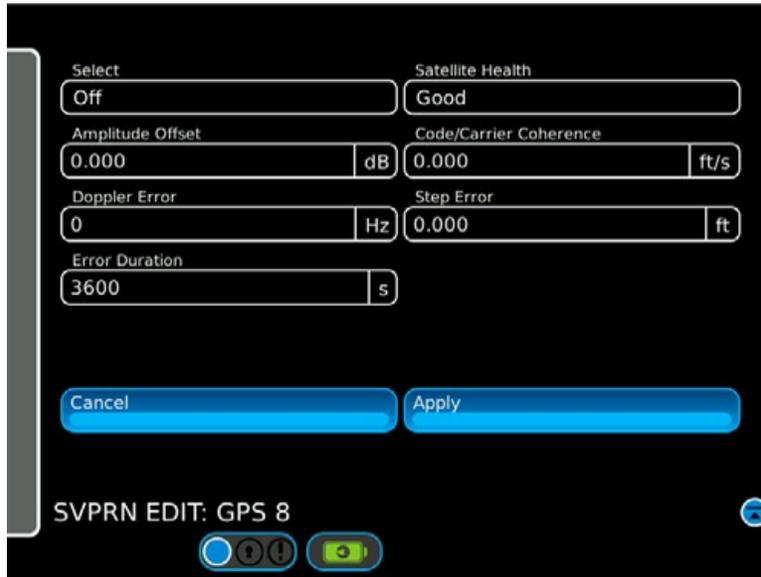


Fig. 3-9 SV PRN Edit Window

Control Component	Description
Select	Drop down selections: On - Turns SV on Off - Turns SV off Replace - Opens SV select window. To replace current SV, highlight desired SV and press Apply.
Doppler Error	Numeric Pad: Sets SV Doppler shift +/- 5kHz in 1 Hz increments. NOTE: Doppler shift for each SV is applied dynamically throughout the simulation run time. This parameter introduces a step change in Doppler (used for RAIM testing).
Amp. Offset	Numeric Pad: Sets SV carrier amplitude offset from nominal +15 dB to -15 dB in .1 dB increments. NOTE: If PRN Signal is set to Variable - SV amplitudes are set according to SV geometry and RF Level setting. If set to Fixed - equal SV amplitudes are set.
Duration	Numeric Pad: Sets the duration in time for which the Doppler error will be applied to the SV signal output.
Step Error	Numeric Pad: Sets SV pseudo range error +/- 1000m in .001 m increments or +/- 3280.839 ft in .001 ft increments.
Code/Carrier Coherence	Numeric Pad: Sets frequency variation between SV code carriers 2m/S range in 1mm/S increments or 6.561 ft/S range in .001 ft/S increments.

Test Set Functions

Control Component	Description
Satellite Health	Drop down: Allows selection of GOOD or BAD. (Carried in GPS Nav Data) NOTE: Not displayed for Galileo SV's
GAL Integrity	Allows selection of CONNECTED or DISCONNECTED (Carried in Galileo Nav Data). Only displayed in Galileo SV's. NOTE: Not displayed for GPS SV's
Cancel	Cancel parameter change, reverts to previous setting
Apply	Applies parameter change

3.2.8 Route Function Window

The Route Function Window is used to organize and configure the waypoints used in a dynamic simulation. Up to 9,999 waypoints may be used in a dynamic simulation. The Route Function Window is also used to load saved routes, manage routes and validate routes.

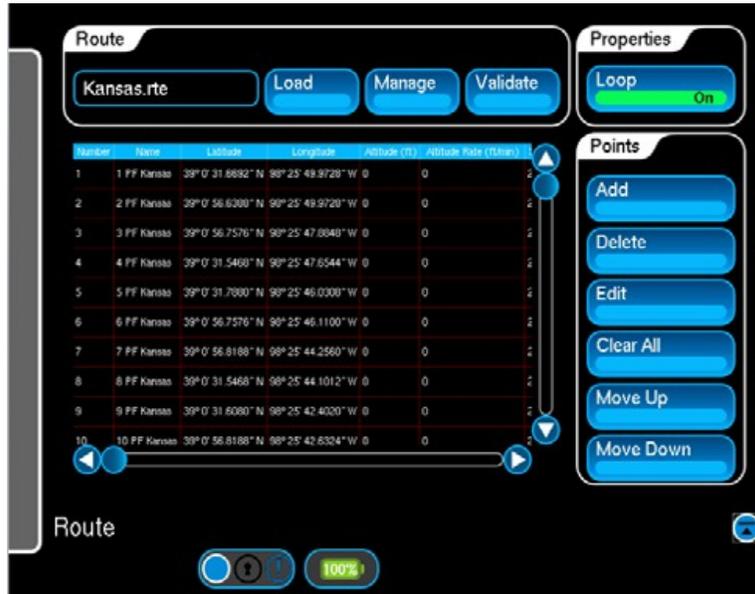


Fig. 3-10 Route Function Window

Control Component	Description
Load	Opens Find Route Window to load a saved route. Highlight the saved route and press Open. The route name will be displayed in the Route window.
Manage	Opens Manage Routes Window to save, rename or delete a route. Highlight route and press Delete to delete a route. Press Save to save the current route. Highlight route and then press on the File Name Window to rename a route.
Validate Route	Validates the current route to let the user know if there are any route errors. When Validate Route is pressed the route is checked and if no errors are found no error message is displayed, however if any errors are detected an "Error(s) found in route" message is displayed along with a description of the error.
Loop On Loop OFF	Loop ON will force the body in motion to travel from the last route point to the first route point which will effectively create an endless loop along the route. Loop OFF will stop the body in motion once it has reached the last route point in the route.
Clear All	When selected this will clear all of the information from the current route enabling the user to enter a new series of route points without having to perform a number of deletes.
Add	Opens Stored Waypoints Window. To add a waypoint to the route, highlight the route and press Next to display the Route Edit Window.

Test Set Functions

Control Component	Description
Delete	Deletes the selected waypoint from the route.
Edit	Opens the Route Edit Window to edit the selected waypoint.
Move Up	Moves the highlighted waypoint up in the list of waypoints.
Move Down	Moves the highlighted waypoint down in the list of waypoints.

3.2.9 Route Edit Stored Window

The Route Edit Stored Window is used to display all stored waypoints.



Fig. 3-11 Route Edit Stored Window

Control Component	Description
Sorted By	Drop down selections: Code, Name, City, Country, Latitude, Longitude and Altitude.
Cancel	Closes the Route Edit Stored Window and returns to the Route Window.
Next	Opens the Route Edit Window for configuration of the highlighted waypoint.

3.2.10 Route Edit Edit Window

The Route Edit Edit Window is used to configure individual waypoints, including the Altitude Rate, Speed, Acceleration and Turn Radius used during dynamic simulations.

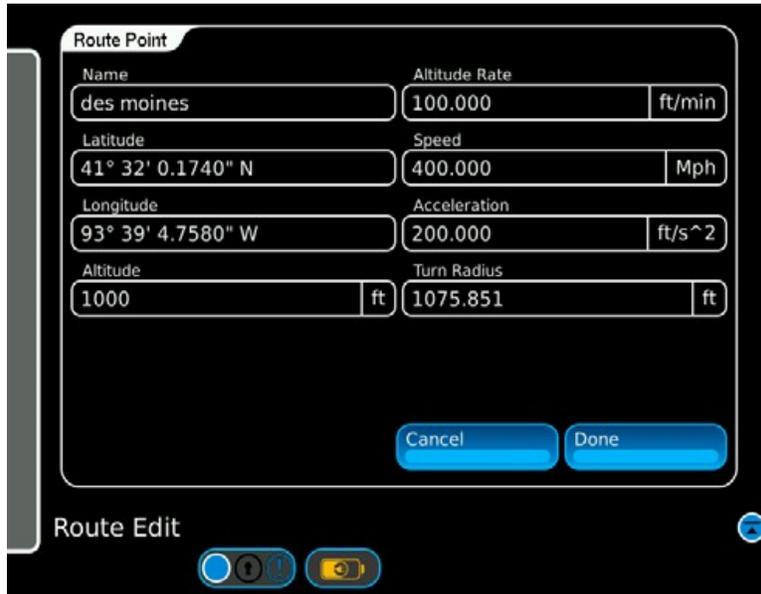


Fig. 3-12 Route Edit Edit Window

Control Component	Description
Name	Alpha Numeric Pad: Allows editing of selected waypoint name.
Latitude	Numeric Pad: Latitude entered in decimal format Example: 37°39.0000N (37 degrees, 39.0000 minutes North) Sign: N or S.
Longitude	Numeric Pad: Longitude entered in decimal format Example: 97°26.0000E (97 degrees, 26.0000 minutes East) Sign: E or W.
Altitude	Numeric Pad: Altitude: 0 to 100,000 ft in 1 ft steps or 0 to 18,288 M in 1 M steps.
Turn Radius	Numeric Pad: Turn Radius: 3.281 to 328,084 ft in .001 ft steps or 1 to 100,000 m in .001 m steps. NOTE: To calculate the minimum turning radius of the body in motion, the following calculation can be performed using the individual speed and acceleration of each route point. $\text{Turn Radius} = \frac{\text{Speed (squared) m/s}}{\text{Acceleration m/s/s}}$ NOTE: The separation between waypoints should be greater than four times the turning radius between the waypoints.
Acceleration	Numeric Pad: Acceleration: +/-328.084 ft/s^2 in .001 ft/s^2 steps or +/- 100 m/s^2 in .001 m/s^2 steps.
Speed	Numeric Pad: Speed: 0 to 1150.000 Mph in .001 Mph steps or 0 to 1850.745 Km/h in .001 Km/h steps.

Test Set Functions

Control Component	Description
Altitude Rate	Numeric Pad: Altitude Rate: +/-5,905 ft/min in .001 ft/min steps or +/-1800 m/min in .001 m/min steps.
Cancel	Closes the Route Edit Edit Window and returns to the Route Window.
Done	Closes the Route Edit Edit Window and returns to the Route Window.

3.2.11 Waypoint Function Window

The Waypoint Function Window is used to configure the waypoints that comprise a 3D Navigation simulation.

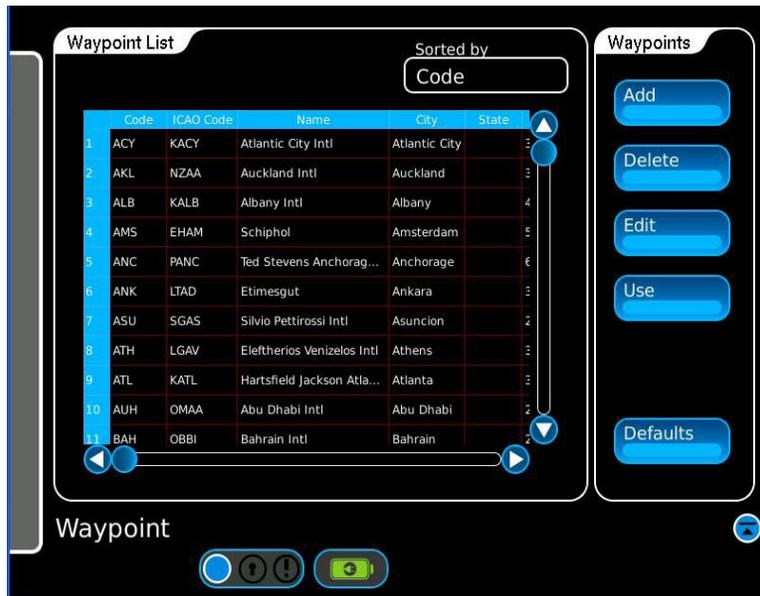


Fig. 3-13 Waypoint Function Window

Control Component	Description
Sorted By	Drop down selections: Code, ICAO Code, Name, City, Country, Latitude, Longitude, Altitude.
Add	Opens Waypoint Edit Window, so that a new waypoint may be created.
Delete	Deletes selected waypoint. NOTE: Allow approximately 15 seconds for the selected waypoint to be deleted after pressing Delete. NOTE: Permanent waypoints can't be deleted.
Edit	Opens Waypoint Edit Window for editing of selected waypoint.
Use	Opens the Simulation Window and loads the Latitude, Longitude and Altitude from the selected waypoint. Used in a Static simulation only. NOTE: This field is locked when SIMULATION = DYNAMIC.
Defaults	Deletes all user entered waypoints from GPWG-1000.

Display Component	Description
Code	Displays Waypoint Code.
Name	Displays Waypoint Name.
City	Displays Waypoint City.
Country	Displays Waypoint Country.
Latitude	Displays Waypoint Latitude in decimal format. Example: 37°39.0000N (37 degrees, 39.0000 minutes North) Sign: N or S.
Longitude	Displays Waypoint Longitude in decimal format. Example: 97°26.0000E (97 degrees, 26.0000 minutes East) Sign: E or W.
Altitude	Displays Altitude 0 to 100,000 ft in 1 ft steps.

3.2.12 Waypoint Edit Stored Window

The Waypoint Edit Stored Window is used to display the Current Stored Waypoints. Waypoints can be selected from a table, to be edited on the Waypoint Edit Edit Window.



Fig. 3-14 Waypoint Edit Window

Control Component	Description
Sorted by	Drop down selections: Code, Name, City, Country, Latitude, Longitude and Altitude.
Cancel	Cancels Waypoint edits, closes Waypoint Edit Window and reverts to Waypoint Window.
Next	Opens Waypoint Edit Window.

3.2.13 Waypoint Edit Edit Window

The Waypoint Edit Edit Window is used to make changes to a selected waypoint or create a new waypoint. Waypoints may be selected from a table on the Waypoint Window or Waypoint Edit Stored Window. Permanent waypoints can't be edited.



Fig. 3-15 Waypoint Edit Edit Window

Control Component	Description
Code	Alpha Numeric Pad: Enter or change waypoint Code.
ICAO Code	Alpha Numeric Pad: Enter or change waypoint ICAO Code.
Name	Alpha Numeric Pad: Enter or change waypoint Name.
City	Alpha Numeric Pad: Enter or change waypoint City.
Country	Alpha Numeric Pad: Enter or change waypoint Country.
Latitude	Incremental Data Entry: Enter or change waypoint Latitude in decimal format. Example: 37°39.0000N (37 degrees, 39.0000 minutes North) Sign: N or S.
Longitude	Incremental Data Entry: Enter or change waypoint Longitude in decimal format. Example: 97°26.0000E (97 degrees, 26.0000 minutes East) Sign: E or W.
Altitude	Numeric Pad: Enter or change waypoint Altitude 0 to 100,000 ft in 1 ft steps.
Cancel	Cancels Waypoint edits, closes Waypoint Edit Window and opens Waypoint Window.
Done	Closes Waypoint Edit Window and opens Waypoint Window, saving the edited waypoint into the Waypoint List.

3.2.14 GPS RX Function Window

The Internal GPS Receiver may be used to obtain a current Almanac, location and UTC for use in simulations. This removes the requirement for a periodic manual Yuma text format almanac (*.alm), download from the U.S. Coast Guard website and subsequent upload to the GPSG-1000 memory.

When testing a GPS receiver, if the simulated position is too far from the last acquired position or the simulated time and date are too far from the last acquired time and date the receiver will initiate a warm start which, dependent on receiver type, will take longer than a hot start to acquire a position fix. As the last location would likely be the current position, the latitude and longitude from the internal GPS receiver may be used by the simulation, which would then allow the receiver under test to hot start.



Fig. 3-16 GPS Receiver Window

Control Component	Description
GPS Receiver	Selects internal GPS receiver.
Load Almanac from GPS Rx	Loads almanac from internal GPS receiver. Download status is displayed in the Almanac Status display window. Note: It may take up to 20 minutes for the data from the first SV to be downloaded, and it may take up to 30 minutes to complete a download of almanac data from the entire GPS constellation
GPS Receiver Reset	Initiates a Cold Boot of the internal GPS receiver.
Record Trajectory	When activated this control begins recording trajectory data produced by the internal receiver. The recording will continue until the Stop Recording button is pressed. The data will be stored in a file with the following naming convention MMDDYYYY_HHMMSS.nme when the stop recording button is pressed. NOTE: The Record Trajectory function should only be initiated once a 3D fix has been achieved by the receiver.

Display Component	Description
Current Data/Time	Displays the current date and UTC time received by the internal GPS Receiver.
Position Fix	Indicates No Position Fix, 2D Solution or 3D Solution
Latitude	Waypoint Latitude in decimal format. Example: 37°39.0000N (37 degrees, 39.0000 minutes North) Sign: N or S.
Longitude	Waypoint Longitude in decimal format. Example: 97°26.0000E (97 degrees, 26.0000 minutes East) Sign: E or W.
Altitude	Displays Altitude as determined by the internal GPS receiver.
Speed	Displays Speed as determined by the internal GPS receiver.
Almanac Status	Indicates current week and status of the Almanac being received by the internal GPS receiver.
Active Satellite	Displays SV's in view.
SNR	GPS Receiver SNR figure.

3.2.15 Maintenance Function Window

Selecting the Maintenance icon from the Launch Bar Menu will display the Maintenance sub-menu. The Maintenance sub-menu contains the Calibration and Diagnostics icons.

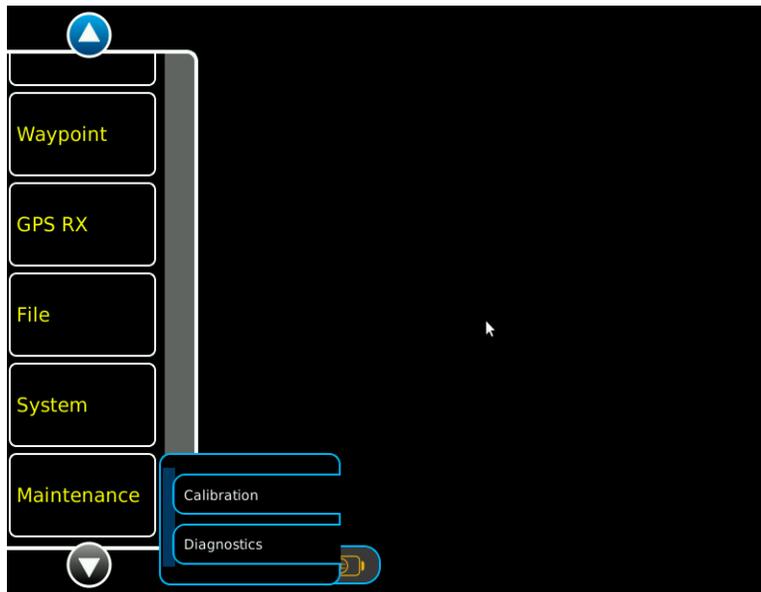


Fig. 3-17 Maintenance Menu

3.2.16 Calibration Function Window

Selecting Calibration from the Maintenance sub-menu will display the Calibration Password Entry Window. The Calibration Function Window is password protected. Contact VIAVI Solutions for the default password. Enter the password to open the Calibration Function Window. See [Chapter 5 - Maintenance](#), for details.

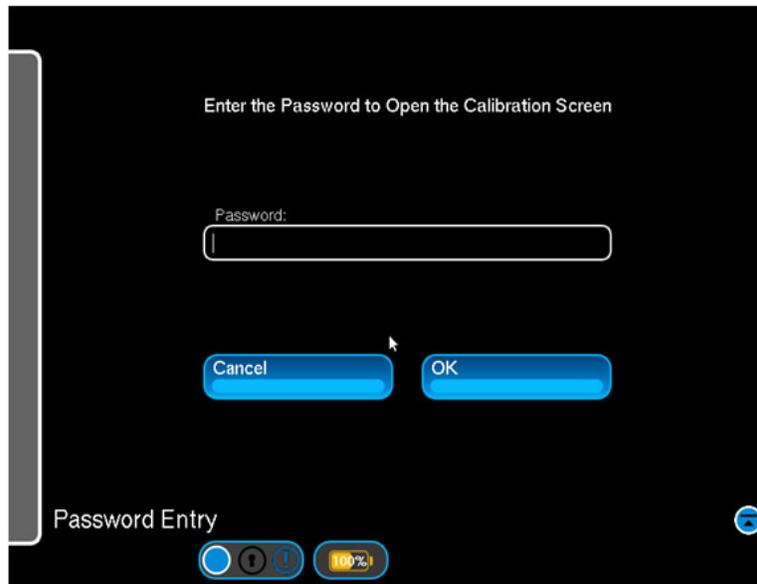


Fig. 3-18 Calibration Password Window

3.2.17 Diagnostics Function Window

Selecting Diagnostics from the Maintenance sub-menu will display the Diagnostics Function Window. See Chapter 5 - Maintenance for details.



Fig. 3-19 Diagnostics Function Window

3.2.18 File Almanacs Function Window

The File Almanacs Function Window is used to manage the Almanac files stored in the GPSG-1000 and to manage the Almanac file used during the simulation.

NOTE: Only the almanac used for GPS simulations can be updated, the Galileo almanac is fixed and cannot be modified.

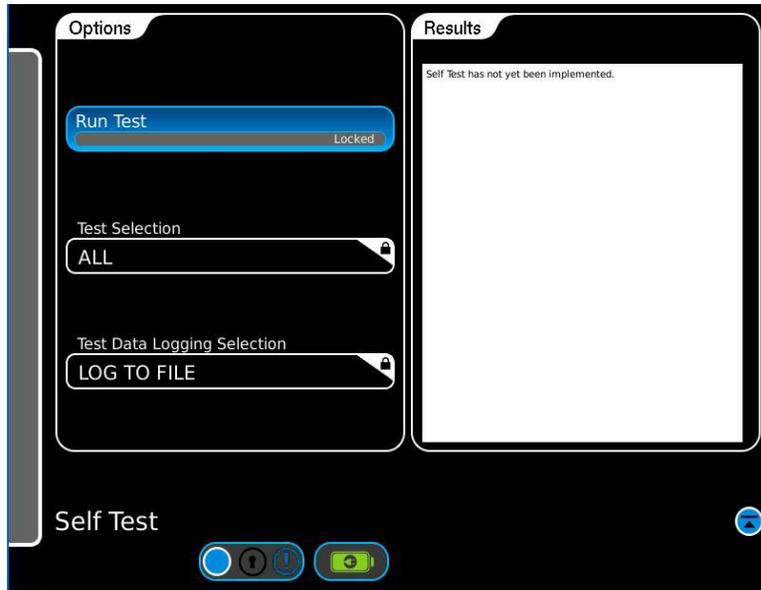


Fig. 3-20 File Almanacs Function Window

Control Component	Description
Load Almanac	Opens the Load Almanac Window. Select Almanac file and press Open to load Almanac file for use in GPS simulations. Selected file name will be displayed in the Current Almanac File Window.
Manage Almanacs	Opens the Manage Almanacs Window. Press Save to save the Current Almanac File to the Almanac file list. To delete a saved Almanac file, select Almanac file from list and press Delete.
GPS Rx	Opens the GPS Rx page and begins an almanac download from the GPS constellation.
Default	Loads the default system almanac for use. The default almanac is from GPS week 574, dated Aug. 22, 2010.
Clear Almanacs	Deletes ALL user created almanac files stored in the unit.
Import from USB	Copies almanac files from a USB drive to the internal storage area of GPSG-1000.
Export to USB	Copies all almanac files from the internal storage area of GPSG-1000 to a USB drive.

Display Component	Description
Current Almanac File	Displays the file name of the Almanac file currently used for GPS simulations.

3.2.19 File Routes Function Window

The File Routes Function Window is used to manage the Route files stored in the GPSG-1000 and to manage the Route file used during a dynamic simulation.



Fig. 3-21 File Routes Function Window

Control Component	Description
Load Route	Opens the Load Route Window. Select Route file and press Open to load Route file for use in dynamic simulation. Selected file name will be displayed in the Current Route File Window.
Manage Routes	Opens the Manage Routes Window. Press Save to save the Current Route File to the Route file list. To delete a saved Route file, select Route file from list and press Delete.
Load Default	Loads the default route file.
Clear Routes	Deletes ALL route files stored in the unit.
Import from USB	Copies route files from a USB drive to the internal storage area of GPSG-1000.
Export to USB	Copies all route files from the internal storage area of GPSG-1000 to a USB drive.

Display Component	Description
Current Route File	Displays the file name of the Route file currently used for dynamic simulations.

3.2.20 File Settings Function Window

The File Settings Function Window is used to manage the Settings files stored in the GPSG-1000 and to manage the Current Settings File.

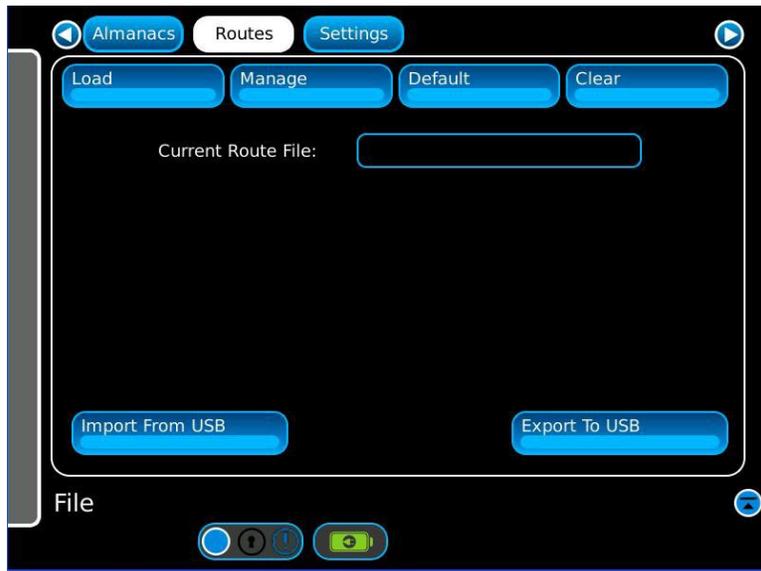


Fig. 3-22 File Settings Function Window

Control Component	Description
Load Settings	Opens the Load Settings Window. Select Settings file and press Open to load Settings file for setup of the unit. Selected file name will be displayed in the Current Settings File Window.
Manage Settings	Opens the Manage Settings Window. Press Save to save the Current Settings File to the Settings file list. To delete a saved Settings file, select Settings file from list and press Delete.
Load Default	Loads factory default settings.
Clear Settings	Deletes ALL settings files stored in the unit.
Import from USB	Copies settings files from a USB drive to the internal storage area of GPSG-1000.
Export to USB	Copies all settings files from the internal storage area of GPSG-1000 to a USB drive.

Display Component	Description
Current Settings File	Displays the file name of the settings file currently used to setup the unit.

3.2.21 File Trajectory Function Window

The File Trajectory Function Window is used to manage the trajectory files stored in the GPSG-1000 and to load the trajectory file used during a trajectory mode simulation.



Fig. 3-23 File Trajectory Function Window

Control Component	Description
Load Trajectory	Loads the Trajectory Window. Select trajectory file and press Open to load trajectory file for use in trajectory simulation. Selected file name will be displayed in the Current Trajectory File Window.
Manage Trajectory	Opens the Manage Trajectory Window. Press Save to save the Current Trajectory File to the trajectory file list. To delete a saved trajectory file, select NMEA file from list and press Delete.
Clear Trajectory	Deletes ALL trajectory files stored in the unit.
Default Trajectory	Loads the default system trajectory file for trajectory mode simulation playback.
Import from USB	Copies trajectory files from a USB drive to the internal storage area of GPSG-1000.
Export to USB	Copies all trajectory files from the internal storage area of GPSG-1000 to a USB drive.

Display Component	Description
Current Trajectory File	Displays the file name of the trajectory file currently used for trajectory simulation.

3.2.22 Kml Function Window

The Kml Function Window is used to manage the Kml files stored in the GPSG-1000 and to manage the Kml file used during a trajectory simulation.



Fig. 3-24 Kml Window

Control Component	Description
Load Traj	Opens the Load Kml Windows. Select a Kml file and press Open to load the Kml file. Selected file name will be displayed in the Kml File Window. During the load process the latitude, longitude and absolute altitude data from the Kml file, along with the Maximum Velocity, Conversion Sampling Rate, and Minimum Turning Radius from control components of the Kml Window will be used to create a trajectory file 2stored in GDT format on the unit. The data loaded onto the unit during the conversion of the Kml file can be played as a trajectory simulation.
Load Route	Opens the Load Kml Window. Select a Kml file and press Open. The latitude, longitude and absolute altitude data from the Kml file will be inserted onto the Route page along with the Maximum Velocity and Minimum Turning Radius from the Kml Window, and the Acceleration from the selected motion model. The data loaded onto the Route page can then be played as a dynamic simulation, although further manual editing of the route data may be necessary for proper playback.
Clear Settings	Deletes ALL Kml files stored in the unit.
Import from USB	Copies Kml files from a USB drive to the internal storage area of GPSG-1000.
Export to USB	Copies all Kml files from the internal storage area of GPSG-1000 to a USB drive.

Display Component	Description
Current Settings File	Displays the file name of the Kml file currently used to setup the unit.
Maximum Velocity	0 to 1118 Mph or 0 to 1800 Km/h
Conversion Sampling Rate	1, 2, 4, or 5 Hz
Minimum Turning Radius	0 to 328081 ft or 0 to 99999 m

3.2.23 Waypoint Window

The Waypoint Window is used to manage the user entered waypoints stored in the GPSG-1000.

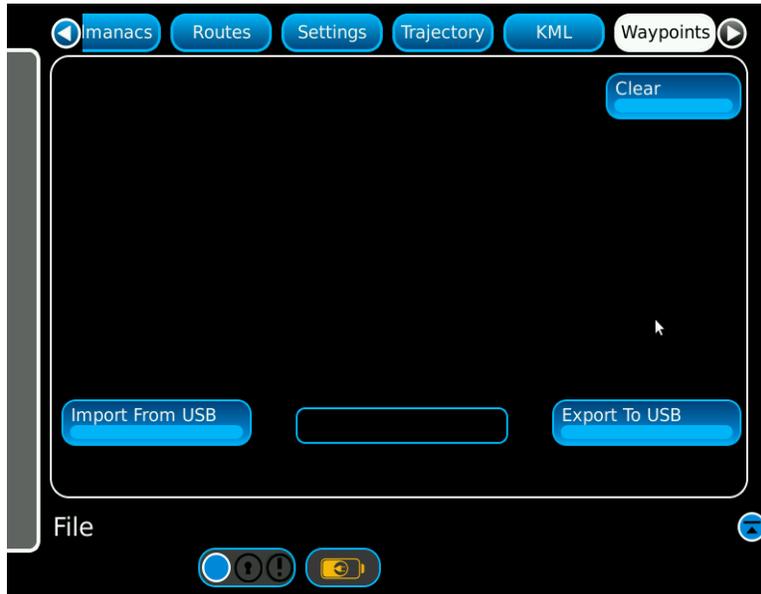


Fig. 3-25 Waypoint Window

Control Component	Description
Clear Settings	Deletes all user entered waypoints stored in the unit.
Import from USB	Copies user entered waypoints from a USB drive to the internal storage area of GPSG-1000.
Export to USB	Copies all user entered waypoints from the internal storage area of GPSG-1000 to a USB drive.

3.2.24 System Function Window

Selecting the System icon from the Launch Bar Menu will display the System sub-menu. The System sub-menu contains the Options, System Configuration and System Update icons. See Chapter 5 - Maintenance for details.

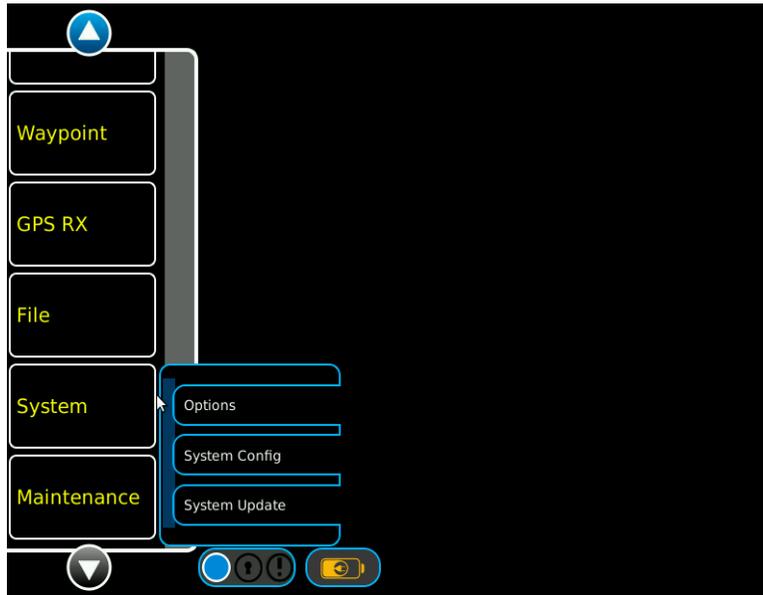


Fig. 3-26 System Menu

Chapter 4 - Testing GPS/ Galileo Receivers

4.1 INTRODUCTION

This chapter provides details of standard tests for GPS receivers.

4.1.1 Antenna Coupler Installation

Perform the following steps to Install the Antenna Coupler

STEP	PROCEDURE
1.	Ensure the GPSG-1000 is within 50 ft of the aircraft under test GPS antenna (top fuselage).
2.	Place the Shot Bag weight over the center section of the GPS Antenna Coupler.
3.	Connect the 50 ft RF Coax Cable to the GPSG-1000 Coupler TX TNC connector.
4.	Perform Setup procedure 4.1.3
5.	Place the Antenna Coupler over the GPS antenna on the top side of the aircraft frame.

NOTE:

In a dual or triple GPS system installations, additional Antenna Couplers may be used via a power splitter.

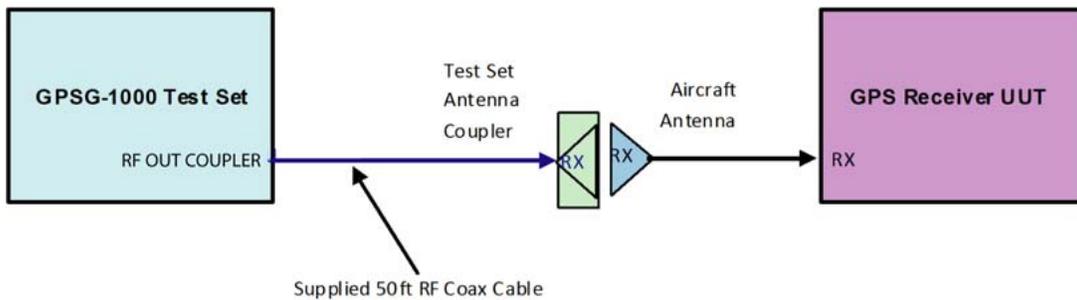


Fig. 4-1 GPSG-1000 RF Connection

4.1.2 Setup Basic Static Simulation

Perform the following steps for Setup.

STEP	PROCEDURE
1.	Press Power On/Off Key for a minimum of one second to power up test set.
2.	Select Launch Bar tab to display launch bar.
3.	Select Setup function key to display Setup Window.
4.	Select Simulation tab.
5.	Confirm the following settings and change as necessary. GNSS: GNSS = GPS Carrier = L1 SBAS = Off Simulation = Static Digital Noise = OFF – when coupling to the receiver antenna. ON – when connecting directly to the receiver, bypassing the antenna/LNA.
NOTE:	Use of digital noise via receiver antenna, will result in degraded SV Signal to Noise ratio and may cause receiver to loose track or not obtain a stable fix. Fading = None PRN Signal = Fixed Position Source = User Simulation Start Time: Clock = Internal RF Output: RF Level = When setting the output level of GPS generated signal, a setting of 115 to -120 dB should be adequate for most receivers. When directly connecting to a receiver, the nominal gain of the antenna should be taken into consideration and the output level of the GPSG-1000 adjusted accordingly. RF Port = COUPLER (if using antenna coupler) or DIRECT (direct connect to GPS UUT). Units = Imperial
6.	Select Almanac tab on the File page and press Load . Select an almanac from the list of available items that has been obtained from the internal GPS receiver, or the U.S. Coast Guard Navigation website that is no more that 30 days old, and then press the load key.
7.	Select I/O tab. Loss: Coupler Loss = Figure in dB marked on Antenna Coupler. Coupler Cable = Figure in dB marked on RF Coax Cable. Direct Cable = Figure in dB marked on RF Coax Cable. Input/Output: Ext Ref Out = OFF Reference Source - INT Trigger = Auto
8.	Select Simulation Function Key from the Launch Bar.

STEP	PROCEDURE
9.	Perform the following steps to complete Simulation: PVT: Latitude = For Optional entry of test Latitude Longitude = For Optional entry of test Longitude Altitude = For Optional entry of test Altitude
10.	Select RUN key to start simulation.
11.	Select STOP key to discontinue simulation.

NOTE:

Most GPS receivers expect ACTIVE antennas, this means they supply a DC voltage to the antenna connector. The GPSG-1000 has built in DC voltage blocking on the GPSG-1000 TX Port.

CAUTION	GPS TX PORT: APPLIED DC SHOULD NOT EXCEED +50 V
----------------	--

NOTE:

Some receivers “sense” current draw on the DC supply to their active antenna. If there is no current drawn, they may assume that no antenna is connected. In such cases, the current draw must be simulated by some resistive load and perhaps a series inductor between the signal line and the ground. Such a device may need to be custom built, depending on the receiver requirements.

NOTE:

It is recommended that the receiver under test is “cold started” and a fresh almanac obtained from the GPSG-1000 simulation. This process may take several minutes, dependent on specific receiver.

NOTE:

Some receivers will not obtain a stable fix when using a simulation time earlier than the selected almanac. Generally it is best to utilize an almanac that is dated at least one day before the simulation date.

NOTE:

NOTE: It is important that the receiver under test is not able to receive signals from the real GPS constellation as the pseudo-ephemeris data of the simulation is different enough from the real constellation that the mix of data can cause problems with the receivers positional calculation.

4.1.3 Setup Basic Dynamic Simulation

Perform the following steps for Setup:

STEP	PROCEDURE
1.	Press Power On/Off key for a minimum of one second to power up test set.
2.	Select Launch Bar tab to display launch bar.
3.	Select Setup function key to display Setup Window.
4.	Select Simulation tab.
5.	Confirm the following settings and change as necessary: GNSS: GNSS = GPS Carrier = L1 SBAS = Off Simulation = Dynamic Digital Noise = OFF when coupling to the receiver antenna. ON when connecting directly to the receiver, bypassing the antenna/LNA.
	NOTE: Use of digital noise via receiver antenna, will result in degraded SV Signal to Noise ratio and may cause receiver to loose track or not obtain a stable fix. Fading = None PRN Signal = Fixed Position Source = User Simulation Start Time: Clock = User Date = For optional entry of date Time = For optional entry of time RF Output: RF Level = When setting the output level of GPS generated signal, a setting of -115 to -20 dB should be adequate for most receivers. When directly connecting to a receiver, the nominal gain of the antenna should be taken into consideration and the output level of the GPSG-1000 adjusted accordingly. RF Port = COUPLER (if using antenna coupler) or DIRECT (direct connect to GPS UUT) Units = Imperial
6.	Select Almanac tab on the File page and press Load Default .
7.	Select I/O tab. Loss: Coupler Loss = Figure in dB marked on Antenna Coupler Coupler Cable = Figure in dB marked on RF Coax Cable Direct Cable = Figure in dB marked on RF Coax Cable Input/Output: Ext Ref Out = OFF Reference Source = INT Trigger = Auto
8.	To enter a route, select Route function key from the Launch Bar.
9.	Select Route Points Add button.
10.	Select a waypoint from the Stored Waypoints table.
11.	Select the Next button.

STEP	PROCEDURE
12.	Enter the desired information on the Route Point edit page and press the Done button.
13.	Complete entering all the Route points.
14.	To save Route for future use select Route function key from the Launch Bar. Select Route Manage button, then enter file name on the Manage Routes popup and press Save .
15.	Select Simulation tab.
16.	Select RUN key to start simulation.
17.	Select STOP key to stop simulation.

NOTE:

Most GPS receivers expect active antennas. This means they supply a DC voltage to the antenna connector. The GPSG-1000 has built in DC voltage blocking on the GPSG-1000 TX Port.

NOTE:

Some receivers 'sense' current draw on the DC supply to their active antenna. If there is no current drawn, they may assume that no antenna is connected. In such cases, the current draw must be simulated by some resistive load and perhaps a series inductor between the signal line and the ground. Such a device may need to be custom built, depending on the receiver requirements.

NOTE:

It is recommended that the receiver under test is 'cold started' and a fresh almanac obtained from the GPSG-1000 simulation. This process may take several minutes, dependent on the specific receiver.

NOTE:

Some receivers will not obtain a stable fix when using a simulation time earlier than the selected almanac. Generally it is best to utilize an almanac that is dated at least one day before the simulation date.

4.1.4 Setup Basic Trajectory Simulation

Perform the following steps for Setup:

STEP	PROCEDURE
1.	Press Power On/Off Key for a minimum of one second to power up test set.
2.	Select Launch Bar tab to display launch bar.
3.	Select Setup function key to display Setup Window.
4.	Select Simulation tab.
5.	Confirm the following settings and change as necessary: GNSS: GNSS = GPS Carrier = L1 SBAS = Off Simulation = Trajectory Digital Noise = OFF – when coupling to the receiver antenna. ON – when connecting directly to the receiver, bypassing the antenna/LNA.
NOTE:	Use of digital noise via receiver antenna will result in degraded SV Signal to Noise ratio and may cause receiver to loose track or not obtain a stable fix. Fading = None PRN Signal = Fixed Position Source = User Simulation Start Time: Clock = User Date = For optional entry of date Time = For optional entry of time RF Output: RF Level = When setting the output level of GPS generated signal, a setting of -115 to -120 dB should be adequate for most receivers. When directly connecting to a receiver, the nominal gain of the antenna should be taken into consideration and the output level of the GPSG-1000 adjusted accordingly. RF Port = COUPLER (if using antenna coupler) or DIRECT (direct connect to GPS UUT) Units = Imperial
6.	Select Almanac tab on the File page and press Load Default .
7.	Select I/O tab. Loss: Coupler Loss = Figure in dB marked on Antenna Coupler Coupler Cable = Figure in dB marked on RF Coax Cable Direct Cable = Figure in dB marked on RF Coax Cable Input/Output: Ext Ref Out = OFF Reference Source = INT Trigger = Auto
8.	Select GPS RX function key from the Launch Bar.
9.	Ensure that the GPS receiver antenna is correctly connected to the GPSG-1000 and that the test set has an unobstructed view of the sky.
10.	To start the recording process press Record Trajectory button.

STEP	PROCEDURE
11.	Press Stop Recording button to stop the recording process.
12.	To load a data file for playback, select File function key from the Launch Bar.
13.	Select the Trajectory tab and press the Load button.
14.	On the Load Trajectory popup, select the desired file from the list and press the Load button.
15.	Select Simulation function key from the Launch Bar.
16.	Select RUN key to start simulation.
17.	Select STOP key to stop simulation.

NOTE:

When a field containing NMEA sentences is imported to the GPSG-1000 for playback, at a minimum the file must contain sentence GGA or RMC. If the file contains only GGA messages the GPSG-1000 will use the date specified on the Setup page of the unit. If sentence RMC is available in the imported file, then the date of the simulation will match that of the data within the file. In either of the previous two cases, the correctly dated almanac file must be loaded to match the date of the simulation if the user intends to match the SV constellation simulated by the GPSG-1000 to that of the SV constellation in view by the receiver at the time of the recording.

NOTE:

Most GPS receivers expect active antennas. This means they supply a DC voltage to the antenna connector. The GPSG-1000 has built in DC voltage blocking on the GPSG-1000 TX Port.

NOTE:

Some receivers 'sense' current draw on the DC supply to their active antenna. If there is no current drawn, they may assume that no antenna is connected. In such cases, the current draw must be simulated by some resistive load and perhaps a series inductor between the signal line and the ground. Such a device may need to be custom built, depending on the receiver requirements.

NOTE:

It is recommended that the receiver under test is 'cold started' and a fresh almanac obtained from the GPSG-1000 simulation. This process may take several minutes, dependent on the specific receiver.

NOTE:

Some receivers will not obtain a stable fix when using a simulation time earlier than the selected almanac. Generally it is best to utilize an almanac that is dated at least one day before the simulation date.

4.1.5 GPS Receiver Communication

Some receivers may have maintenance pages the user can access to view SV parameters and positional information. Access may either be directly via a display/control or by the use of proprietary software.

For a standardized means of accessing all receiver data most receivers support the NMEA-183 protocol. NMEA -183 compliant receivers send data continuously through either a serial or USB interface, in the form of text sentences, which may be monitored by PC using a suitable application. The NMEA-183 protocol supports six basic sentences, and each provides a different data type. Refer to table 4-1. The first word in each sentence is the three letter data type.

Data Type	Description
GGA	Fix information
GLL	Latitude and longitude information
GSA	Overall satellite data
GSV	Detailed data for satellites in view
RMC	Recommended minimum data for GPS
VTG	Vector track and speed over ground

Table 4-1 Basic NMEA-183 Sentences

The information from the GSA sentence can be used to verify if the receiver has achieved a position fix and may be used in TTFF measurements. The GSV sentence provides the C/N0 (carrier-to-noise) ratios for each satellite that the receiver is tracking, which may be used for sensitivity tests.

4.1.6 Sensitivity

GPS receivers usually have two sensitivity figures specified: Acquisition Sensitivity and Signal Tracking Sensitivity. Acquisition Sensitivity specifies the lowest power level at which the receiver is able to achieve a position fix. Signal Tracking Sensitivity is the lowest power level at which a receiver is able to track an individual satellite.

4.1.6.A Signal Tracking Sensitivity

Perform the following steps for signal tracking sensitivity test.

- | STEP | PROCEDURE |
|------|--|
| 1 | If connecting GPSG-1000 via Antenna Coupler, perform Antenna Coupler Installation procedure Section 4.1.1. If directly connecting GPSG-1000 to GPS receiver under test, proceed to step 2. |
| 2. | Perform Setup procedure Section 4.1.2. |
| 3. | Select Launch Bar tab to display launch bar. Select SV PRN function key to display the SV PRN Function Window. The GPS SV's in view will be displayed in a table. |
| 4. | Turn ON a single high elevation SV by selecting ON/OFF field to ON in the SV line and then select Apply . Select the close icon to close the Function Window. |



Fig. 4-2 SV PRN Single SV Selection

- Select **RF Level** and set to -136 dBm.

NOTE:

This is 6 dB above the typical GPS receiver positional tracking sensitivity of -142 dBm. If the active antenna is not in circuit, the gain of the antenna should be subtracted from these figures.

STEP	PROCEDURE
6.	Reduce the RF level in 0.1 dB increments until the specified C/N0 is displayed on the receiver test page or read from the receiver using the NMEA-183 protocol.

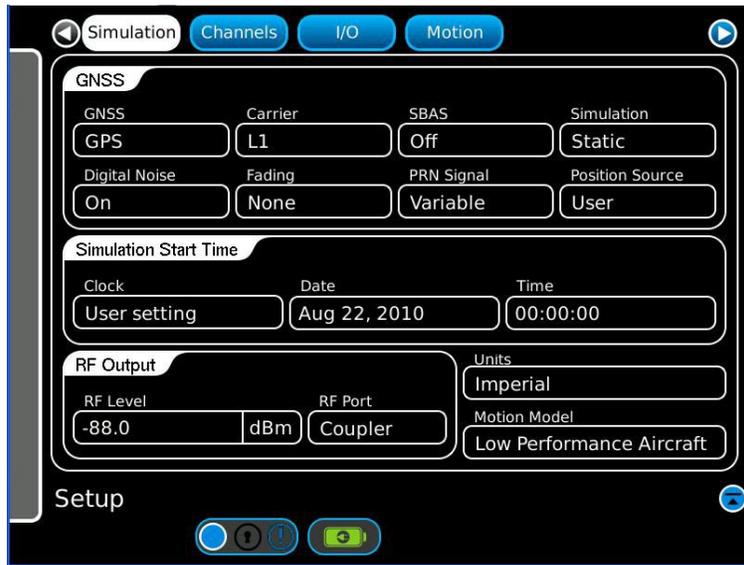


Fig. 4-3 Simulation Function Window

4.1.6.B Acquisition Sensitivity

Perform the following steps for acquisition sensitivity test.

STEP	PROCEDURE
1	If connecting GPSG-1000 via Antenna Coupler, perform Antenna Coupler Installation procedure Section 4.1.1. If directly connecting GPSG-1000 to GPS receiver under test, proceed to step 2.
2.	Perform Setup procedure Section 4.1.2.
3.	Select Launch Bar tab to display launch bar. Select SV PRN function key to display the SV PRN Function Window. The GPS SV's in view will be displayed in a table.
4.	Turn ON all SV's by selecting ON/OFF field to ON in each SV line, then select Apply . Select the close icon to close the Function Window. On the Setup Simulation Function Window Select PRN Signal drop down menu. Select VARIABLE to ensure the relative SV signal levels are set proportional to the respective pseudo ranges
5.	Select RF Level and set to -136 dBm.

NOTE:

This is 6 dB above the typical GPS receiver positional tracking sensitivity of -142 dBm. If the active antenna is not in circuit, the gain of the antenna should be subtracted from these figures.

6. Increase the RF Level in steps of 0.5 dB, until positional fix is displayed on the receiver or read from the receiver using the NMEA-183 protocol. Allow several minutes at each power level.
7. Increase the **RF Level** in steps of 0.5 dB until the positional fix is displayed on the receiver or read from the receiver using the NMEA-183 protocol. Allow several minutes at each power level.

NOTE:

This is 6 dB above the typical GPS receiver positional tracking sensitivity of -142 dBm. If the active antenna is not in circuit, the gain of the antenna should be subtracted from these figures.

4.1.6.C C/N₀ Measurement Options

In scenarios where measurement speed is important, such as a production environment, you can use a higher C/N₀ value and extrapolate the sensitivity information from the result.

There is a linear relationship between RF power and C/N₀ ratio, refer to table 4-2. As an alternative to measuring the receiver’s C/N₀ ratio at the given sensitivity level, it is possible to derive sensitivity based on the C/N₀ at a different power level. Typical receiver C/N₀ ratio is 28 to 32 dB-Hz to achieve a position fix. If the receiver reports a C/N₀ value of 28 dB-Hz at -145 dBm, it also reports a C/N₀ value of 43 dB-Hz at -130 dBm.

NOTE:

It is important that a given receiver is first characterized by measuring the acquisition sensitivity to ensure that receiver self-interference (e.g. spurs) or digitization noise, does not adversely effect the C/No figure before applying this technique.

While the exact RF level used to measure sensitivity varies from one receiver to the next, the ratio of the receiver of C/N₀ to RF power level is perfectly linear.

RF Level	Receiver C/N ₀
-110.0 dBm	56 dB -Hz
-115.0 dBm	56 dB -Hz
-120.0 dBm	53 dB -Hz
-125.0 dBm	48 dB -Hz
-130.0 dB	43 dB -Hz
-135.0 dB	38 dB -Hz
-140.0 dB	33 dB -Hz
-145.0 dB	28 dB -Hz

Table 4-2 Typical Receiver C/N₀ as a function of RF level

When a high input level is used to stimulate the C/N₀ ratio, the receiver reports the maximum possible C/N₀ value allowed by the chipset. Typically this figure is between 54 to 66 dB -Hz, (56 dB - Hz in Table 4-2 example).

4.1.7 Measuring Time to First Fix (TTFF) and Position Accuracy

TTFF and position accuracy measurements are important parameters in GPS receiver testing. In many GPS applications, the time it takes for the receiver to return its actual location can significantly affect the receiver’s usability. In addition, the accuracy with which a receiver returns its reported location is important.

For a receiver to obtain a position fix, it must download the almanac and ephemeris information from the satellite through a navigation message. Because it takes 30 seconds for a receiver to download an entire GPS frame, a “cold start” TTFF condition can take anywhere from 30 to 60 seconds.

Signal strength also is a factor in correlation lock time and hence TTFF.

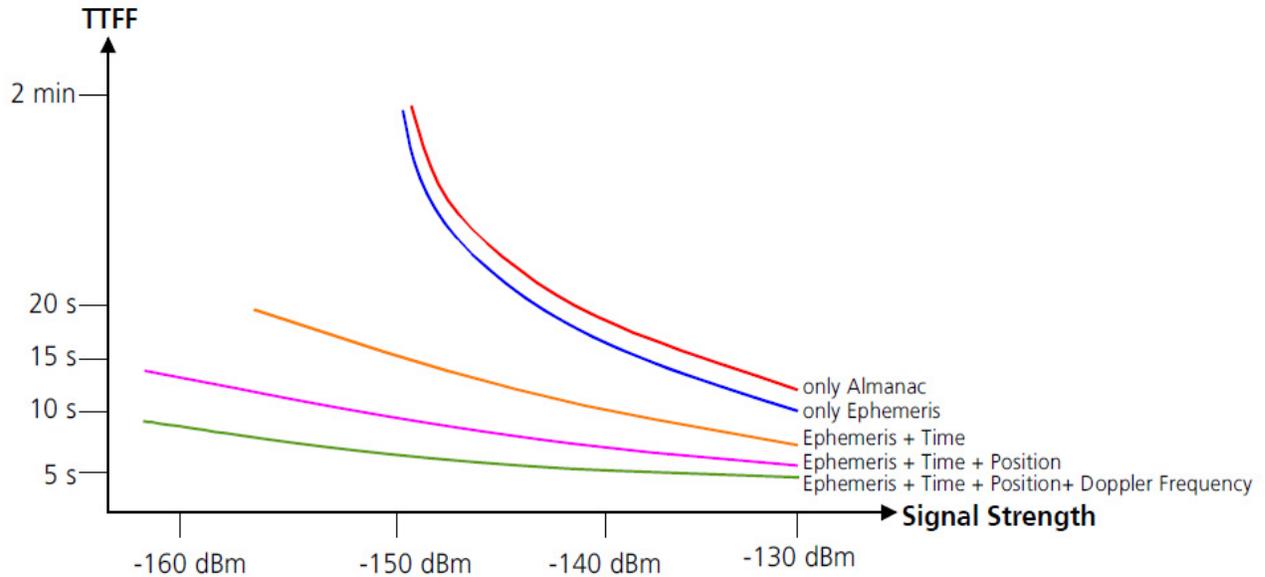


Fig. 4-4 TTFF vs. Signal Strength

Many receivers specify several TTFF conditions, including Acquisition (cold and warm start), Reacquisition (hot start) and Positional Accuracy.

4.1.7.A Acquisition (cold start)

Under this condition the receiver does not have any current Almanac or Ephemeris data and has no memory of previous location. Firstly, at least one GPS frame must be downloaded from each of the SV's in view however, as the receiver does not even know its approximate location and hence what SV's may be in view, this requires all SV PRN codes to be searched, over 5000 Hz Doppler frequency shift. Most modern receivers achieve a position fix from a cold start condition in 30 to 60 seconds. In older receivers this process may take several minutes.

Perform the following steps for Acquisition (cold start) TTF measurement.

STEP	PROCEDURE
1.	If connecting GPSG-1000 via Antenna Coupler, perform Antenna Coupler Installation procedure Section 4.1.1. If directly connecting GPSG-1000 to GPS receiver under test, proceed to step 2.
2.	Perform Setup procedure Section 4.1.2.
3.	Ensure GPS receiver is in cold start mode i.e. no almanac or ephemeris in memory.
4.	Select Launch Bar tab to display launch bar. Select SV PRN function key to display the SV PRN Function Window. The GPS SV's in view will be displayed in a table (Fig 4-4).
5.	Turn ON all SV's by selecting ON/OFF field to ON in each SV line and then select Apply . Select the close icon to close the Function Window.
6.	On the Setup Simulation Function Window select PRN Signal drop down menu. Select VARIABLE , this ensures the relative SV signal levels are set proportional to the respective pseudo ranges.
7.	Select RF Level and set to the receiver manufacturers TTFF RF level.
8.	Select Run key to restart simulation and measure the Time to Fix (TTF).

4.1.7.B Acquisition (warm start)

The receiver has some almanac information that is less than one week old but does not have any ephemeris information.

NOTE:

Ephemeris information is only valid for 4 hrs. Typically, the receiver knows the time to within 20 seconds and the position to within 100 km. Most modern GPS receivers achieve a position fix from a warm condition in less than 60 seconds but can sometimes achieve a position fix in much less time.

Perform the following steps for Acquisition (warm start) TTF measurement.

STEP	PROCEDURE
1,	If connecting GPSG-1000 via Antenna Coupler, perform Antenna Coupler Installation procedure Section 4.1.1. If directly connecting GPSG-1000 to GPS receiver under test, proceed to step 2.
2.	Perform Setup procedure Section 4.1.2.
3.	Ensure GPS receiver is in warm start mode i.e. no ephemeris in memory or receiver has not seen an ephemeris for over 4 Hrs.
4.	Select Launch Bar tab to display launch bar. Select SV PRN function key to display the SV PRN Function Window. The GPS SV's in view will be displayed in a table.
5.	Turn ON all SV's by selecting ON/OFF field to ON in each SV line and select Apply . Select the close icon to close the Function Window.
6.	On the Setup Simulation Function Window select PRN Signal drop down menu. Select VARIABLE , this ensures the relative SV signal levels are set proportional to the respective pseudo ranges.
7.	Select RF Level and set to the receiver manufacturers TTFF RF level.
8.	Select Run key to restart simulation and measure the Time to Fix (TTF).

4.1.7.C Reacquisition (hot start)

The receiver has up-to-date almanac and ephemeris information, has not been turned off for more than two hours and has not moved location more than 100m. In this scenario, the receiver needs to obtain only timing information from each SV to return its position fix location. Most modern GPS receivers return a position fix from a hot start condition within 0.5 to 20 seconds.

Perform the following steps for Reacquisition (hot start) TTF measurement.

STEP	PROCEDURE
1.	If connecting GPSG-1000 via Antenna Coupler, perform Antenna Coupler Installation procedure Section 4.1.1. If directly connecting GPSG-1000 to GPS receiver under test, proceed to step 2.
2.	Perform Setup procedure Section 4.1.2.
3.	Select Launch Bar tab to display launch bar. Select SV PRN function key to display the SV PRN Function Window. The GPS SV's in view will be displayed in a table.
4.	Turn ON all SV's by selecting ON/OFF field to ON in each SV line and select Apply . Select the close icon to close the Function Window.
5.	On the Setup Simulation Function Window select PRN Signal drop down menu. Select VARIABLE , this ensures the relative SV signal levels are set proportional to the respective pseudo ranges.
6.	Select RF Level and set to the receiver manufacturers TTFF RF level.
7.	On the Simulation Function Window select the Run key to start the simulation. Wait until a position fix is achieved and select the Stop Key .
8.	Wait 60 seconds and then select Run key to restart simulation and measure the Time to Fix (TTF).

4.1.7.D TTFF Accuracy

As GPS satellites circle the earth every 12 hours, the range of available satellites varies substantially throughout the course of one day. TTFF and position accuracy are usually specified at a specific power level and to ensure that your receiver returns the appropriate result under a broad range of conditions it is useful to verify the accuracy of both of these specifications under a variety of circumstances.

The GPSG-1000 allows the user to enter a specific UTC time, which correlates with the almanac loaded in the test set. This feature allows a 3D position to be entered, which is then simulated utilizing either optimal geometry satellites automatically determined, or user selected satellites, available in that location, at that time, thereby providing a means to verify receiver positional accuracy under variable conditions.

NOTE:

As GPS and Galileo time are different, the GPSG-1000 allows a common frame of reference by utilizing UTC time for testing.

When measuring TTFF, first start the GPSG-1000. After five seconds, manually place the receiver into “cold” start mode. Once the receiver obtains a position fix, it reports the TTFF information. Example results for Cold and Hot TTFF are shown in Table 4-3.

All table simulations utilize the same 3D position.

Initial UTC	Cold TTFF (S)	Hot TTFF (S)	Maximum SV C/No	SV's
10:14:02m	38.21	1.30	46	6,9,12,14,2
14:06:18	32.01	0.52	49	16,21
16:12:01m	33.09	0.60	47	11,4,8
18:32:22	36.45	1.21	46	24,9,7,15
Average	34.94	0.90	47	
Standard DEV	2.88	0.40	1.41	

Table 4-3 TTFF Values for Four Simulations at Different UTC

4.1.7.E Positional Accuracy

3D position accuracy and repeatability can be determined by creating simulations at various UTC's. It is important to test accuracy at various UTC's, because the available satellites and their geometries, change substantially even over the course of several hours. An example of latitude, longitude and altitude information, taken at four different UTC's, is shown in Table 4-4.

Initial UTC	Latitude	Longitude	Alt (MSL)	Horizontal Error (m)
10:14:02m	37.658331	-97.438891	603.000000	0.268341
14:06:18	37.658325	-97.438888	597.000000	0.900046
16:12:01m	37.658320	-97.438887	598.000000	1.457469
18:32:22	37.658310	-97.438891	601.000000	2.559818
Average	34.94	97.438889	599.750000	1.296419
Standard DEV	2.88	0.00000156	2.75378527	.0972312
SIM Position DEC	2.88	-97.438889	-	
SIM Position	2.88	97:96:20 E	600.000000	

Table 4-4 Horizontal Accuracy for Various UTC Simulations

Table 4-4 shows that you can calculate horizontal error in meters absolutely based on the simulated position. The horizontal error is determined from the equation:

$$Error(m) = \sqrt{\left((LatitudeError(m) \times 111325m)^2 + (LongitudeError(m) \times 111325m)^2 \right)}$$

The accuracy that a receiver can attain, is highly dependent on the available satellites that it has to lock to. Whilst a receiver's accuracy will vary over the course of several hours (when satellites change), the positional repeatability for a given UTC will usually result in only a small deviation. With the GPSG-1000, you can perform multiple trials of a particular simulated 3D position. This also can confirm that the GPSG-1000 does not add uncertainty to the simulated GPS signal.

4.1.8 RAIM Testing and SV Geometry

The orbital characteristics of SV's within a GPS constellation are contained in the transmitted almanac and ephemeris data. The GPSG-1000 does not permit the user to directly change individual SV orbital parameters, therefore individual SV Elevation and Azimuth, at any UTC within the simulation, are determined by almanac and the ephemeris generated from the almanac.

RAIM requires at least 5 SV's to be in view and monitors specific accuracy boundaries which if crossed, will initiate specific alerts. Positional accuracy is dependent on SV geometry, examples of poor geometry are groups of SV's with azimuth angles close together and/or groups of SV's with low elevation angles. Positions with low elevation SV 's will also exhibit low relative RF Levels, due to the longer pseudo ranges. Due to the SV orbital plane inclination of 55 deg, positions in temperate latitudes, the equator and polar regions.

Temperate latitudes exhibit SV azimuths that range in an arc either side of 90 and 270 degs.

Equator exhibits SV azimuths through a full 360 degs and elevations up to 90 deg.

Polar regions at 0 and 180 deg. Polar regions are devoid of satellites. Polar positions exhibit SV elevations that are low on the horizon.

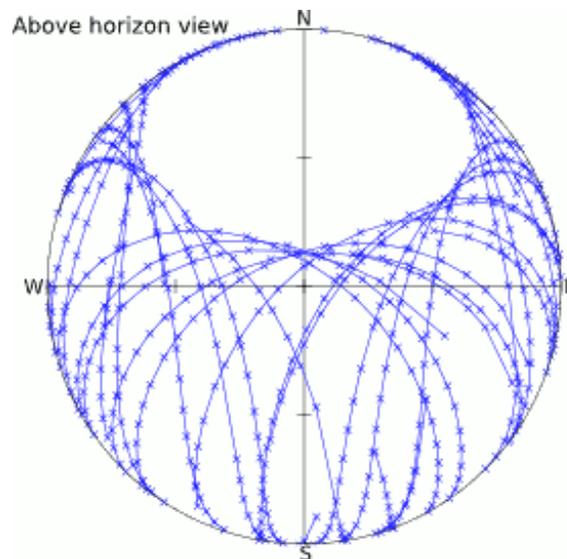


Fig. 4-5 Global SV Tracks

The simulated position and Almanac/Ephemeris UTC, will determine the individual SV's elevation, azimuth and RF level. The SV PRN Elevation and Azimuth indications are used to select combinations of SV's that exhibit poor geometry for RAIM testing.

A bad geometry scenario may be setup in the SV PRN table by selecting only low elevation SV's, only SV's with closely spaced azimuths or only high elevation SV's.

Alternatively polar positions may be simulated, which inherently have low elevation SV's. SV health may be set to BAD to ensure the receiver does not use that SV.

Chapter 5 - Maintenance

5.1 INTRODUCTION

5.1.1 Visual Inspections

Visual inspections should be performed periodically depending on operating environment, maintenance and use.

5.1.2 External Cleaning

STEP	PROCEDURE
1.	Clean front panel buttons and display face with soft lint-free cloth. If dirt is difficult to remove, dampen cloth with water and a mild liquid detergent.
2.	Remove grease, fungus and ground-in dirt from surfaces with soft lint-free cloth dampened (not soaked) with isopropyl alcohol.
3.	Remove dust and dirt from connectors with soft-bristled brush.
4.	Cover connectors, not in use, with suitable dust cover to prevent tarnishing of connector contacts.
5.	Clean cables with soft lint-free cloth.
6.	Paint exposed metal surface to avoid corrosion.

5.2 MAINTENANCE PROCEDURES

5.2.1 Battery Replacement

Perform the following steps to replace battery:

STEP	PROCEDURE
1.	Verify the GPSG-1000 is OFF and not connected to AC power via the AC Adapter.
2.	Place the GPSG-1000 on a flat surface, lower side up.
3.	Lift the battery cover Pull Tab to a vertical position to release the Battery Cover and lift away from the Case Assembly. NOTE: Some batteries may be fitted with a sliding catch. Depress catch to release battery. Tip the unit backwards to release the battery. Remove the battery from the battery housing (Fig 5-1).
4.	Install new battery in the battery housing.
5.	Replace the battery cover on the case assembly by locating the lipped end of the cover in the case assembly. Lift the pull tab and push the battery cover down, ensuring the catch engages. Release the pull tab and ensure battery lays flat inside the recess. NOTE: Some batteries may be fitted with a sliding catch. Depress catch to install the battery.

WARNING

DISPOSE OF OLD BATTERY ACCORDING TO LOCAL STANDARD SAFETY PROCEDURES.



Fig. 5-1 Battery Replacement

5.2.2 GPSG-1000 Software Update Procedure

Perform the following steps to Update GPSG-1000 Software via the USB port using a USB memory device*:

NOTE: A Service Information Letter (SIL) is released with each new software release. The SIL contains important information regarding the software update content, and the software update process. The SIL should be read carefully before any update is attempted.

STEP	PROCEDURE
1.	Using your PC, obtain the latest software update zip file from VIAVI Solutions.
2.	Insert a USB memory device* into the PC and copy the zip file to the root directory of the USB memory device.
3.	Remove any "Instrument" directories that may reside on the root directory of the USD memory device. NOTE: VIAVI recommends using a blank USB device for this procedure.
4.	Unzip the file onto the root directory of the USB memory device.
5.	Upon completion, an Instrument/Common/ directory will be created that contains all the rpm files for the update.
6.	Safely remove the USB memory device from the PC.
7.	Power up the GPSG-1000.
8.	Once booted, select System then select System Update from the drop down menu.

STEP	PROCEDURE
9.	Insert the USB memory device in USB Host 1 or Host 2 Port.

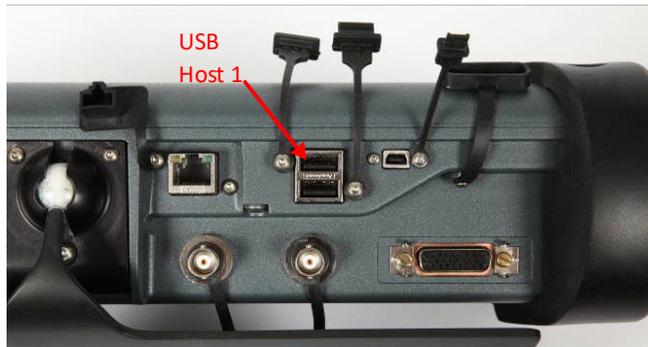


Fig. 5-2 USB Ports

10. Wait 5 to 10 seconds for the device to be recognized and select **Copy from USB.**** The status screen should indicate 'Copying Software Update'.

NOTE: This step may take several minutes.

NOTE: RPMs with older version numbers will not be displayed.

NOTE: Once all of the files have been copied from the USB Memory Device to the GPSG-1000 internal memory, the files to be updated will be displayed in the RPM LIST window and the message FILES ARE READY TO INSTALL will be displayed in the STATUS window.

11. Select **Install Software.** The update will start and the progress screen appears.
12. When all RPM files have been installed a pop up will be displayed instructing the operator to PLEASE CYCLE POWER ON THE UNIT. To cycle power on the unit press and hold the Power On button on the front of the GPSG-1000 for one second and release.

Note: During the update process the system is performing many operations and may take up to 45 seconds to respond to the power down request.

13. Remove the USB memory device and follow the instructions displayed on the unit.

* Recommended USB memory Device: VIAVI Solutions PN 67325.

** If you experience a USB Error when trying to copy from USB, the USB memory device being used may not be compatible with the GPSG-1000.

5.2.3 GPSG-1000 Debug Files

Debug Files:

If the GPSG-1000 encounters a problem during the boot process and is unable to boot up properly, a debug file may be obtained from the GPSG-1000 and sent to VIAVI Solutions to assist in determining the cause of the boot issue.

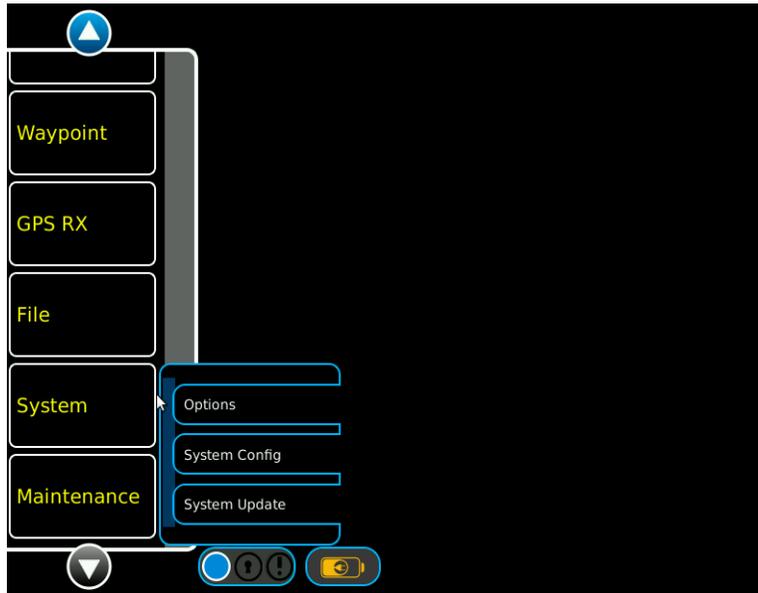
To obtain a copy of the debug files, install a USB memory device into one of the USB ports on the GPSG-1000. Press the power button to turn on the GPSG-1000. During the boot process two text files will be created on the USB Memory Device (Fig. 2-5). One file is called "gps1000rs232.txt"; and the other file is called "gps1000last_rs232.txt"; these files contain the latest debug files.

Each time the GPSG-1000 is booted with the USB Memory Device installed in one of the USB ports, the debug files are overwritten with the latest boot information. The information contained in the debug file is not intended for use by the user. Both files should be sent to VIAVI Solutions if support is being requested for a boot issue.

5.2.4 Identifying Installed Software Version

Perform the following steps to identify the software version installed in the GPSG-1000.

STEP	PROCEDURE
14.	Press the Power On button to turn the test set on.
15.	Allow the test set to complete the boot process, approximately 5.5 mins.
16.	Open the Launch Bar by touching the light gray bar located on the left side of the User Interface and scroll down to the System function key.



STEP	PROCEDURE
17.	Touch the System function key to open the System sub-menu and select System Update.
18.	In the Version window the unit serial number and currently installed software version number is displayed. In the following example, "1000372866" is the unit serial number, and "2.0.0,0" is the currently installed software version number.



5.2.5 GPSG-1000 Almanac Update

Perform the following steps to Update GPSG-1000 Almanac using a USB memory device*:

STEP	PROCEDURE
1.	Obtain the current GPS almanac for the week from the United States Coast Guard Navigation Center at http://www.navcen.uscg.gov/?pageName=gpsAlmanacs and save the file as " current.alm " or as " weekXYZ.alm " with XYZ being the current almanac week (week617.alm).
2.	Copy the almanac file, named " current.alm " to the USB memory device (VIAVI Solutions P/N 67325) under the directory name of Instrument/almanacs/ plus almanac file name (/Instrument/almanacs/week617.alm).
3.	Power up the GPSG-1000.
4.	Select System , then select System Update from the drop down menu on the GPSG-1000.
5.	Insert the USB memory device into USB Host 1 Port or Host Port 2.
6.	Wait 5 to 10 seconds for the device to be recognized and then select Copy from USB .
7.	The Almanac file will be copied to the GPSG-1000.
8.	The status message should read 'Upgrade Done'.
9.	Remove the USB memory device.
10.	Proceed to Setup window, then press Almanac Source . Press File , then select the newly loaded almanac file to load.

5.2.6 Maintenance Function Windows

Selecting the Maintenance icon from the Launch Bar Menu will display the Maintenance sub-menu. The Maintenance sub-menu contains the Calibration and Diagnostics icons.

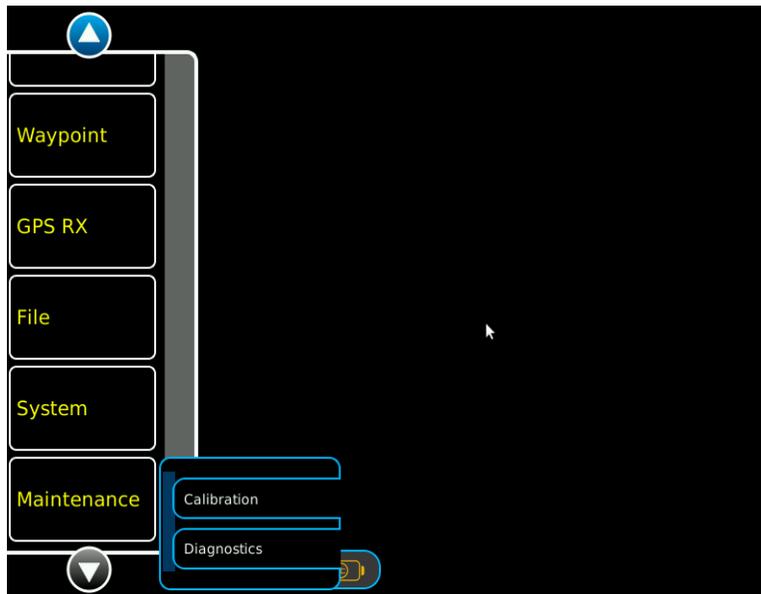


Fig. 5-3 Maintenance Menu

5.2.6.A Calibration Function Window

Selecting Calibration from the Maintenance sub-menu will display the Calibration Password Entry Window. The Calibration Function Window is password protected. Contact VIAVI Solutions for the default password. Enter the password to open the Calibration Function Window.

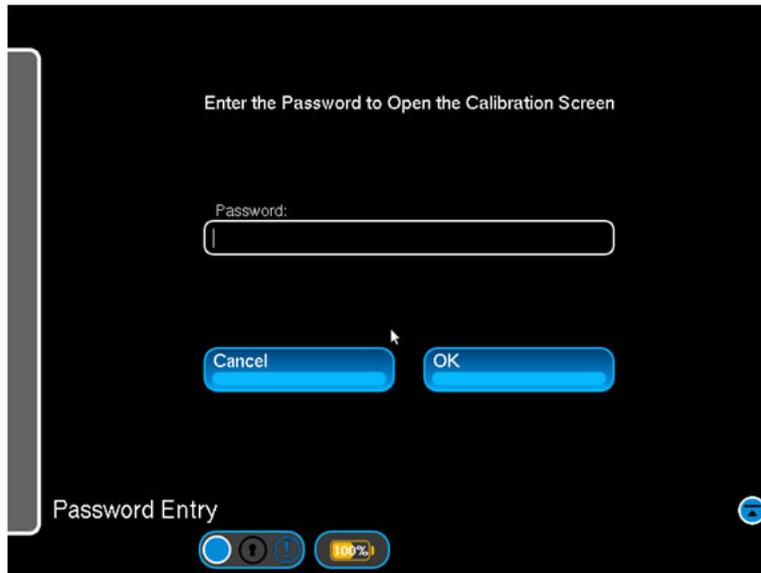


Fig. 5-4 Calibration Password Window

Control Component	Description
Password	Alpha Numeric Pad: Enter password to open the Calibration Function Window. NOTE: Contact VIAVI Solutions for the default password.
Cancel	Closes the Calibration Password Window.
OK	After the Calibration Password has been entered, pressing OK will validate the password and open the Calibration Window if the password is accepted. NOTE: Invalid Password is displayed if the password is entered incorrectly.
Change	Opens Change Password Window. Enter old password, new password and reenter new password to change the password and open the Calibration Function Window.

5.2.6.B Diagnostics Function Window

Selecting Diagnostics from the Maintenance sub-menu will display the Diagnostics Function Window. The Diagnostics Function Window provides control for generating test signals, with specific power and frequency parameters.

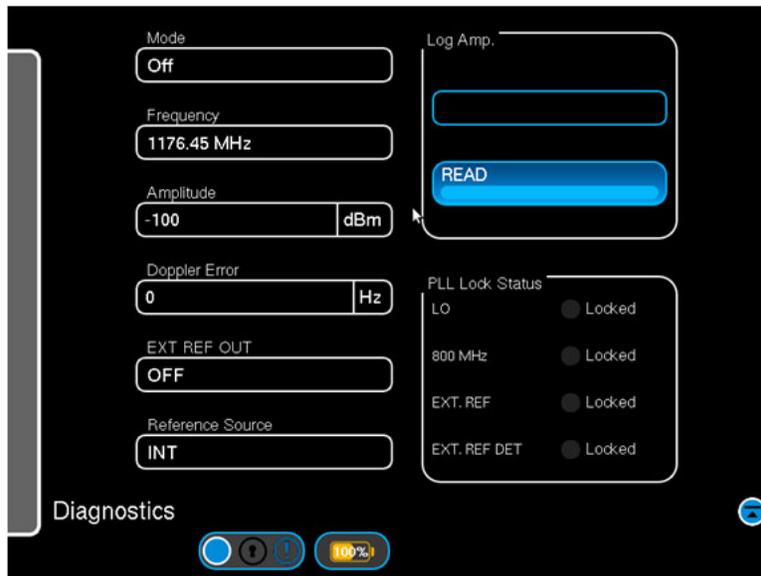


Fig. 5-5 Diagnostics Function Window

Control Component	Description
Mode	Drop down selections: OFF - Diagnostics output disabled and simulation is allowed. CW - Diagnostics output enabled, output is CW and simulation is locked. MODULATED - Diagnostics output enabled, output is modulated GPS signal and simulation is locked.
Frequency	Drop down selections: 1176.45 MHz, 1207.14 MHz, 1227.60 MHz, 1278.75 MHz or 1575.42 MHz.
Amplitude	Numeric pad: Power in dBm. Range -93 dBm to +155 dBm DIRECT or -68 dBm to -130 dBm COUPLER
Doppler Error	Numeric Pad: +/- 5000Hz in 1 Hz increments.
EXT REF OUT	Drop down selections: ON or OFF.
Reference Sources	Drop down selections: INT or EXT.
LOG AMP	Displays the output from the internal up convertor module. Displayed in dB.
Read	Reads the output from the internal up convertor module.
PLL Lock Status	Indicates the state of the LO, 800 Mhz, EXT. REF and EXT. REF DET. ON (Green) indicates locked condition, OFF (Gray) indicates unlocked condition.

5.2.7 System Function Windows

Selecting the System icon from the Launch Bar Menu will display the System sub-menu. The System sub-menu contains the Options, System Configuration and System Update icons.

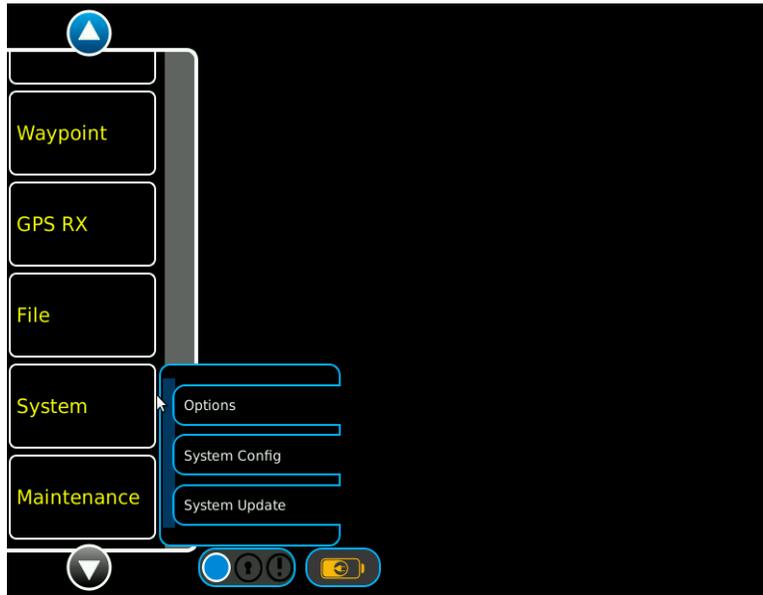


Fig. 5-6 System Menu

5.2.7.A Options Function Window

Selecting Options from the System sub-menu will display the Options Function Window. The Options Function Window provides control for installing or removing options and displays currently installed options.



Fig. 5-7 Options Function Window

Control Component	Description
Copy from USB	Initiates Copy of Option License files from a USB memory device installed in USB Host 1 or USB Host 2.
Copy from Server	Initiates Copy of Option License files from a server. NOTE: Factory use only.
Install License	Installs Option License files that have been copied to the internal memory.
Remove License	Removes Option License files. NOTE: This will permanently remove installed options.
Display Component	Description
Status	Displays status messages to inform the user of progress or errors.
Serial Number	Displays the serial number of the GPSG-1000.
Unique ID	Displays the Unique ID of the GPSG-1000.
Option	Displays installed options.
User	Displays User log-in ID. NOTE: Default is ALL if no user login required.
Installed	Displays date option was installed.
Expires	Displays date option expires. NOTE: If no expiration date displays -1.
Server IP	Numeric Pad: Enter the Server IP address.

5.2.7.B System Configuration Function Window

Selecting System Configuration from the System sub-menu will display the System Configuration Function Window. The System Configuration Function Window displays five selectable tabs across the top of the screen. Status, Hardware, UI Options, Network and Date/Time.

5.2.7.C Status

The Status tab displays test memory status, operating time, hardware module temperatures and provide internal SD card formatting control.

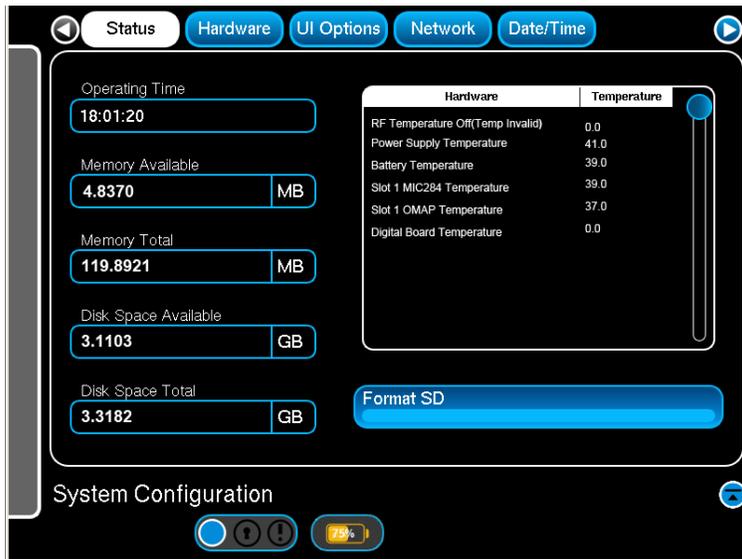


Fig. 5-8 System Configuration - Status

Display Component	Description
Operating Time	Displays the total operating time in hrs: mins:secs since power up.
Memory Available	Displays memory available to software resources in GB, MB or KB.
Memory Total	Displays total test set memory in GB, MB or KB.
Disk Space Available	Displays remaining disk space available in GB, MB or KB for settings and profile storage.
Disk Space Total	Displays total test set disk space in GB, MB or KB.
RF Temperature	Displays the current RF card temperature in degrees Celsius.
Power Supply Temperature	Displays the current power supply module temperature in degrees Celsius.
Battery Temperature	Displays the current battery pack temperature in degrees Celsius.

Display Component	Description
Slot 1 MIC284 Temperature	Displays the current PXI slot 1 controller MIC284 temperature in degrees Celsius.
Slot 1 OMAP Temperature	Displays the current PXI slot 1 controller OMAP processor temperature in degrees Celsius.
Digital Board Temperature	Displays the current PXI digital board temperature in degrees Celsius.

Control Component	Description
Format SD	Formats the internal SD memory card overwriting all stored data. NOTE: The user will be prompted YES or NO prior to execution of formatting. Caution: Formatting will result in complete irretrievable loss of almanac, route, setting, Nmea, Kml, and waypoint data

5.2.7.D Hardware

The Hardware tab displays hardware module/board identification, version and software revision numbers for configuration control purposes.

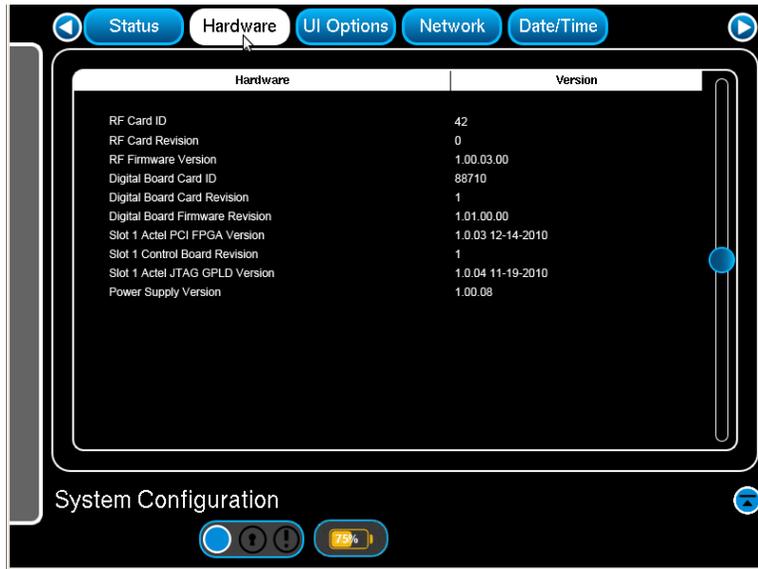


Fig. 5-9 System Configuration - Hardware

Display Component	Description
Digital Board Card ID	Displays digital board card ID number
Digital Board Card Revision	Displays digital board card version number
Digital Board Bus Firmware Version	Displays digital board firmware version number
Digital Board Application Firmware Version	Displays digital board application firmware version number
Upconverter Card ID	Displays upconverter card ID number
Upconverter Card Revision	Displays upconverter card revision number
Upconverter Firmware Version	Displays upconverter firmware version number
RF Combiner Card ID	Displays RF combiner card ID number
RF Combiner Card Revision	Displays RF combiner card revision number
RF Combiner Firmware Version	Displays RF combiner card firmware version number
Slot 1 PCI Net Version	Displays PCI net version number

Slot 1 CPLD Version	Displays Slot 1 CPLD version number
Slot 1 FPGA Version	Displays Slot 1 FPGA version number
Slot 1 Board Revision	Displays Slot 1 Board Revision number
Power Supply Version	Displays power supply version number

5.2.7.E UI Options

The UI Options tab controls the screen backlight level.

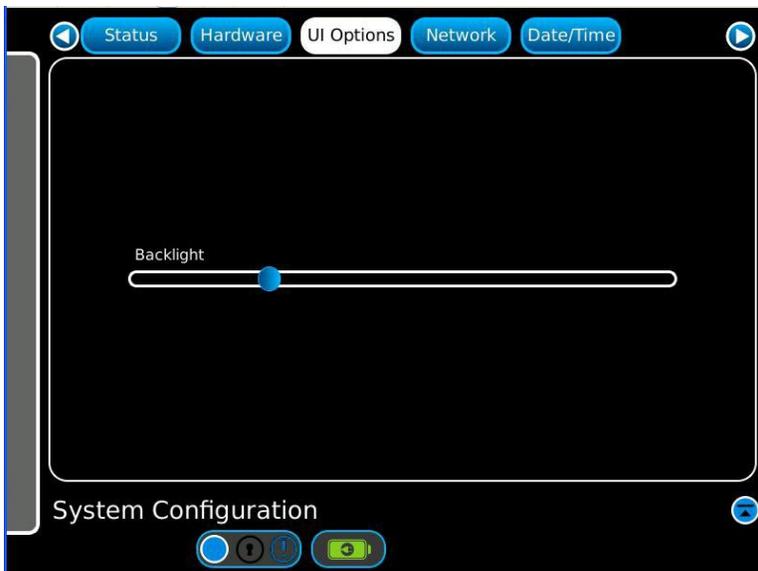


Fig. 5-10 System Configuration – UI Options

Control Component	Description
Backlight	Move the slider to the right to increase backlight level. Move the slider to the left to reduce backlight level.

5.2.7.F Network

The Network tab controls the test set Ethernet adapter local area connection settings. The Ethernet bus is used for remote control of the test set.

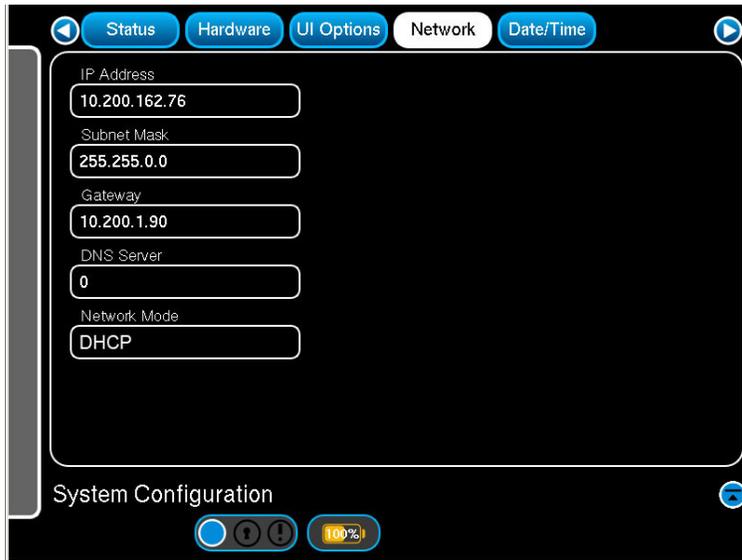


Fig. 5-11 System Configuration – Network

Control Component	Description
IP Address	Numeric pad: IP address, entry in the format 10.200.120.148 (example).
Subnet Mask	Numeric pad: Subnet mask, entry in the format 255.255.255.0 (example).
Gateway	Numeric pad: Gateway, entry in the format 10.101.0.1 (example). NOTE: This field is only active when Network Mode = DHCP.
DNS Server	Connection specific Domain Name Server suffix. NOTE: Reserved for future use.
Network Mode	Drop down menu: Selections Network Off – Disables Ethernet adapter. DHCP – Uses dynamically allocated address from DHCP server. Static IP - Uses entered static IP address. NOTE: Server will populate IP Address, Subnet Mask and Gateway fields automatically. NOTE: The unit must be connected to a LAN before any change to this field is allowed.

5.2.7.G Date/Time

The Date/Time tab controls the test set date /time clock parameters.



Fig. 5-12 System Configuration – Date/Time

Control Component	Description
Time	Numeric pad: Time entry in the 24 Hour format HH:MM:SS.
Date	Numeric pad: Date entry in the format MM:DD:YYYY. NOTE: The unit time and date will be automatically updated once a 3D fix is registered by the unit's internal GPS receiver.

THIS PAGE INTENTIONALLY LEFT BLANK.

Chapter 6 - Principles of Operation

6.1 PRINCIPLES OF OPERATION

6.1.1 GPSG-1000

6.1.1.A Satellite Simulation

The orbit parameters for each satellite are configurable in terms of the standard Keplerian (almanac) elements. The almanac used for simulation may be selected from a list, maintained by a file management system. The files may be obtained from the built-in GPS receiver, as a current almanac load or may be loaded from a USB flash drive in Yuma .alm format.

The standard Keplerian elements (almanac) are used to calculate the enhanced Keplerian Elements (ephemeris), which are in turn used to generate the satellite motion, and are broadcast as part of the navigation message.

As almanac data is typically valid for several days, the GPSG-1000 does not update the standard Keplerian (almanac) elements during the course of the simulation.

The GPSG-1000 computes the enhanced Keplerian (ephemeris) elements by extrapolation of the configured standard Keplerian (almanac) elements. Any enhanced Keplerian elements not included in the standard Keplerian elements are set to zero. The GPSG-1000 generates updated enhanced Keplerian (ephemeris) elements at a fixed time interval of 4 hours, this being the update rate supported by both GPS and Galileo. The GPSG-1000 generates in real time the positions of all simulated Satellites i.e. positions are not pre-computed for the entire simulation run.

6.1.1.B Satellite Selection

For each simulated GNSS system the GPSG-1000 will perform an independent satellite selection process and if the total number of visible satellites exceeds the maximum number of hardware channels allocated to that system, then the GPSG-1000 will select those satellites which approximate the minimum DOP for that system. The GPSG-1000 updates its satellite selection every 60 minutes.

NOTE:

In the case of the 6 channel GPSG-1000, with large numbers of simulated satellites it becomes possible for many more satellites to be visible at the user location than there are available hardware satellite channels. If this happens the GPSG-1000 allocates channels on a 'best effort' basis but does allow the operator to override the selection manually.

The GPSG-1000 allows the operator to manually replace any selected satellite with another visible satellite from the same GNSS system, with the manually selected satellite remaining selected until it is no longer visible, or until it is manually replaced. The manually de-selected satellite will remain eligible for re-selection at the next automatic update.

6.1.2 GPS System

The **NAVSTAR**, (**N**avigation **S**atellite **T**iming **A**nd **R**anging), **GPS**, (**G**lobal **P**ositioning **S**ystem) is a satellite based navigation system offering precision navigation capability. The system was originally designed for military use, funded and controlled by the U.S. Department of Defense. Civilian access has been permitted to specific parts of the GPS.

GPS offers a number of features making it attractive for use in aircraft navigation. Civilian users can expect a position accuracy of 100 m or better in three dimensions. The GPS signal is available 24 hours per day throughout the world and in all weather conditions. GPS offers resistance to intentional (jamming) and unintentional interference. The equipment necessary to receive and process GPS signals is affordable and reliable and does not require atomic clocks or antenna arrays. For the GPS user, the system is passive and requires a receiver only, without the requirement to transmit.

GPS determines the position of the user by triangulation. By knowing the position of the satellite and the distance from the satellite, combinations of satellites can be used to determine the exact position of the receiver. The fundamental means for GPS to determine distance is the use of time. Distance is computed by using accurate time standards and by measuring changes in time.

The GPS System is comprised of three segments:

- Space Segment
- Control Segment
- User Segment

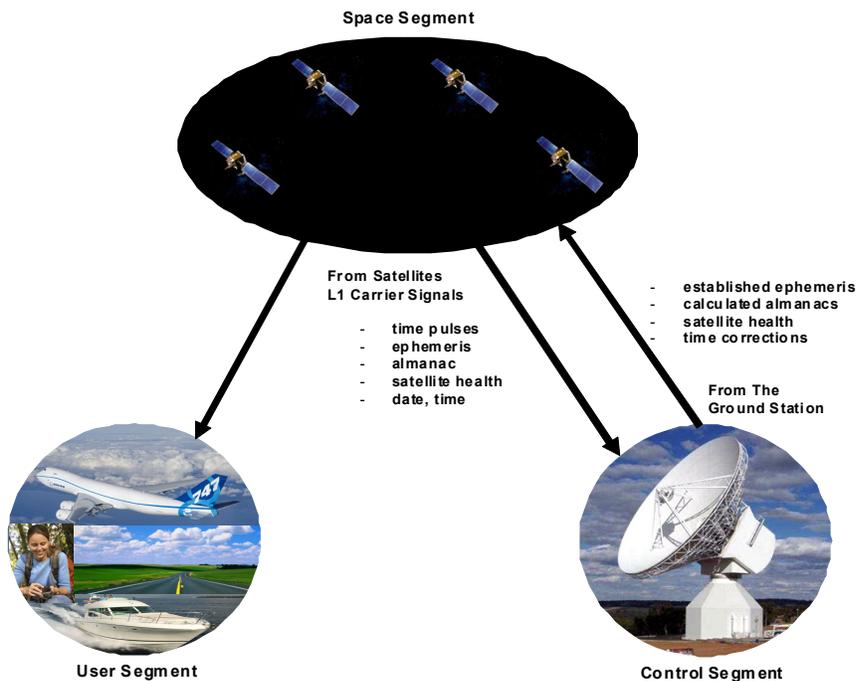


Fig. 6-1 GPS System Segments

6.1.2.A Space Segment

The Space segment consists of the GPS space vehicles (SV's) or Satellites, nominally 24 SV's plus spares. The terms SV and satellite shall be interchangeable in this document. Each vehicle has a 12 hour orbit at 20,200 km above the earth and repeats same ground track daily. 5 to 12 SV's are visible from anywhere on earth.

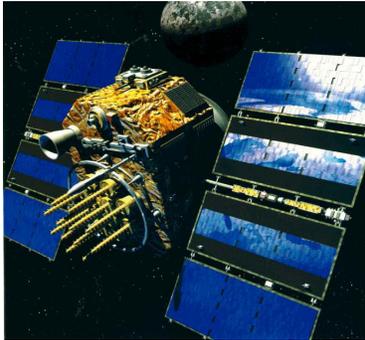


Fig. 6-2 GPS Satellite

Six orbital planes are used, each spaced equally around the earth, separated by 60 degrees ($360 \text{ degrees} / 6 \text{ planes} = 60 \text{ degrees}$) and inclined 55 degrees from equatorial plane. The planes are named A to F. Each orbital plane hosts four satellites. These satellites are not spaced evenly on each plane. Spacing between adjacent satellites varies from 31.13 degrees to 119.98 degrees. Each plane exhibits a different angular spacing for the satellites resident to it.

A computer model determines the satellite spacing to accommodate a single satellite failure and still maintain optimal satellite geometry.

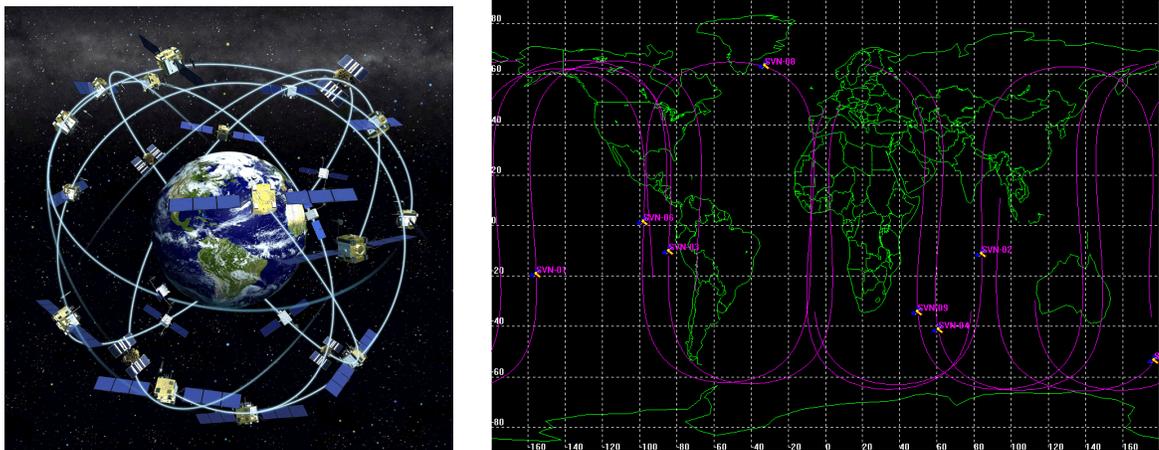


Fig. 6-3 GPS Satellite Orbital Planes

Fig. 6-3 shows the motion of nine satellites. The ground tracks show the movement of these satellites over a twelve hour period and the position of the satellites at one moment in time.

The ground tracks show a number of features. Each satellite follows a unique path over the ground. Also, every satellite operates between 55 degrees North and 55 degrees south.

The primary mission of GPS satellites is the transmission of precisely timed GPS signals and the data stream required to decode the signals to produce a position. The timing signals are referenced to atomic clocks, either cesium or rubidium.

With the GPS satellites in constant motion, the number of satellites in view and their relative location is dynamic. A 24 satellite configuration provides adequate satellite coverage to perform three-dimensional position fixing. Failures of satellites and/or the requirement for more than four satellites may result in inadequate satellite coverage.

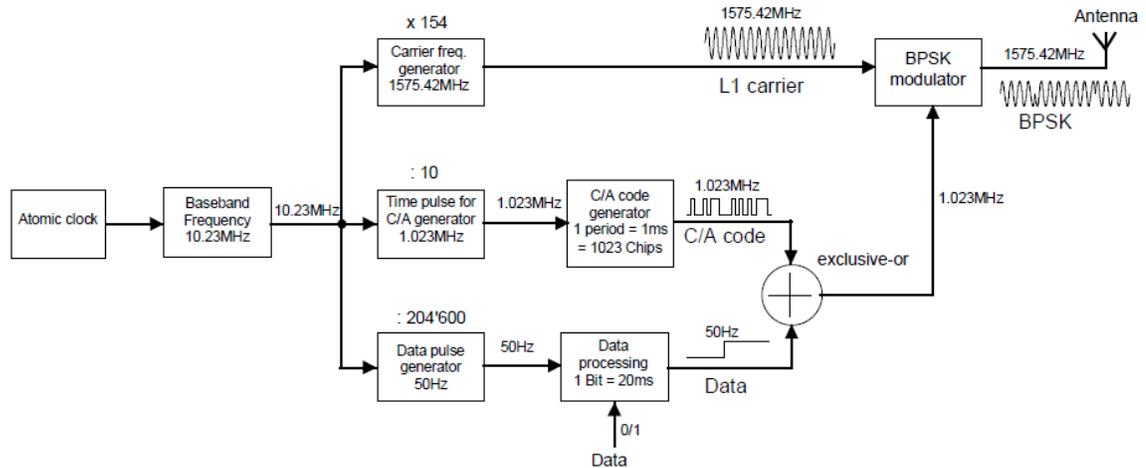


Fig. 6-4 GPS SV Block Schematic

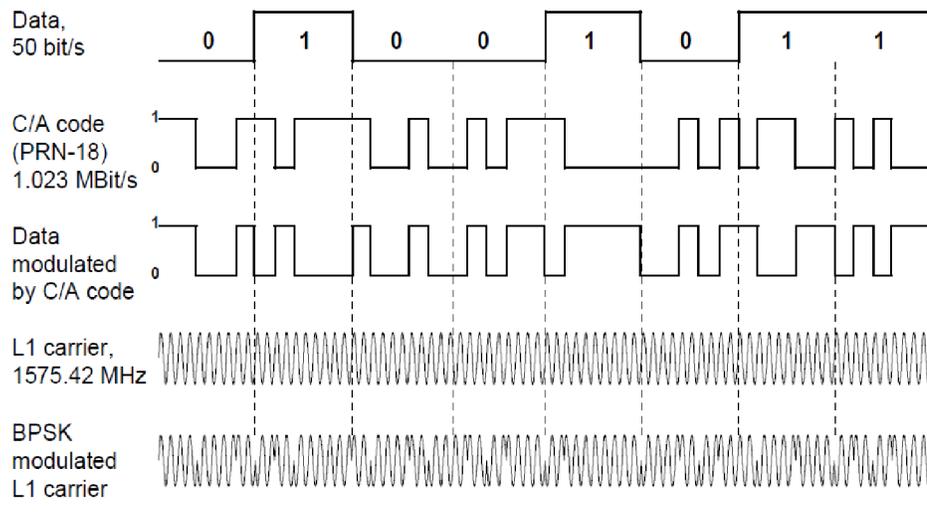


Fig. 6-5 GPS SV Signal Data Structure

Each GPS satellite transmits a unique signature assigned to it on the same carrier frequency. This signature consists of a Pseudo Random Noise (PRN) Code of 1023 zeros and ones, broadcast with a duration of 1 ms and continually repeated. The PRN code is exclusively OR'd (modulo 2 added on), with 50 bit/s Navigation Data (Nav Data). The combined code is then used to BPSK modulate a 1575.42 MHz carrier frequency. The resultant signal is spread spectrum.

6.1.2.B Control Segment

Six unmanned monitoring stations are located throughout the world. Each Station constantly monitors and receives information from the GPS satellites and sends the orbital and clock information to the master control station. Five of these stations (except Hawaii) have the ability to upload information to the GPS satellites

Colorado Springs is designated a Master Control Station (MCS). The MCS constantly receives GPS satellite, orbital and clock information from the monitor stations. The MCS makes precise corrections to the data as necessary and sends the information, known as ephemeris data, to the GPS satellites using ground based antennas.

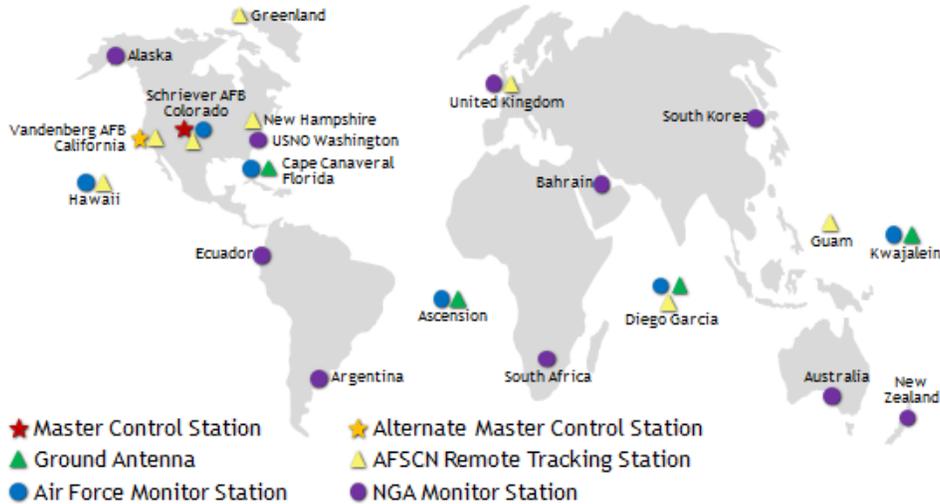


Fig. 6-6 GPS Monitor Stations

The objective of the GPS control segment is:

- Maintain each of the satellites in its proper orbit through infrequent, small commanded maneuvers.
- Make corrections and adjustments to the satellite clocks and payload as needed.
- Track the GPS satellites and generate and upload navigation data to each of the GPS satellites.
- Command major relocations in the event of satellite failure to minimize the impact.

6.1.2.C User Segment

The signals broadcast from the GPS satellites form the means for a GPS receiver to perform the timing and distance calculations. GPS receivers are passive devices, meaning that signals are received only with no requirement or means to transmit.

GPS ranging signals are broadcast on two frequencies: L1 (1575.42 MHz) and L2 (1227.6 MHz). The L1 frequency is available for civilian use. The L2 frequency was designed primarily for Military use.

6.1.3 SPS Standard Positioning Service

The Clear Acquisition Code, or C/A, is the principal civilian ranging signal and is always broadcast in a clear or unencrypted form. The use of this signal is sometimes called the Standard Positioning Service or SPS. This signal may be degraded intentionally but is always available. The signal creates a short Pseudo Random Noise (PRN) code broadcast a rate of 1.023 MHz. The satellite signal repeats itself every millisecond. The C/A code is also used to acquire the P Code.

6.1.3.A PPS Precise Positioning Service

P Code is never transmitted in the clear and is encrypted with a W code. When encrypted the signal is known as P(Y) code and is not available to civilian users. The C/A PRN's are unique for each satellite however, the P-code PRN is actually a small segment of a master P-code approximately 2.35×10^{14} bits in length (235,000,000,000,000 bits) and each satellite repeatedly transmits its assigned segment of the master code.

6.1.4 Position Calculation

Position calculations consists of the following elements:

- Deciding which satellites to acquire and track
- Code and frequency correlation
- Measure distance to satellites
- Obtain satellite positions
- Adjust local clock bias
- Perform triangulation calculations (Trilateration)
- Adjust for time delay errors

6.1.4.A SV's to Acquire and Track

The L1 and L2 frequencies broadcast a GPS Navigation Message (Nav Data) as part of their signal. This low frequency (50 bits per second) data stream provides the receiver with a number of critical items required in determining a position. A data bit frame consists of 1500 bits divided into five, six second 300-bit subframes. A data frame is transmitted every thirty seconds. An entire set of twenty-five frames (125 subframes) makes up the complete Navigation Message that is sent over a 12.5 minute period.

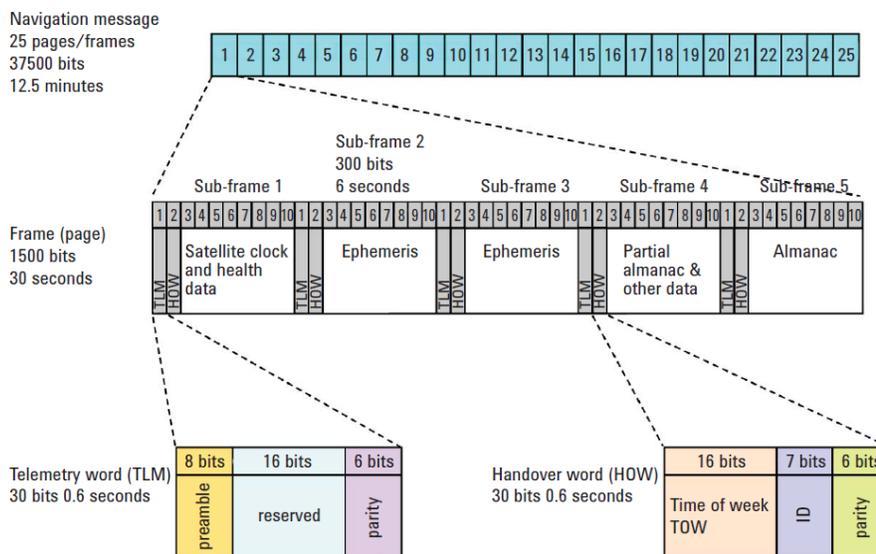


Fig. 6-7 GPS Navigation Data

Subframes

Subframes 1 to 5 each provide a synchronization, hand-over word and a C/A code time ambiguity removal. The remainder of the data is formatted as follows:

Subframe 1:

- Contains the time values of the transmitting satellite, including the parameters for correcting signal transit delay and onboard clock time, as well as information on satellite health and an estimate of the positional accuracy of the satellite.

Subframe 2 and 3:

- Ephemeris.

Subframe 4:

- Ionospheric model, UTC data, flags for each satellite indicating whether anti-spoofing is on, almanac (approximate satellite ephemeris allowing the receiver to select the best set of satellites or to determine which satellites are in view) and health information for satellite number 25 and greater.

Subframe 5:

- Almanac and health information for satellite number 1 to 24.

The reception and decoding of the data stream is performed automatically by a receiver without any intervention by the operator. The information within this data is critical to GPS operation. If a GPS receiver has never seen the GPS constellation before and does not know its approximate location, the first action of the receiver is to acquire any SV in view. Once a satellite has been acquired, the almanac is downloaded.

Refer to Fig. 6-8. Subframes 4 and 5 contain almanac information. Once the almanac is acquired, the information it contains is used to determine which satellites are in view and select the set of satellites with the best geometry. The almanac structure for one SV PRN is shown in Fig. 6-8. Almanac data is typically updated every 24 hours. Data for a few weeks is also provided in case of a delay in update. Once a receiver has an almanac loaded in its memory, it can be used for a faster acquisition of satellites on the next occasion of use. Once a satellite has been acquired, its ephemeris information can be obtained.

```
***** Week 572 almanac for PRN-03 *****
ID:                                03
Health:                            000
Eccentricity:                      0.1350402832E-001
Time of Applicability(s):          405504.0000
Orbital Inclination(rad):          0.9279594421
Rate of Right Ascen(r/s):          -0.8203642210E-008
SQRT(A) (m 1/2):                   5153.669922
Right Ascen at Week(rad):          0.3102266431E+001
Argument of Perigee(rad):          1.020882249
Mean Anom(rad):                    -0.7818025351E+000
Af0(s):                             0.5941390991E-003
Afl(s/s):                           0.3637978807E-011
week:                               572
```

Fig. 6-8 GPS Almanac

The almanac provides a basic description of each satellite orbit. Refer to Fig. 6-9. Two parameters are commonly displayed on GPS receivers which describe the basic position of a satellite relative to a GPS receiver at a specific location.

Elevation describes the angle of a satellite relative to the horizontal plane. If a satellite is directly above the point of observation on the ground, then the elevation is 90°. If the satellite is at the horizon, then the elevation is 0°.

Azimuth is the angle between a reference plane and a point. In the case of satellites the reference plane is the plane of the horizon based on true North. The Azimuth is the angle between the satellite and true North (North = 0°, East = 90°, South = 180°, West = 270°).

Of course many other parameters are used to define satellite orbit. Each satellite will downlink a more precise description of its orbit, which is contained in sub-frames 2 and 3, and is known as ephemeris. With this information the receiver can determine the

satellite's position at any time and combine this with the receiver distance from the satellite, yielding a GPS position.

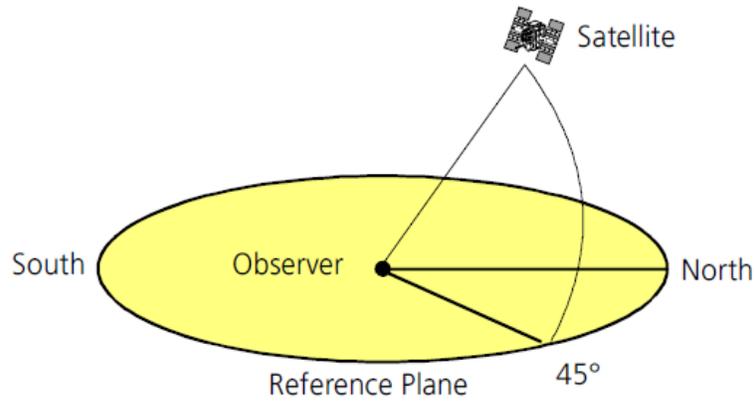


Fig. 6-9 Satellite Relative Position

The health information transmitted in subframe 5, is critical to prevent a receiver from using the ranging information from a satellite that has been declared unfit for navigation purposes.

The remainder of the information found in the data stream (clock corrections, ionospheric model, UTC data) are used to resolve potential sources of GPS position errors.

6.1.4.B Code and Frequency Correlation

The power of the received GPS signal in open sky is at least -160 dBW (-130 dBm). The maximum of the spectral power density of the received signal is -190 dBm/Hz. The spectral power density of the thermal background noise is approximately -174 dBm/Hz (at a temperature of 290 K). Refer to Fig. 6-10. The maximum received signal power is approximately 16 dB below the thermal background noise level

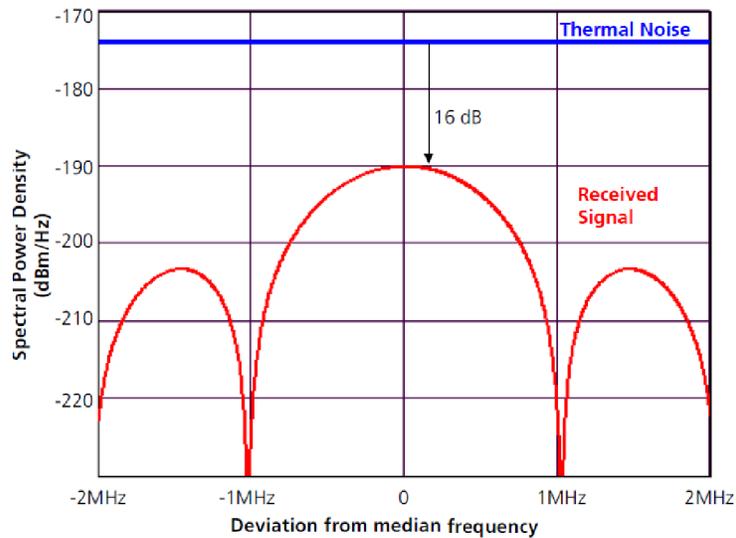


Fig. 6-10 GPS Received Signal

To recover the data from spread spectrum signal at the receiver, the energy spread over a wide bandwidth must be correlated or de-spread into a narrow bandwidth by frequency and code shifting. Fig. 6-11 shows the criticality of correlation in terms of recovering the signal.

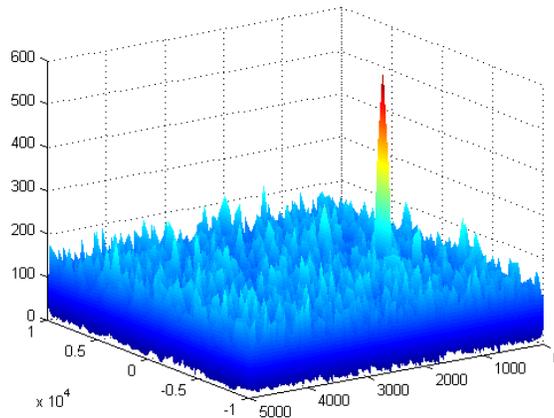


Fig. 6-11 GPS Received Signal

Each GPS satellite transmits a unique PRN code. The receiver first demodulates received BPSK signal to extract the satellite PRN code overlaid with Nav Data. The receiver then generates a local copy of the PRN code and then shifts the timing of the local code by 1 bit, relative to a receiver time mark, until all 1,023 bits of the local code are in phase (correlated), with the PRN code received from the satellite. A modulo 2 addition process is used to recover the Nav Data.

If all 1,023 bit shifts have been tried without achieving correlation, the receiver local oscillator frequency is offset to the next value and the process is repeated. The reason for this frequency offset, is because satellites and receivers are in relative motion to one another and hence Doppler shift in the transmitted carrier frequency occurs. The transmitted signals can be shifted by up to +/- 5000 Hz at the point of reception.

The determination of the signal travel time and data recovery therefore requires not only correlation with all possible codes at all possible phase shifts, but also identification of the correct phase carrier frequency.

In the case of a receiver cold start, where the receiver does not have a current almanac loaded, every PRN would be tried until an SV is found in view, after which the almanac can be downloaded and used to determine which SV's to acquire next. Because the search for the first SV may take some time, GPS receiver cold starts take appreciably longer than warm starts, where the GPS receiver has a current almanac stored in memory.

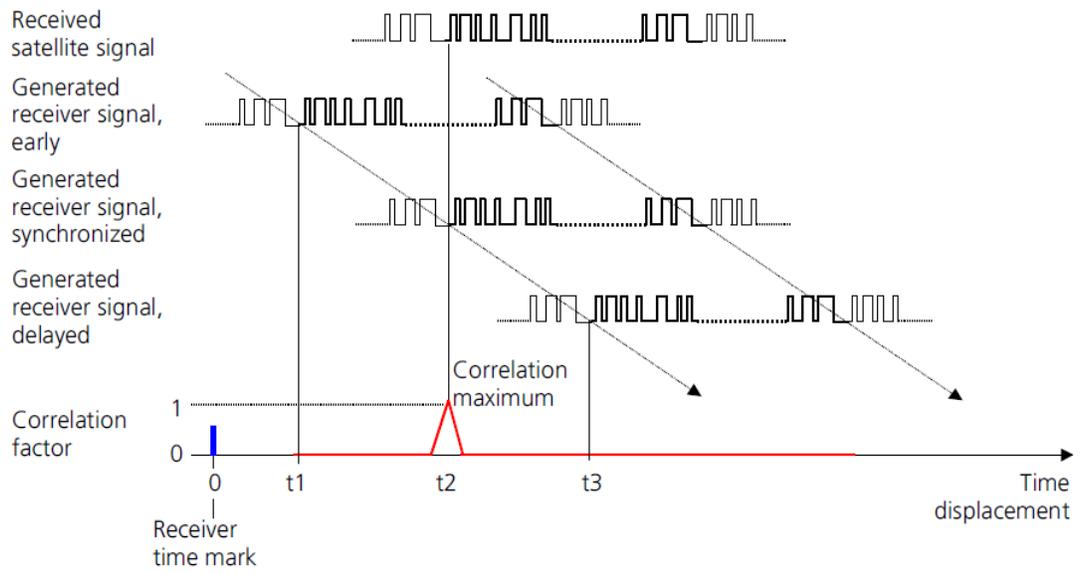


Fig. 6-12 GPS Code Correlation Process

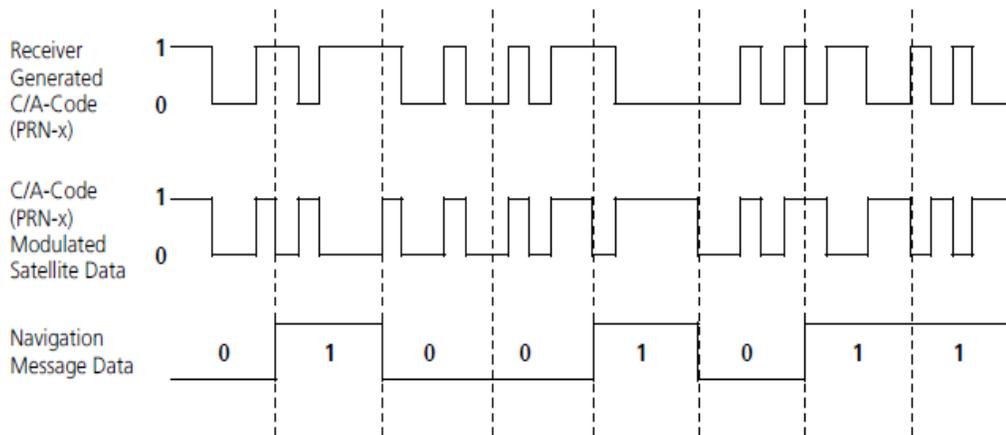


Fig. 6-13 GPS Nav Data Recover by Moduo 2 Addition

The spectral power density of the received GPS signal lays at approximately 16 dB below the spectral power density of the thermal or background noise. The demodulation and de-spreading of the received GPS signal causes a system gain G of:

$$G_G = \frac{\text{Modulation rate of C/A - Code}}{\text{Data rate of information signal}} = \frac{1023\text{bps}}{50\text{bps}} = 20,500 = 43\text{dB}$$

After de-spreading, the power density of the usable signal is greater than that of the thermal or background signal noise.

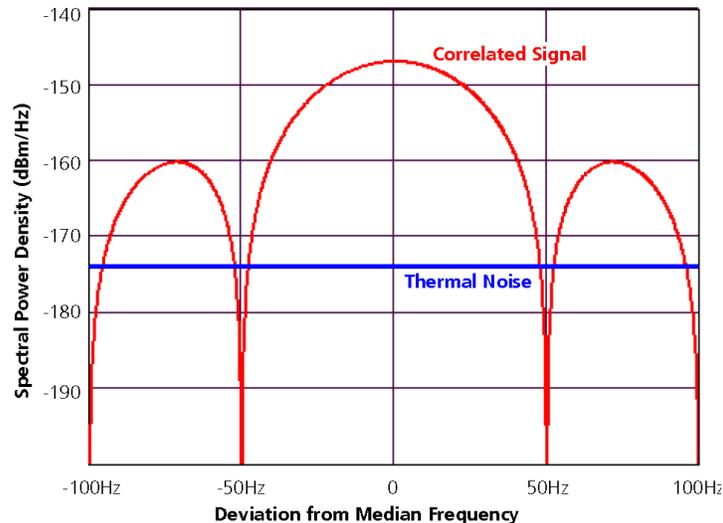


Fig. 6-14 GPS Signal After De-spreading

6.1.4.C Measuring Distance (Pseudo Range)

GPS satellites orbit 200km above the earth and are distributed in such a way that from any point on the ground there is line-of-sight contact to at least four satellites.

Each one of these satellites is equipped with onboard atomic clocks. In order to make them even more accurate, they are regularly adjusted or synchronized from various control points on Earth. GPS satellites transmit their exact position and onboard clock time to Earth.

These signals are transmitted at the speed of light (300,000 km/s) and therefore require approximately 67.3 ms to reach a position on the Earth's surface directly below the satellite. The signals require a further 3.33 μ s for each additional kilometer of travel. To establish position, all that is required is a receiver and an accurate clock.

By comparing the arrival time of the satellite signal with the onboard clock time the moment the signal was transmitted, it is possible to determine the signal travel time.

Distance = Velocity * Time: Velocity is 300,000 km/s and Time is the travel time of the signal.

To measure the travel time:

- Receiver generates the same codes as the Satellite (PRN codes)
- Measure delay between incoming codes and self generated codes
- $D = \text{Speed of light} * \text{measured delay (Pseudo Range)}$

The first word of every single frame, the Telemetry word (TLM), contains a preamble sequence 8 bits in length (10001011) used for synchronization purposes, followed by 16 bits reserved for authorized users. As with all words, the final 6 bits of the telemetry word are parity bits.

The handover-word (HOW) immediately follows the telemetry word in each subframe. The handover-word is 17 bits in length (a range of values from 0 to 131071 can be represented using 17 bits) and contains within its structure the start time for the next subframe, which is transmitted as time of the week (TOW).

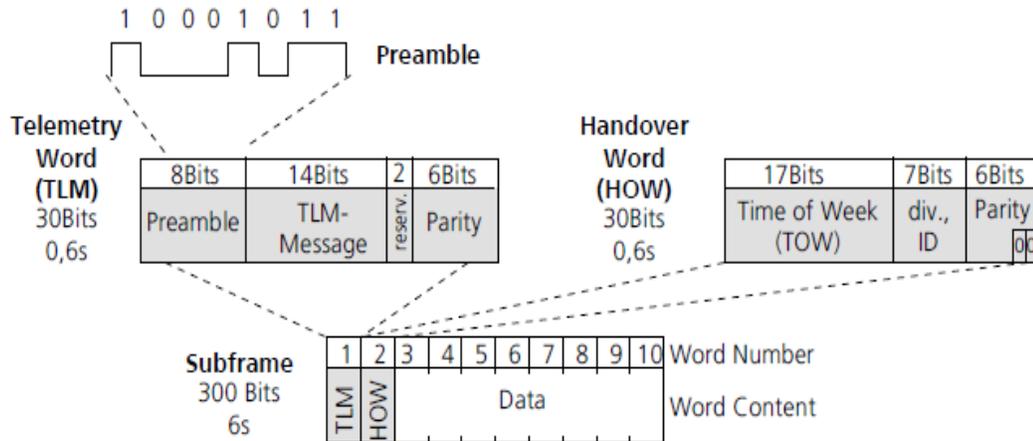


Fig. 6-15 GPS Subframe Hand-Over Word

The transmission time in the first bits of the preamble are provided in the Navigation Message in the TOW Message of the previous frame. This time is given in Satellite Time. Information in the Navigation Message allows translation into Receiver Time. If the preamble is validated, the arrival time of the first bits in the preamble is measured. This time is given in Receiver Time.

Refer to Fig. 6-16. Due to the atomic clocks onboard the satellites, the time at which the satellite signal is transmitted is known very precisely. All satellite clocks are adjusted to be synchronized with each other and UTC (universal time coordinated). In contrast, the receiver clock is not synchronized to UTC and is therefore slow or fast by Δt_0 (clock bias). The sign Δt_0 is positive when the user clock is fast. The resultant time error Δt_0 , causes inaccuracies in the measurement of signal travel time and the distance R . As a result, an incorrect distance is measured that is known as a pseudorange.

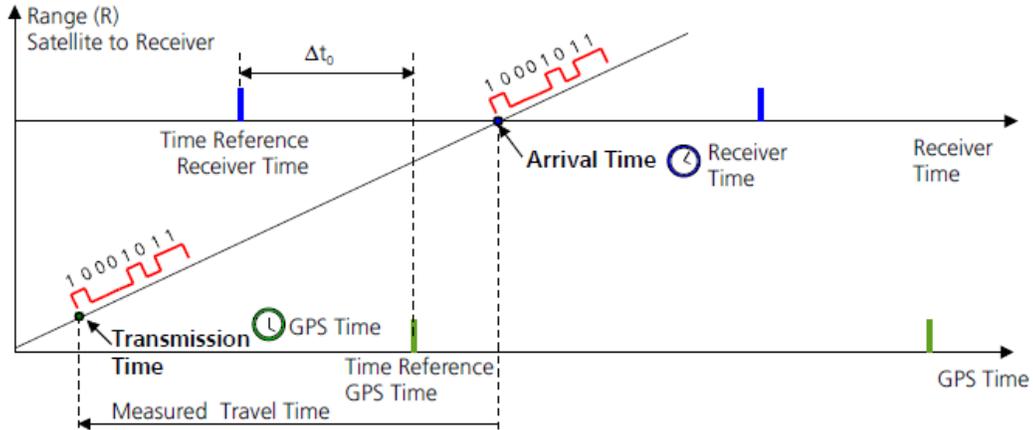


Fig. 6-16 GPS Pseudo Range

6.1.4.D Obtain Satellite Positions

GPS receivers download an almanac into memory which defines where in the sky each satellite is, moment by moment. GPS satellites are constantly monitored by the U.S. Department of Defense. Slight orbital errors are caused by gravitational pulls from the moon and sun and by the pressure of solar radiation on the satellites. Radar is used to check each satellite's exact altitude, position and speed. This information (ephemeris data), is then relayed back up to the respective satellite, which in turn transmits the ephemeris data in Nav Data subframes 2 and 3. Ephemeris data is updated every two hours and is valid for four hours.

6.1.4.E Clock Bias

To solve the problem of clock bias, consider a receiver is placed on a straight line beneath two satellites. As the position of all GPS satellites is known via information contained in the almanac and ephemeris, the distance between any two satellites (S), is known. By measuring the travel times from each satellite, it is possible to exactly establish the distance (D) despite having an imprecise receiver clock, using the following formula:

$$D = \frac{(\Delta t_1 - \Delta t_2) \times c + S}{2}$$

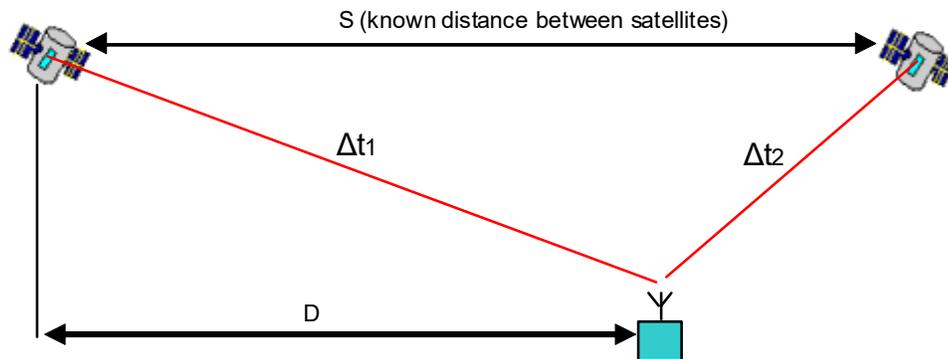


Fig. 6-17 GPS Pseudo Range

In this example two pseudo ranges were employed to determine a position in one dimensional space. To calculate a position in two dimensional space, three pseudo ranges are required, Latitude, Longitude and Δt .

To calculate a position in three dimensional space, four pseudo ranges are required; Latitude, Longitude, Altitude and Δt . The number of pseudo ranges (GPS satellites), must exceed the number of unknown dimensions by a value of one.

6.1.4.F Triangulation Calculations (Trilateration)

Consider triangulation in 2D space. If location of point A is known, and the distance to point A is known, desired position lies somewhere on a circle.

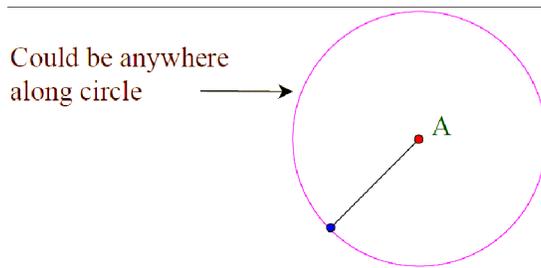


Fig. 6-18 Triangulation using one known point
Distance to two points is known, desired position is in one of two locations.

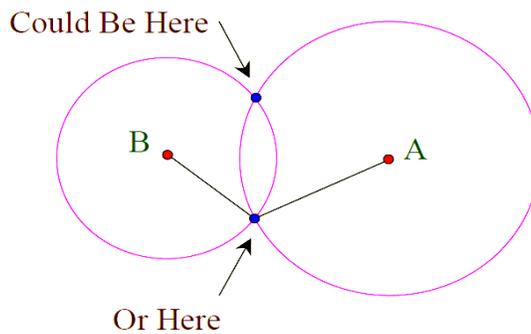


Fig. 6-19 Triangulation using two known point
Distance to three points is known, position is known.

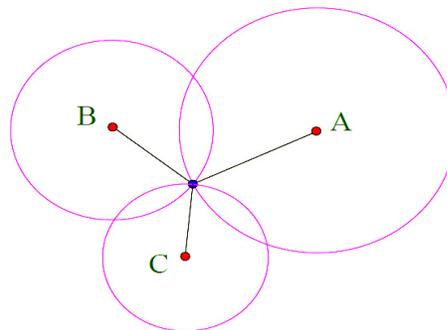


Fig. 6-20 Triangulation using three known point
Consider triangulation in 3D Space. Distance to two points is known.

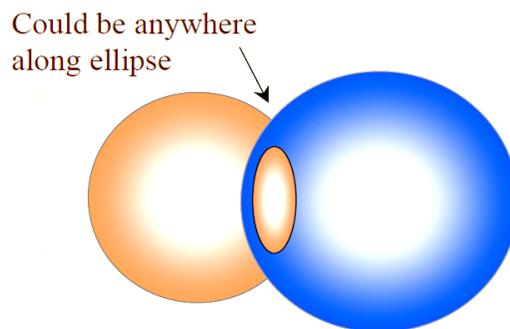


Fig. 6-21 Triangulation using two known points in 3D space

Distance to three points is known, position is known in 3D space.

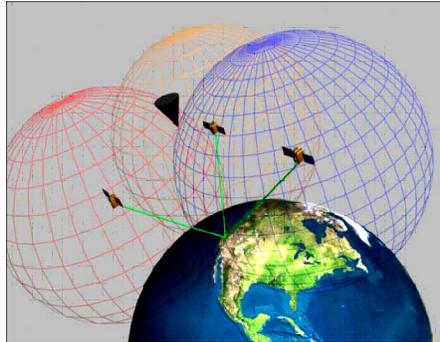


Fig. 6-22 Triangulation using three known points in 3D space

6.1.4.G Time Delay Errors

Sources of Time Delay Error are:

Ephemeris data:

The data concerning ephemeris errors may not exactly model the true satellite motion. The disparity in ephemeris data can introduce 1 to 5 meters of positional error. Ephemeris data is valid for a period of about 4 hours

Satellite clocks:

The data concerning the satellite's four atomic clocks may not reflect the exact rate of clock drift. Distortion of the signal by measurement noise can further increase positional error. Clock drift disparity can introduce 0 to 2.5 meters of positional error and measurement noise can introduce 0 to 10 meters of positional error.

Receiver Clock Inaccuracies and Rounding Errors:

Despite the synchronization of the receiver clock with the satellite time during the position determination (compensation for clock bias), the remaining inaccuracy of the time still leads to an error of about 2 m in the position determination. Rounding and calculation errors of the receiver sum up approximately to 1 m.

Multi-path:

GPS signals can also be affected by multi-path issues where the radio signals reflect off of surrounding terrain such as buildings, canyon walls, and hard ground. These delayed signals can result in periodic signal cancellation but typically they change dynamically with location and may just cause short term inaccuracy.

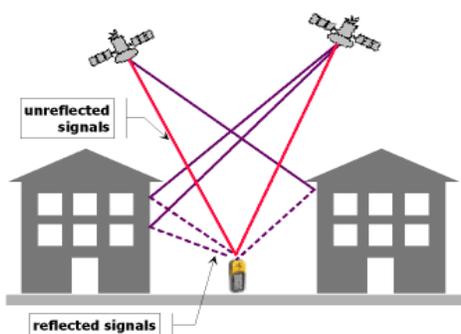


Fig. 6-23 Multi-path Delays

6.1.4.H Atmospheric Delays

Ionosphere:

The ionosphere is an atmospheric layer situated between 90 to 1000 km above the Earth's surface. The gas molecules in the ionosphere are heavily ionized. The ionization is caused mainly by solar radiation, hence the thickness of this layer varies during the course of the day. Signals from the satellites travel through a vacuum at the speed of light. However, in the ionosphere the velocity of these signals slows down due to the ionized gas, an effect called dispersion, which is frequency dependent.

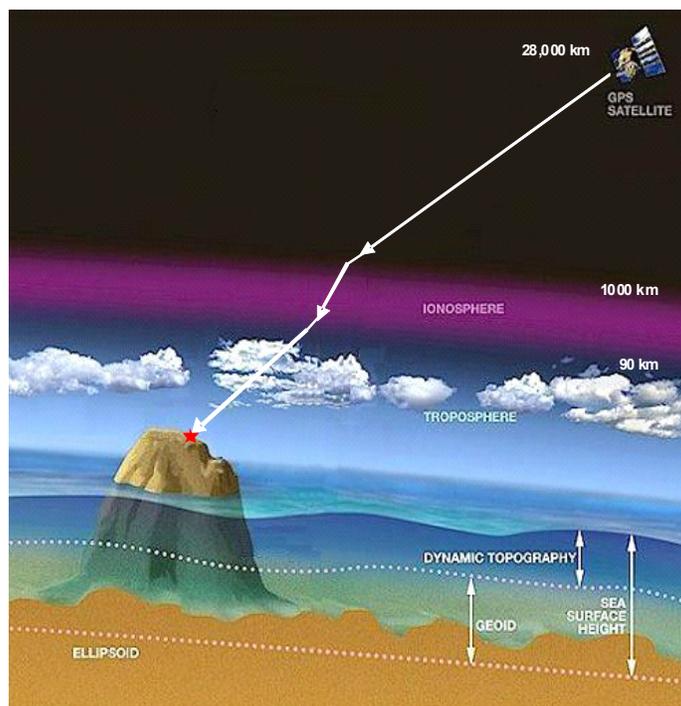


Fig. 6-24 Atmospheric Delays

Ionospheric dispersion is one of the most significant error sources. These effects are smallest when the satellite is directly overhead and become greater for satellites nearer the horizon as the signal passes through the ionosphere at a shallow angle, hence a thicker band has to be traversed. Two methods can be used to correct for ionospheric delays.

- Once the receiver's approximate location is known, a mathematical model can be used to estimate and compensate for these errors.
- Because ionospheric delay affects the speed of microwave signals differently based on frequency, a second carrier frequency, L2 can be used to measure atmosphere dispersion and apply a more precise correction to help compensate for this error. This is the method employed in military GPS receivers using L1 and L2.

This can also be realized in more expensive civilian GPS receivers without decrypting the P(Y) signal carried on L2 by tracking the carrier wave instead of the modulated code. To do this on lower cost receivers, a new civilian code signal on L2 called L2C was added to the satellites. This new signal allows a direct comparison of the L1 and L2 signals using the coded signal instead of the carrier wave.

Troposphere:

The troposphere is the lower part of the earth's atmosphere (0 -15km), that encompasses our weather. It's full of water vapor and varies in temperature and pressure and causes a variable but predictable delay. This delay is corrected using a simple model based on pressure, temperature and altitude.

The errors of the GPS system are summarized in table 6-1. The individual values are no constant values, but are subject to variances, all numbers are approximate values. Altogether this sums up to an error of between ± 12 to ± 15 meters.

Type of Time Delay Error	Positional Error
Ephemeris Errors	± 2.5 m
Satellite Clock Errors	± 2 m
Multi-path Delays	± 1 m
Receiver Clock Inaccuracies and Rounding Errors:	± 1 m
Ionospheric Delays	± 5 m
Tropospheric Delays	± 0.5 m

Table 6-1 PS Positional Error Sources

6.1.5 GPS Timekeeping

Most clocks are synchronized to Coordinated Universal Time (UTC) however, the atomic clocks on the satellites are set to GPS time. GPS time is not corrected to match the rotation of the Earth, so it does not contain leap seconds or other corrections that are periodically added to UTC. GPS time was set to match Coordinated Universal Time (UTC) in 1980, but has since diverged. The lack of corrections means that GPS time remains at a constant offset with International Atomic Time (TAI) ($TAI - GPS = 19$ seconds). Periodic corrections are performed on the on-board clocks to correct relativistic effects and keep them synchronized with ground clocks.

The GPS navigation message data includes the difference between GPS time and UTC, which as of January 1, 2017 is 18 seconds due to the Leap second added to UTC December 31, 2016. Receivers subtract this offset from GPS time to calculate UTC and specific time zone values. New GPS units may not show the correct UTC time until after receiving the UTC offset message.

The GPSG-1000 updates the values related to leap second changes that are within the navigation message data every 60 minutes. The timing of the leap second value updates are based on the simulation start time. Values related to the timing of upcoming leap seconds are stored in a data file within the GPSG-1000. Values related to announcing upcoming leap seconds to receivers are transmitted 60 days prior to the leap seconds rollover date, and are maintained for 60 days after the event.

The GPS-UTC offset field can accommodate 255 leap seconds (eight bits) which, given the current rate of change of the Earth's rotation (with one leap second introduced approximately every 18 months), should be sufficient to last until approximately the year 2300. As opposed to the year, month, and day format of the Gregorian calendar, the GPS date is expressed as a week number and a seconds-into-week number.

GPS	2010-10-12 13:31:38	week 1605	221498 s	cycle 1 week 0581 day 2
UTC	2010-10-12 13:31:23	Tuesday	day 285	MJD 55481.56346

Fig. 6-25 GPS v. UTC Time Format

The week number is transmitted as a ten-bit field in the C/A and P(Y) navigation messages, and so it becomes zero again every 1,024 weeks (19.6 years). GPS week zero started at 00:00:00 UTC (00:00:19 TAI) on January 6, 1980, and the week number became zero again for the first time at 23:59:47 TC on August 21, 1999 (00:00:19 TAI on August 22, 1999).

To determine the current Gregorian date, a GPS receiver must be provided with the approximate date (to within 3,584 days) to correctly translate the GPS date signal. To address this concern the modernized GPS navigation message uses a 13-bit field, which only repeats every 8,192 weeks (157 years), thus lasting until the year 2137 (157 years after GPS week zero).

6.1.6 GNSS Accuracy

A GNSS receiver determines its Position (horizontal and vertical), its Velocity and the Time from the signals of at least four satellites by means of triangulation. The precision of the computations by triangulation depends on the constellation of all satellites of which the signals are taken into account (four or more). As the number and position of satellites will seldom be ideal, the maximum obtainable precision will be diluted in practice. Here we present the different terms of dilution of precision.

Dilution of precision (DOP) is a measure of the quality of the GPS data being received from the satellites. DOP is a mathematical representation for the quality of the GPS position solution. The main factors affecting DOP are the number of satellites being tracked and where these satellites are positioned in the sky. The effect of DOP can be resolved into HDOP, VDOP, PDOP and TDOP.

HDOP (Horizontal Dilution Of Precision) is a measure of how well the positions of the satellites, used to generate the Latitude and Longitude solutions, are arranged. PDOP less than 4 gives the best accuracy, between 4 and 8 gives acceptable accuracy and greater than 8 gives unacceptable poor accuracy. Higher HDOP values can be caused if the satellites are at high elevations.

VDOP (Vertical Dilution Of Precision) is a measure of how well the positions of the satellites, used to generate the vertical component of a solution, are arranged. Higher VDOP values mean less certainty in the solutions and can be caused if the satellites are at low elevations.

TDOP (Time Dilution Of Precision) is a measure of how the satellite geometry is affecting the ability of the GPS receiver to determine time.

PDOP (Positional Dilution OF Precision) is a measure of overall uncertainty in a GPS position solution with TDOP not included in the estimated uncertainty. The best PDOP (lowest value) would occur with one satellite directly overhead and three others evenly spaced about the horizon. $PDOP = \sqrt{HDOP^2 + VDOP^2}$.

GDOP (Geometric Dilution Of Precision) is a measure of the overall uncertainty in a GPS position solution. $GDOP = \sqrt{TDOP^2 + HDOP^2 + VDOP^2}$ or in another form $GDOP = \sqrt{PDOP^2 + TDOP^2}$. GDOP value should be less than 5.

The Position Accuracy = Dilution Of Precision (DOP) times Measurement Precision. So, if the Measurement Precision = 1m and the DOP = 5, then the best position accuracy will be 5m.

6.1.7 GNSS Augmentation

Augmentation of GNSS, is a method of improving the navigation system accuracy, reliability and availability through the integration of external information into the calculation process. SBAS (Satellite Based Augmentation System) and RAIM (Receiver Autonomous Integrity Monitoring System) are GNSS augmentation systems.

Satellite Based Augmentation System (SBAS)

SBAS is a system that supports wide-area or regional augmentation through use of additional satellite broadcast messages that contain correctional data obtained from multiple ground stations at surveyed locations.

The effects of the ionosphere generally change slowly and can be averaged over time. The effects for any particular geographical area can be easily calculated by comparing the GPS-measured position to a known surveyed location. This correction is also valid for other receivers in the same general location.

The data is transmitted via satellites in the SBAS system and is transmitted on the GPS L1 frequency using a special pseudo-random number, allocated for SBAS use. This allows the civilian L1 C/A code receivers that support SBAS, to use the correctional data.

All SBAS satellites support the same protocols and therefore can support seamless augmentation from one region to another.

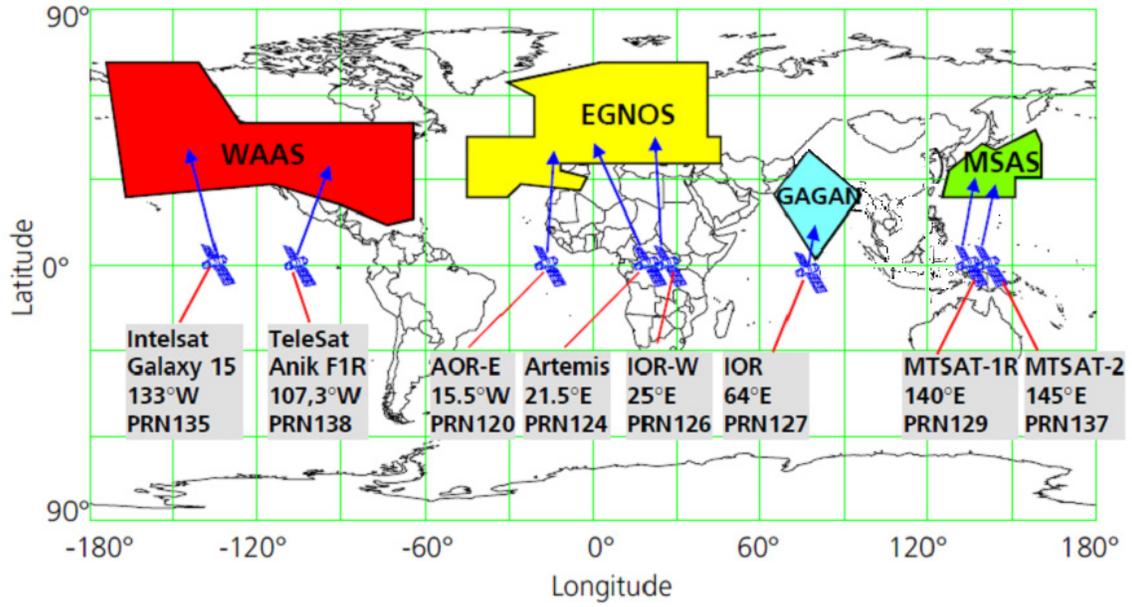


Fig. 6-26 SBAS Coverage

6.1.7.A SBAS Systems

WAAS (Wide Area Augmentation System)

Developed and managed by the FAA, to augment GPS, with the goal of improving its accuracy, integrity, and availability. WAAS is intended to enable aircraft to rely on GPS for all phases of flight, including precision approaches to any airport within its coverage area. The system communicates with several ground stations and provides atmospheric corrections & early warning of GPS failures. The data rate is higher than L1 C/A code at 250 Hz and two geostationary satellites provide area coverage.

EGNOS (European Geostationary Navigation Overlay System)

Managed by the European tripartite group. Corrections for GPS and GLONASS. Similarly to WAAS, EGNOS is mostly designed for aviation users which enjoy unperturbed reception of direct signals from three geostationary satellites up to very high latitudes. The use of EGNOS on the ground, especially in urban areas is limited due to relatively low elevation of geostationary satellites: about 30° above horizon in central Europe and much less in the North of Europe. To address this problem, ESA released in 2002 SISNeT, an Internet service designed for continuous delivery of EGNOS signals to ground users. SV PRN 126 is used for test purposes at this time (2010).

MSAS (Multi-Functional Satellite Augmentation System)

Managed by the Japanese Civil Aviation Bureau (JCAB), a satellite navigation system which supports differential GPS, designed to supplement the GPS system by reporting (then improving) on the reliability and accuracy of those signals. MSAS for aviation use was commissioned on September 27, 2007. Two geostationary satellites provide area coverage.

GAGAN (GPS Aided Geo Augmented Navigation)

The GAGAN system is a planned implementation of a regional Satellite Based Augmentation System (SBAS) by the Indian government. It is a system to improve the accuracy of a GNSS receiver by providing reference signals. Two geostationary satellites will eventually provide area coverage. One SV is currently deployed, PRN 127.

6.1.7.B RAIM (Receiver Autonomous Integrity Monitoring System)

A unique aviation requirement of GPS avionics is RAIM. While GPS provides the user with unparalleled levels of accuracy, one significant deficiency of GPS is integrity, or the ability of the system to provide a timely warning if the navigation solution is inaccurate or erroneous. Navigation systems prior to GPS, particularly aviation applications, provided a means to warn the aircraft that the signal was outside certain limits. For example, a Category I ILS provides this warning within six seconds.

The only means available for the GPS system itself to provide the user with a warning of system unreliability is through the data message forming part of the GPS signal. The "health" flag found in subframe 4 and 5 will alert the receiver to a failure of a GPS satellite.

The time lag from the beginning of the failure to when it is incorporated in the health flag (up to eight hours) represents an unacceptably long period of time for aviation.

To overcome this, RAIM was developed and is a mandatory feature of all aviation-grade receivers. RAIM uses combinations of satellites to determine the receiver position. Should a large discrepancy between position solutions occur, a RAIM alert is created rendering the GPS navigator unreliable. Different phases of flight use different values of "integrity alarm limits" prior to issuing a RAIM alert.

The ability of a receiver to perform RAIM computations is dependent upon the number of satellites in view, their geometry and the mask angle which is dependent upon the ability of the antenna to track satellites near the horizon and any local terrain. Whereas GPS needs a minimum of four satellites to produce a three-dimensional position, a minimum of five satellites are required for RAIM. For this reason, RAIM may not be available in circumstances of poor satellite coverage or poor satellite geometry.

Phase of Flight	Alarm Limit	Time to Alarm
Enroute (oceanic, domestic, random and JV routes)	2.0 nm	30 sec
Terminal	1.0 nm	10 sec
RNAV Approach Non Precision	0.3 nm	10 sec

Table 6-2 RAIM Alarms

6.1.8 GPS Modernization Signals

A process of GPS system modernization is now underway, which involves the introduction of new signals to provide improvements in accuracy and integrity.

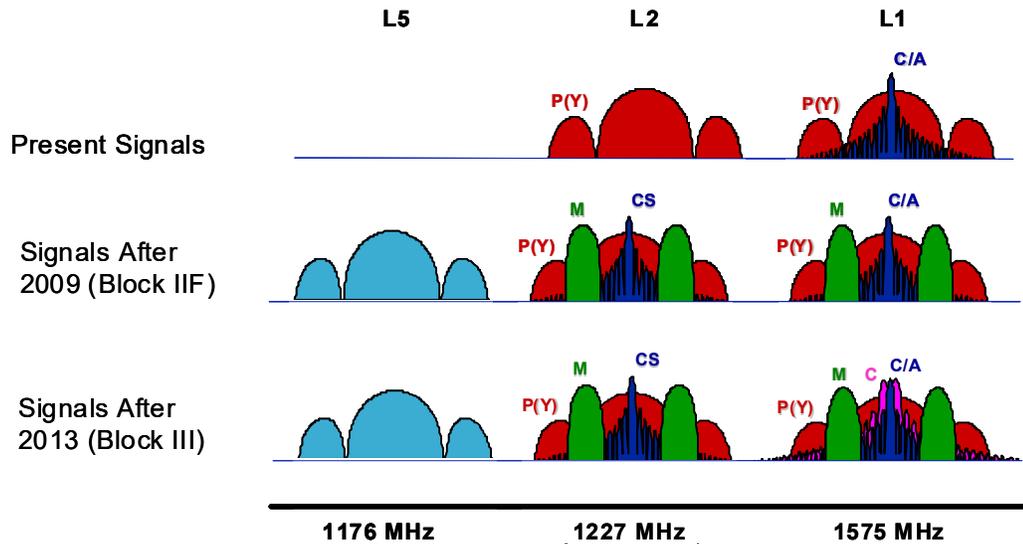


Fig. 6-27 GPS Modernization Signals

6.1.8.A L2CS

The L2CS system provides a civilian-use signal transmitted on a frequency other than the L1 frequency used for the Coarse Acquisition (C/A) signal, and broadcast on the L2 frequency. Because it requires new hardware onboard the satellite, it is only transmitted by the so-called Block IIR-M and later design satellites. The L2CS signal is tasked with improving accuracy of navigation, providing an easy to track signal, and acting as a redundant signal in case of localized interference.

Unlike the C/A code, L2CS contains two distinct PRN code sequences to provide ranging information; the *Civilian Moderate* length code (called CM), and the *Civilian Long* length code (called CL). The CM code is 10,230 bits long, repeating every 20 ms. The CL code is 767,250 bits long, repeating every 1500 ms. Each signal is transmitted at 511,500 bits per second (bit/s); however, they are multiplexed together to form a 1,023,000 bit/s signal.

CM is modulated with the CNAV Navigation Message (see below), whereas CL does not contain any modulated data and is called a *data-less sequence*. The long, data-less sequence provides for approximately 24 dB greater correlation (~250 times stronger) than L1 C/A-code.

When compared to the C/A signal, L2CS has 2.7 dB greater data recovery and 0.7 dB greater carrier-tracking, although its transmission power is 2.3 dB weaker.

6.1.8.B CNAV Navigation Message

The CNAV data is an upgraded version of the original NAV navigation message. It contains higher precision representation and nominally more accurate data than the NAV data. The same type of information (Time, Status, Ephemeris, and Almanac) is still transmitted using the new CNAV format; however, instead of using a frame / subframe architecture, it features a new pseudo-packetized format made up of 12-second 300-bit message packets.

In CNAV, two out of every four packets are ephemeris data and at least one of every four packets will include clock data, but the design allows for a wide variety of packets to be transmitted.

With a 32-satellite constellation, and the current requirements of what needs to be sent, less than 75% of the bandwidth is used. Only a small fraction of the available packet types have been defined; this enables the system to grow and incorporate advances.

Important changes in the new CNAV message

CNAV message uses Forward Error Correction (FEC) in a rate 1/2 convolution code, so while the navigation message is 25 bit/s, a 50 bit/s signal is transmitted.

The GPS week number is now represented as 13 bits, or 8192 weeks, and only repeats every 157.0 years, meaning the next return to zero won't occur until the year 2137. This is longer compared to the L1 NAV message's use of a 10-bit week number, which returns to zero every 19.6 years.

There is a packet that contains a GPS-to-GNSS time offset. This allows for interoperability with other global time-transfer systems, such as Galileo and GLONASS, both of which are supported.

The extra bandwidth enables the inclusion of a packet for differential correction, to be used in a similar manner to SBAS and which can be used to correct the L1 NAV clock data.

Every packet contains an alert flag, to be set if the satellite data can not be trusted. This means users will know within 6 seconds if a satellite is no longer usable. Such rapid notification is important for safety-of-life applications, such as aviation.

Finally, the system is designed to support 63 satellites, compared with 32 in the L1 NAV message.

L2CS Frequency information

An immediate effect of having two civilian frequencies being transmitted is the civilian receivers can now directly measure the ionospheric error in the same way as dual frequency P(Y)-code receivers. However, if a user is utilizing the L2C signal alone, they can expect 65% more position uncertainty than with the L1 signal.

6.1.8.C L5

Civilian, safety of life signal planned to be available with first GPS IIF launch (2009). Two PRN ranging codes are transmitted on L5: the in-phase code (denoted as the I5-code); and the quadrature-phase code (denoted as the Q5-code). Both codes are 10,230 bits long and transmitted at 10.23 MHz (1ms repetition). In addition, the I5 stream is modulated with a 10-bit Neuman-Hofman code that is clocked at 1 kHz and the Q5-code is modulated with a 20-bit Neuman-Hofman code that is also clocked at 1 kHz.

- Improves signal structure for enhanced performance
- Higher transmitted power than L1/L2 signal (-3 dB, or twice as powerful)
- Wider bandwidth provides a 10× processing gain
- Longer spreading codes (10× longer than C/A)
- Uses the Aeronautical Radio-Navigation Services band
- The recently launched GPS IIR-M7 satellite transmits a demonstration of this signal.

L5 Navigation message

The L5 CNAV data includes SV ephemerides, system time, SV clock behavior data, status messages and time information, etc. The 50 bit/s data is coded in a rate 1/2 convolution coder. The resulting 100 symbols per second (sps) symbol stream is modulo-2 added to the I5-code only; the resultant bit-train is used to modulate the L5 in-phase (I5) carrier. This combined signal will be called the L5 Data signal. The L5 quadrature-phase (Q5) carrier has no data and will be called the L5 Pilot signal.

L5 Frequency information

Broadcast on the L5 frequency (1176.45 MHz, $10.23 \text{ MHz} \times 115$), which is an aeronautical navigation band. The frequency was chosen so that the aviation community can manage interference to L5 more effectively than L2.

6.1.8.D L1C

Civilian use signal, broadcast on the L1 frequency (1575.42 MHz), which currently contains the C/A signal used by all current GPS users. The L1C will be available with first Block III launch, currently scheduled for 2013. The PRN codes are 10,230 bits long and transmitted at 1.023 Mbps. It uses both Pilot and Data carriers like L2C.

The modulation technique used is BOC(1,1) for the data signal and TMBOC for the pilot. The Time Multiplexed Binary Offset Carrier (TMBOC) is BOC(1,1) for all except 4 of 33 cycles, when it switches to BOC(6,1). Of the total L1C signal power, 25% is allocated to the data and 75% to the pilot. Implementation provides C/A code to ensure:

- Backward compatibility.
- 1.5 dB increase in minimum C/A code power to mitigate any noise floor increase.
- Data-less signal component pilot carrier improves tracking.
- Greater civil interoperability with Galileo L1.

CNAV-2 Navigation message

The L1C navigation message, called CNAV-2, is 1800 bits (including FEC) and is transmitted at 100 bit/s. It contains 9-bit time information, 600-bit ephemeris, and 274-bit packetized data payload

6.1.8.E M Code (Military)

A major component of the modernization process, a new military signal called M-code was designed to further improve the anti-jamming and secure access of the military GPS signals. The M-code is transmitted in the same L1 and L2 frequencies already in use by the previous military code, the P(Y) code. The new signal is shaped to place most of its energy at the edges (away from the existing P(Y) and C/A carriers).

Unlike the P(Y) code, the M-code is designed to be autonomous, meaning that users can calculate their positions using only the M-code signal. P(Y) code receivers must typically first lock onto the C/A code and then transfer to lock onto the P(y)-code.

The M-code is intended to be broadcast from a high-gain directional antenna, in addition to a wide angle (full Earth) antenna. The directional antenna's signal, termed a *spot beam*, is intended to be aimed at a specific region (i.e. several hundred kilometers in diameter) and increase the local signal strength by 20 dB (10X voltage field strength, 100X power). A side effect of having two antennas is that the GPS satellite will appear to be two GPS satellites occupying the same position to those inside the spot beam.

While the full-Earth M-code signal is available on the Block IIR-M satellites, the spot beam antennas will not be available until the Block III satellites are deployed.

Other M-code characteristics are:

- Satellites will transmit two distinct signals from two antennas: one for whole Earth coverage, one in a spot beam.
- Modulation is Binary Offset Carrier (BOC) and occupies 24 MHz of bandwidth
- Uses a new MNAV navigational message, which is packetized instead of framed, allowing for flexible data payloads
- There are four effective data channels; different data can be sent on each frequency and on each antenna.
- Can include FEC and error detection
- The spot beam is ~20 dB more powerful than the whole Earth coverage beam
M-code signal at Earth's surface: -158 dBW for whole Earth antenna, -138 dBW for spot beam antennas.

6.1.9 The Galileo System

Galileo is the European global navigation satellite system which provides a highly accurate, guaranteed global positioning service under civilian control. It is inter-operable with GPS and GLONASS, the two other global satellite navigation systems.



Fig. 6-28 Galileo Satellite (GIOVE Test SV)

A user can take a position with the same receiver from any of the satellites in any combination. By offering dual frequencies as standard, Galileo delivers real-time positioning accuracy down to the meter range. Galileo guarantees availability of the service under all but the most extreme circumstances and informs users within seconds of a failure of any satellite. This makes it suitable for applications where safety is crucial, such as running trains, guiding cars and landing aircraft.

The first experimental satellite, part of the so-called Galileo System Test Bed (GSTB-V1), was launched in 2003. The objective of this satellite was to characterize the critical technologies, developed under ESA contracts. Two initial test satellites were launched GIOVE-A, in 2005, and GIOVE-B, in 2008, to validate the basic Galileo space segment. Four In Orbit Validation (IOV) satellites are scheduled to be launched in the 2010 to 2011 time frame, to complete the validation of the space segment in conjunction with the ground segment. A further 16 satellites are currently funded, which will provide a minimum operational capability. The balance of 14 satellites required to reach Full Operational Capability (FOC), as of 2010, are not currently funded.

The fully deployed Galileo system will consist of 30 satellites (27 operational + 3 active spares), positioned in three circular Medium Earth Orbit (MEO) planes at 23 222 km altitude above the Earth, and at an inclination of the orbital planes of 56 degrees with reference to the equatorial plane. The Galileo navigation signals provide good coverage even at latitudes up to 75 degrees north, which corresponds to the North Cape, and beyond.

The large number of satellites together with the optimization of the constellation, and the availability of the three active spare satellites, ensures that the loss of one satellite has no discernible effect on the user. The use of BOC (Binary Offset Carrier) Modulation minimizes interference with GPS BPSK.

6.1.9.A Ground Element

Two Galileo Control Centers:

- Located in Europe
- Combine range of facilities: orbit control, integrity, mission control, satellite control, services products, Precise Time Facilities (PTF)

Fifteen Galileo Up-Link Stations:

- Located around the globe
- Five Telemetry, Telecommand and Tracking Stations
- Nine Mission Up-Link Stations

Thirty Galileo Sensor Stations:

- Located around the globe
- Monitor quality of the satellite navigation signal (Signal In Space, SIS) Services

6.1.9.B Services

The Galileo system consists of five main services:

OS (Open Service):

'Free to air' and for use by the mass market; Simple timing and positioning down to 1 meter.

CS (Commercial Service) (Encrypted):

Higher data rate, improved accuracy to the centimeter. Guaranteed service for which service providers charge fees.

SoL (Safety Of Life):

Open service; For applications where guaranteed accuracy is essential; Integrity messages will warn of errors.

PRS (Public Regulated Service): (Encrypted):

Continuous availability even in time of crisis; Government agencies will be main users.

SAR (Search And Rescue):

System picks up distress beacon locations; Feasible to send feedback, confirming help is on its way. Based on Cospas-Sarsat system re-broadcasts distress messages.

Signal	E5 (E5a + E5b)				E1		
Centre Frequency	1191.795 (E5)				1575.42		
	1176.45 (E5a)		1207.14 (E5b)				
Nominal Bandwidth	51.15 (E5)				24.552		
	20.46 (E5a)		20.46 (E5b)				
Modulation	ALTBOC				INTERPLEX/CBOC		
Sub-carrier	a-I	a-Q	b-I	b-Q	A	B	C
Sub-modulation	None	None	None	None	BOC(15,2 .5)	CBOC(6,1 ,1)	CBOC(6,1 ,1)
Services	F/NAV V (OS)	Pilot	I/NAV (OS/CS/SoL)	Pilot	G/NAV (PRS)	I/NAV (OS/CS/SoL)	Pilot
Code Rate (Mc/s)	10.23	10.23	10.23	10.23	2.5575	1.023	1.023
Encrypted	No	No	No	No	Yes	No	No
Sequence Length (primary x secondary)	10230 x 20	10230 x 100	10230 x 4	10230 x 100	25575 x 1	4092 x 1	4092 x 25
Symbol rate (sps)	50	N/A	250	N/A	100	250	N/A

Table 6-3 Galileo Signals

6.1.9.C GPS Receivers

Signal

The strength of the received GPS signal relies on the following parameters:

- Signal strength of satellite
- Attenuation in transmitter hardware
- Gain of transmission antenna (in direction to the receiver)
- Free space loss due to distance of satellite and receiver
- Attenuation by the atmosphere (negligible)
- Deflection and superposition of the direct signal by reflected indirect signals (multi-path)
- Gain of receiver antenna
- Attenuation in receiver hardware
- Signal tracking technique

Noise

The level of noise seen by a GPS receiver consists mainly of thermal noise but also background and inter-modulation noise. Most of the single influences are constant or can be assumed to be constant in the order of measurement accuracy.

SNC

Many GPS receivers indicate signal strengths in manufacturer specific units, which are determined from measurements made on the signals by the signal processing hardware. The values are the result of integrating the output of a signal correlator, that is fed the noisy input signal and a clean local replica of the expected PRN code. The integrated result is a linear indication of the signal-to-noise-ratio, over the bandwidth of the correlated signals.

In any particular receiver, this result can vary due to differences in receiver bandwidth and integration time. Often the result is scaled to be consistent across a product range. The resultant values are often referred to as SNC (Signal-to-Noise-Counts) and are scaled to match a measurement made over a 1 kHz bandwidth. The 1 kHz comes from the fact that many of the early receivers integrated for 1 millisecond, resulting in an effective 1 kHz bandwidth.

Converting SNC to SNR

Normally SNR (Signal to Noise Ratio) is expressed as a power ratio on a logarithmic scale instead of an amplitude ratio on a linear scale.

To convert:

- SNC in a 1 kHz bandwidth = (sA/nA) .
- Where sA = Signal Amplitude and nA is the Noise Amplitude.
- SNR in a 1 kHz bandwidth [in dB] = $20 * \text{Log}_{10}(\text{SNC}) - 3\text{db}$

Converting to C/N_0

A more technically precise and common measurement of GNSS signal strength is known as C/N_0 (carrier-to-noise density) and is the ratio of received carrier (i.e., signal) power to noise density.

Many receivers have the ability to display or output values in these units however, these values are not measured directly, but are calculated from the directly measured SNC count values, refer to table 6-4.

NOTE:

C/N_0 is *not* the same as SNR (signal-to-noise ratio), although the terms are sometimes used interchangeably. Effectively, C/N_0 assumes that the noise has infinite bandwidth (and thus power) and therefore characterizes it using a density, that is, as the amount of noise power per unit of bandwidth.

C/N_0 = the SNR (usually in dB) in a 1 Hz bandwidth. That bandwidth is typically 1000 times less than the actual receiver bandwidth, which implies a 30db change in dB-power units:

- $C/N_0 = \text{SNR}[\text{dB}]@ 1 \text{ kHz} + 30\text{db}$
- Therefore. $C/N_0 = 30 + 10 \cdot \text{Log}_{10}(\text{SNC}^2/2)$
- $= 30 + 10 \cdot \text{Log}_{10}(\text{SNC}^2) - 3$
- $= 27 + 20 \cdot \text{Log}_{10}(\text{SNC})$

SNC	SNR (dB - 1 kHz)	C/N_0 (dB - 1 Hz)
3	6.5	36.5 (very weak signal)
5	11	41
10	7	47
20	23	53
30	26.5	56.5
40	29	59 (very strong signal)

Table 6-4 SNC, SNR and C/N_0

C/N_0 provides a metric that is more useful for comparing one GPS receiver to another than SNR because the bandwidth of the receivers is eliminated in the comparison. Higher C/N_0 results in reduced data bit error rate (when extracting the navigation data from the GPS signals) and reduced carrier and code tracking loop jitter. Reduced carrier and code tracking loop jitter, in turn, results in less noisy range measurements and thus more precise positioning.

Determining Noise Figure

Generally, the GPS decoding chipset on a receiver determines the minimum C/N_0 ratio, required to achieve a position fix. However, it is the noise figure of the entire receiver that determines the C/N_0 ratio that you can achieve at a given power level. When measuring sensitivity it is important to know the minimum C/N_0 ratio required to achieve a position fix.

Refer to table 6-5. Assuming a constant satellite power, you can observe that the C/N_0 ratio reported by the receiver is a function of the noise figure of the receiver.

Noise Figure	RF Power Level	C/N_0
1 dB	-143 dBm	31 dB -Hz
2 dB	-143 dBm	30 dB -Hz
3 dB	-143 dBm	29 dB -Hz
4 dB	-143 dBm	28 dB -Hz
5 dB	-143 dBm	27 dB -Hz
6 dB	-143 dBm	26 dB -Hz

Table 6-5 C/N_0 as a Function of Noise Figure

The noise figure of a receiver is directly proportional to the RF power level and C/N_0 ratio. Based on this relationship, you can measure the receivers noise figure by applying the following formula. $N\ figure = -174dBm/Hz + SVpower + C/N_0$

For example: $-174.0\ dBm + -136.1\ dBm + 30.0\ dB-Hz = 7.9\ dB$.

Rounding C/N_0

Receivers that support the NMEA-183 protocol, report satellite C/N_0 to the nearest decimal digit, therefore estimating noise figure beyond one digit of precision requires you to investigate the C/N_0 rounding of the receiver.

Table 6-6 example results show that RF power levels between -136.6 and -135. dBm all produce the same C/N_0 ratio of 30 dB-Hz. Based on the rounding principles involved when reporting NMEA-183 data, it is safe to assume that a power level of -136.1 dBm produces a C/N_0 ratio of 30.0 dB-Hz.

RF Power Level	Receiver C/N_0
-135.6 dBm	31 dB -Hz
-135.7 dBm	31 dB -Hz
-135.8 dBm	30 dB -Hz
-135.9 dBm	30 dB -Hz
-136.0 dBm	30 dB -Hz
-136.1 dBm	30 dB -Hz
-136.2 dBm	30 dB -Hz
-136.3 dBm	30 dB -Hz
-136.4 dBm	30 dB -Hz
-136.5 dBm	30 dB -Hz
-136.6 dBm	30 dB -Hz
-136.7 dBm	30 dB -Hz
-136.8 dBm	29 dB -Hz
-136.9 dBm	29 dB -Hz
-137.0 dBm	29 dB -Hz
-137.1 dBm	29 dB -Hz

Table 6-6 Correlation of RF Power Level and Receiver C/N_0

Chapter 7 - Product Specifications

7.1 GENERATOR

RF Output Level Direct:-	-93 to -155 dBm in 1 dB steps. ± 2 dB accuracy into 50Ω
DC Isolation:	50V DC
RF Output Level Ant Coupler:-	-68 dBm to -130 dBm in 1 dB steps, ± 2 dB accuracy into 50Ω
Signal Quality:	Spurious: <-35 dBc over the bandwidth (40 MHz) Harmonics: <-45dBc
External Modulation Input:	TTL
Carriers:	Single (GPS and Galileo channels may be mixed)
GPS Carriers:	L1: 1575.420 MHz (C/A, pseudo P(Y), SBAS) L1 no P(y): 1575.420 MHz (C/A, SBAS) L1C: 1575.420 MHz L2: 1227.600 MHz (pseudo P(Y)) L2C: 1227.600 MHz L5: 1176.450 MHz (New Civil SOL)
Galileo Carriers:	E1/L1: 1575.420 MHz (PRS, OS, CS, SOL)(pseudo-G/NAV) E5a: 1191.795 MHz (OS, F/NAV) E5b: 1207.140 MHz (OS,CS,SOL,I/NAV)
Accuracy:	Same as Master Oscillator
Inter Channel Bias:	Zero (Digital Design)
Channels:	1-6, 1-12 SV simulation, selectable GPS: PRN=1 to 32. Galileo: PRN=1 to 30. SBAS: PRN=120 to138.
User Defined Doppler Error:	Selectable frequency offset ± 5.0 kHz 1 Hz increment
Amplitude Offset:	Sets SV carrier amplitude offset from nominal +/-15dB in .1dB increments.
Step Error:	Sets SV psuedo range error +/- 1km in .1m increments or 32,808.4 ft in .1ft increments (used for RAIM testing)
Satellite Health:	Allows selection of GOOD or BAD (carried in GPS Nav Data)

GENERATOR (cont)

Gal Integrity: Allows selection of CONNECTED or DISCONNECTED.
(Carried in Galileo Nav Data*)

Code Carrier Coherence: Sets frequency variation between code carriers
Range 2m/S or 6.562 ft/S
Increment 1mm/S or 001 ft/S

L1 C/A code: Code Rate: 1.023 Mc/s
Primary Code Length: 1023 bits
Modulation: BPSK
Symbol Rate: 50 sps

SBAS Codes: WAAS/EGNOS L1/L5

L1C Code: Code Rate: 1.023 Mc/s
Primary Code length: 10,230 bits
Modulation: BPSK

L1 P(Y) pseudo code: Code Rate: 10.230 Mc/s
Primary Code Length: 15,345,000 bits
Modulation: BPSK
NOTE: Long random codes simulated

L2C Code: CM Code Rate: 511.500 b/s
Primary Code length: 10,230 bits
CL Code Rate: 511.500 b/s
NOTE: Long random codes simulated
Primary Code length: 767,250 bits
Modulation: QPSK

L5 Code: Code Rate: 10.230 Mc/s
Primary Code length: 10,230 bits
Modulation: QPSK

Galileo Codes From Open Service SIS ICD, Draft 1, European Space Agency/
European GNSS Supervisory Authority

Signal	E5 (E5a + E5b)				E1		
Centre Frequency	1191.795 (E5)				1575.42		
	1176.45 (E5a)		1207.14 (E5b)				
Nominal Bandwidth	51.15 (E5)				24.552		
	20.46 (E5a)		20.46 (E5b)				
Modulation	ALTBOC				INTERPLEX/CBOC		
Sub-carrier	a-I	a-Q	b-I	b-Q	A	B	C
Sub-modulation	None	None	None	None	BOC(15,2,5)	CBOC(6,1,1)	CBOC(6,1,1)
Services	F/NAV (OS)	Pilot	I/NAV (OS/CS/SoL)	Pilot	G/NAV (PRS)	I/NAV (OS/CS/SoL)	Pilot
Code Rate (Mc/s)	10.23	10.23	10.23	10.23	2.5575	1.023	1.023
Encrypted	No	No	No	No	Yes	No	No
Sequence Length (primary x secondary)	10230 x 20	10230 x 100	10230 x 4	10230 x 100	25575 x 1	4092 x 1	4092 x 25
Symbol rate (sps)	50	N/A	250	N/A	100	250	N/A

GENERATOR (cont)

NAV Data: Navigation Data is computed in real-time to match the simulation

Positional Simulation: Maximum Relative Velocity (Range Rate) ± 1000 kts
Maximum Relative Jerk ± 500 m/s³
Maximum Altitude 100,000 ft

Positional Simulation Accuracy: Pseudorange <2mm (RMS)
Pseudorange Rate <1mm/s (RMS) with respect to master oscillator
Pseudorange Jerk ± 0.02 m/s³ (RMS over >1s)
Delta Pseudorange <2mm (RMS)
Interchannel Code Phase Alignment ± 0.02 m (RSS)
Interchannel Carrier Phase Alignment ± 0.265 mm (RSS)

7.2 MASTER OSCILLATOR

Frequency: 10 MHz nominal (* see note)

Temperature Stability: ± 0.05 ppm

Aging Rate: ± 0.3 ppm/yr, ± 2.5 ppm/ 10 yr

Uncertainty: ± 1 ppm

External Reference Input

Input Level: 0.25 to 6.0 Vp-p

Input Impedance: 50 ohm nominal

Input Frequency: 10.0 MHz ± 10 Hz

External Reference Output

Output Level: 1.5 Vp-p nominal into 50 Ω

Output Frequency: 10.0 MHz nominal

Reliability

MTBF: >10000 hrs

MTTR: 1hr

7.3 COUPLER

Type: Patch in RF Absorbent Foam

Coupling: -21.5 dB typical at 1575.420 MHz.

Isolation: > 25 dB at 1575.42 MHz
> 30 dB typical at 1575.42 MHz

7.4 BATTERY

Type:	Lithium Ion, Removable Pack
Voltage:	14.4 VDC
Capacity:	6.75 AH
Duration:	4 hrs
Note:	Battery charging temperature range: 0° to 45°C.

7.5 DC INPUT

Input Voltage Range:	11 to 32 VDC
Maximum Input Power:	75 W
Maximum Current Input:	5 A

7.6 PHYSICAL CHARACTERISTICS

Height:	10.63 inches (27.0 cm)
Width:	13.97 inches (35.5 cm)
Depth:	3.425 inches (8.7 cm)
Weight (Test set only):	15.5 lbs. (7 kg)

7.7 ENVIRONMENTAL

Test Set Certifications

Operational Temperature:	-20° to 55° C
Storage Temperature:-	-51° to 71° C when no battery is installed
Operational Humidity:	MIL-PRF-28800F Class 2
Storage Humidity:	MIL-PRF-28800F Class 2
Altitude:	4600 meters Class 1
Vibration Limits:	MIL-PRF-28800F Class 2
Shock, Function:	MIL-PRF-28800F Class 2
Transit Drop:	MIL-PRF-28800F Class 2
Drip Proof:	MIL-PRF-28800F Class 2
Dust:	MIL-PRF-28800F Class 1
Salt Fog:	MIL-PRF-28800F Class 1
Explosive Atmosphere:	MIL-PRF-28800F Class 1
EMI/EMC:	MIL-PRF-28800F and EN-61010-1
Safety Compliance:	UL-61010-1 and EN-61010-1

ENVIRONMENTAL (cont)

EMC

Emissions: MIL-PRF28800F Class 2
EN 61326:1998 Class A
EN 61000-3-2
EN 61000-3-3

Immunity: MIL-PRF28800F Class 2
EN 61326:1998 Class A

External AC-DC Converter Certifications

Safety Compliance: UL 1950 DS
CSA 22.2 No. 234
VDE EN 60 950

EMI/RFI Compliance: FCC Docket 20780 Curve "B"

EMC: EN 61326

External AC to DC Converter

Use: Indoors

Altitude: ≤ 10,000 m

Operating Temperature: 0° to 40° C

Storage Temperature: -20° to 71° C

Transit Case Certifications

Drop Test: FED-STD-101C Method 5007.1 Paragraph 6.3,
Procedure A, Level A

Falling Dart Impact: ATA 300 Category I

Vibration, Loose Cargo: FED-STD-101C Method 5019

Vibration, Sweep: ATA 300 Category I

Simulated Rainfall: MIL-STD-810F Method 506.4 Procedure II of 4.1.2

FED-STD-101C: Method 5009.1 Sec 6.7.1

Immersion: MIL-STD-810F Method 512.4

7.8

ACCESSORIES

RF Coax Cable x 1: Low Loss Coax 50 ft loss calibrated

THIS PAGE INTENTIONALLY LEFT BLANK.

Appendix A - Pin-Out Tables

A.1 ETHERNET CONNECTOR

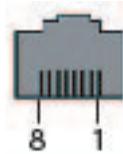


Fig. A-1 Ethernet Pin-Out Diagram

Pin Number	Signal Type	Signal Type	Function
1	Data	Transmit +	Ethernet TX +
2	Data	Transmit -	Ethernet TX -
3	Data	Receive +	Ethernet RX +
4	NC	NC	
5	NC	NC	
6	Data	Receive -	Ethernet RX -
7	NC	NC	
8	NC	NC	

A.2 USB HOST 1 CONNECTOR



Fig. A-2 USB Host 1 Pin-Out Diagram

Pin Number	Signal Type	Signal Type	Function
1	Power	VCC	USB Power
2	Data	Data -	USB Data -
3	Data	Data +	USB Data +
4	GND	GND	Ground

A.3 USB HOST 2 CONNECTOR



Fig. A-3 USB Host 2 Pin-Out Diagram

Pin Number	Signal Type	Signal Type	Function
1	Power	VCC	USB Power
2	Data	Data -	USB Data -
3	Data	Data +	USB Data +
4	GND	GND	Ground

A.4 USB OTG CONNECTOR

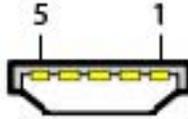


Fig. A-4 USB OTG Pin-Out Diagram

Pin Number	Signal Type	Signal Type	Function
1	Power	VCC	USB Power
2	Data	Data -	USB Data -
3	Data	Data +	USB Data +
4	Control	ID	Identify
5	GND	GND	Ground

A.5 DC POWER CONNECTOR



Fig. A-5 DC Power Connector Pin-Out Diagram

Pin Number	Signal Type	Signal Type	Function
Inner	Power	VCC	HHCP Power
Outer	GND	GND	Ground

A.6 AUX CONNECTOR

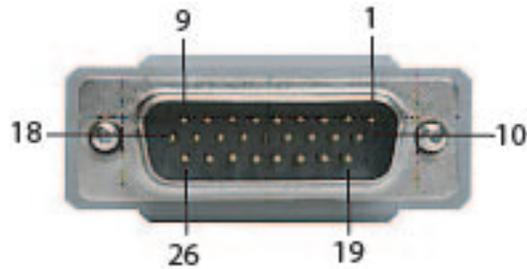


Fig. A-6 AUX Connector Pin-Out Diagram

Pin Number	Signal Type	Signal Type	Function
1	DATA	ARINC 429 in A	ARINC 429 Channel 1 RX A
2	DATA	ARINC 429 in B	ARINC 429 Channel 1 RX B
3	NC	NC	
4	DATA	ARINC 429 Out A	ARINC 429 Channel 1 TX A
5	DATA	ARINC 429 Out B	ARINC 429 Channel 1 TX B
6	NC	NC	
7	Control	RS232 CTS	RS 232 Clear to Send
8	DATA	RS232 TX ¹	RS 232 Transmit
9	Control	RS232 RTS ¹	RS 232 Ready to Send
10	DATA	RS232 RX	RS 232 Receive
11	NC	NC	
12	NC	NC	
13	NC	NC	
14	NC	NC	
15	NC	NC	
16	NC	NC	
17	Ext Trigger Output	3.3V LVTTTL	Trigger Out
18	NC	NC	
19	Ext Trigger Input	3.3V LVTTTL	Trigger In
20	NC	NC	
21	NC	NC	
22	NC	NC	
23	NC	NC	
24	NC	NC	
25	DATA	1 PPS Sync ²	One Pulse Per Second
26	GND	GND	Ground

NOTE 1: RS 232 Settings - Baud Rate 4800, 8 Data Bits, No Parity, 1 Stop Bit.

NOTE 2: Accuracy of 1 PPS signal in relationship to the RF output is typically +/- 30 ns.

THIS PAGE INTENTIONALLY LEFT BLANK.

Appendix B - Terminology

Term	Description
Anti-Spoofing (AS)	Is a policy of the U.S. Department of Defense by which the P-Code is encrypted (by the additional modulation of a so-called W-Code to generate a new "Y-Code"), to protect the militarily important P-Code signals from being "spoofed" through the transmission of false GPS signals by an adversary during times of war. Hence civilian GPS receivers are unable to make direct P-Code pseudo-range measurements and must use proprietary (indirect) signal tracking techniques to make measurements on the L2 carrier wave (for both pseudo-range and carrier phase). All dual-frequency instrumentation must therefore overcome AS using these special signal tracking and measurement techniques.
Availability	The number of hours per day that a particular location has sufficient satellites (above the specified elevation angle, and perhaps less than some specified PDOP value) to make a GPS position determination possible.
BIAS	All GPS measurements are affected by biases and errors. Their combined magnitudes will affect the accuracy of the positioning results (they will bias the position or baseline solution). Biases may be defined as being those systematic errors that cause the true measurements to be different from observed measurements by a "constant, predictable or systematic amount", such as, for example, all distances being measured too short, or too long. Biases must somehow be accounted for in the measurement model used for data processing if high accuracy is sought. There are several sources of biases with varying characteristics, such as magnitude, periodicity, satellite or receiver dependency, etc. Biases may have physical bases, such as the atmosphere effects on signal propagation or ambiguities in the carrier phase measurements, but may also enter at the data processing stage through imperfect knowledge of constants, for example any "fixed" parameters such as the satellite ephemeris information, station coordinates, velocity of light, antenna height errors, etc. Random errors will not bias a solution. However, outlier measurements, or measurements significantly affected by multi-path disturbance (which may be considered a transient, un-modeled bias), will bias a solution if the proportion of affected measurements is relatively high compared to the number of unaffected measurements. For this reason, long period static GPS Surveying is more accurate (less likely to be biased) than "rapid static surveying" or kinematic (single-epoch) positioning.
Binary Shift-Key (BSK) Modulation	BSK is a modulation technique by which a binary message, such the Navigation Message or the PRN codes (consisting of 0's and 1's), is imprinted on the carrier wave. Unlike Amplitude Modulation (AM) and Frequency Modulation (FM), BSK Modulation does not alter the signal level (the "amplitude") or the carrier wavelength (the "frequency"). At a change in value of the message from 0 to 1, or from 1 to 0, the carrier wave is reversed (the phase is "flipped" by 180°). All reversals take place at the zero-crossings of the carrier (sine) wave (i.e., where the phase is zero).

Term	Description
C/A Code	The standard (Clear/Acquisition) GPS PRN code, also known as the Civilian Code or S-Code. A spread spectrum direct sequence code only modulated on the L1 carrier, used by the GPS receiver to acquire and decode the L1 satellite signal, and from which the L1 pseudo-range measurement is made.
Carrier	A radio wave having at least one characteristic (e.g., frequency, amplitude, phase) that can be varied from a known reference value by modulation. In the case of GPS there are two transmitted carrier waves: (a) L1 at 1575.42MHz, (b) L2 at 1227.60MHz, modulated by the Navigation Message (both L1 and L2), the P-Code (both L1 and L2) and the C/A-Code (L1).
Carrier Phase	GPS measurements made on the L1 or L2 carrier signal. May refer to the fractional part of the L1 or L2 carrier wavelength (approximately 19cm for L1, 24cm for L2), expressed in units of meters, cycles, fraction of a wavelength or angle. (One cycle of L1 is equivalent to one wavelength, and similarly for L2.) In carrier phase-based positioning, such as employed in GPS Surveying techniques, carrier phase may also refer to the accumulated or integrated measurement which consists of the fractional part plus the whole number of wavelengths (or cycles) since signal lock-on.
Carrier Aided Tracking	A signal processing strategy that uses the GPS carrier signal to achieve an exact lock-on the PRN code. More efficient and accurate than the standard approach.
Clock Bias	The difference between the receiver or satellite clock's indicated time and a well-defined time scale reference such as UTC (Coordinated Universal Time), TAI (International Atomic Time) or GPST (GPS Time).
Chip	One bit of a spreading sequence.
Channel	A single satellites signal on a single frequency.
Code Phase	GPS measurements based on the C/A-Code. The term is sometimes restricted to the C/A- or P-Code pseudo-range measurement when expressed in units of cycles.
Constellation	Refers to either the specific set of satellites used in calculating a position, or all the satellites visible to a GPS receiver at one time, or the entire ensemble of GPS satellites comprising the Space Segment.
Control Segment	A world-wide network of GPS monitoring and upload telemetry stations operated by, or on behalf of, the US Department of Defense. The tracking data is used by the Master Control Station at Colorado Springs to calculate the satellites' positions (or "broadcast ephemerides") and their clock biases. These are formatted into the Navigation Message which is uploaded on a daily (perhaps more frequently) basis by the Control Segment stations.
Correlator	The GPS receiver "software" or electronic means, implemented in some fashion (either analogue or digital) within a Tracking Channel, used to shift or compare the incoming signal with an internally generated signal. This operation is performed on the PRN codes, but may be used for more "exotic" mixed signals in the case of L2 measurements, where under the policy of Anti-Spoofing (AS) the L2 PRN code is not known. Correlator design may be influenced such that it is optimized for accuracy, mitigation of multi-path, acquisition of signal under foliage, etc.
Cut Off Angle	The minimum acceptable satellite elevation angle (above the horizon) to avoid blockage of line-of-sight, multi-path errors or too high Tropospheric or Ionospheric Delay values. May be preset in the receiver, or applied during data post-processing. For navigation receivers may be set as low as 5°, while for GPS Surveying typically a cutoff angle of 15° is used.

Term	Description
Data Message	Also known as the Navigation Message. A 1500 bit message modulated on the L1 and L2 GPS signal, which contains the satellite's location (or ephemeris), clock (bias) correction parameters, constellation almanac information and satellite health.
Differential GPS (DGPS)	A technique to improve GPS accuracy that uses pseudo-range errors measured at a known Base Station location to improve the measurements made by other GPS receivers within the same general geographic area. It may be implemented in real-time through the provision of a communication link between the GPS receivers, transmitting the correction information in the industry-standard RTCM format, or various proprietary formats. May be implemented in single Base Station mode, in the so-called Local Area DGPS (LADGPS), or using a network of Base Stations, as in the Wide Area DGPS (WADGPS) implementation.
Dilution of Precision (DOP)	An indicator of satellite geometry for a unique constellation of satellites used to determine a position. Positions tagged with a higher DOP value generally constitute poorer measurement results than those tagged with lower DOP. There are a variety of DOP indicators, such as GDOP (Geometric DOP), PDOP (Position DOP), HDOP (Horizontal DOP), VDOP (Vertical DOP), etc.
Dithering	The introduction of digital noise into the system. "Clock dithering" is the process by which the U.S. Department of Defense (DoD) degrades the accuracy of the Standard Positioning Service (i.e. absolute positioning of a C/A-Code capable receiver). "Clock dithering" is the additional satellite clock "bias" induced by the DoD's "Selective Availability" policy that cannot be corrected for by the broadcast Navigation Message clock correction parameters.
Doppler Shift	The apparent change in the frequency of a signal caused by the relative motion of the transmitter and receiver.
Dual Frequency	Refers to the instrumentation that can make measurements on both L-Band frequencies, or to the measurements themselves (e.g., L1 and L2 pseudo-range or carrier phase measurements). Dual-frequency measurements are useful for high precision (pseudo-range-based) navigation because the Ionospheric Delay bias can be determined, and the data corrected for it. In the case of Double-Differenced carrier phase, dual-frequency observations can account for the residual ionospheric bias (for case of long baselines), or aid Ambiguity Resolution for "rapid static" or "kinematic" baseline determination. All "top-of-the-line" GPS receivers are of the dual-frequency variety, and are comparatively expensive because of the special signal processing techniques that must be implemented to make measurements on the L2 carrier under the policy of Anti-Spoofing.
Enhanced Keplerian Elements (ephemeris)	Those elements which describe the position of a satellite in a different orbit and which comprise the standard Keplerian elements (q.v) and harmonic correction terms for the argument of latitude, orbit radius and inclination angle.
Ephemeris (plural: Ephemerides)	The file of values from which a satellite's position and velocity (the so-called "satellite state vector") at any instant in time can be obtained. The "Broadcast Ephemeris (or Ephemerides)" for a satellite are the predictions of the current satellite position and velocity determined by the Master Control Station, uploaded by the Control Segment to the GPS satellites, and transmitted to the user receiver in the Data Message. "Precise Ephemeris (or Ephemerides)" are post-processed values derived by, for example, the International GPS Service (IGS), and available to users post-mission via the Internet.
Fix	A single position with latitude, longitude (or grid position), altitude (or height), time, and date.
Geometric Dilution of Precision (GDOP)	An indicator of the geometrical strength of a GPS constellation used for a position/time solution.

Term	Description
Global Navigation Satellite System (GNSS)	This is an umbrella term used to describe a generic satellite-based navigation/positioning system. It was coined by international agencies such as the International Civil Aviation Organization (ICAO) to refer to both GPS and GLONASS, as well as any augmentations to these systems, and to any future civilian developed satellite system. For example, the Europeans refer to GNSS-1 as being the combination of GPS and GLONASS, but GNSS-2 is the blueprint for an entirely new system
Global Orbiting Navigation Satellite System (GLONASS)	This is the Russian counterpart to GPS. It consists of a constellation of 24 satellites (though the number may vary due to difficulties in funding for the system) transmitting on a variety of frequencies in the ranges from 1597-1617MHz and 1240-1260MHz (each satellite transmits on two different L1 and L2 frequencies). GLONASS provides worldwide coverage, however, its accuracy performance is optimized for northern latitudes, where it is better than GPS's SPS (there being no "Selective Availability" on GLONASS satellites). GLONASS positions are referred to a different Datum to those of GPS, i.e. PZ90 rather than WGS84.
Global Positioning System (GPS)	A system for providing precise location which is based on data transmitted from a constellation of 24 satellites. It comprises three segments: (a) the Control Segment, (b) the Space Segment, and (c) the User Segment.
GPS Time (GPST)	GPST is a form of Atomic Time, as is, for example, Coordinated Universal Time (UTC). GPST is "steered" over the long run to keep within one microsecond of UTC. The major difference is that while "leap seconds" are inserted into the UTC time scale every 18 months or so to keep UTC approximately synchronized with the earth's rotational period (with respect to the sun), GPST has no leap seconds. At the integer second level, GPST matched UTC in 1980, but because of the leap seconds inserted since then, GPST is now (end 1998) ahead of UTC by 12 seconds (plus a fraction of a microsecond that varies from day to day). The relationship between GPST and UTC is transmitted within the Navigation Message.
Height (Orthometric)	The Orthometric Height is the height of a station on the earth's surface, measured along the local plumbline direction through that station, above the Geoid surface. It is approximated by the "Height Above Mean Sea Level", where the MSL Datum is assumed to be defined by the mean tide gauge observations over several years. The relationship between Orthometric Height (H) and Ellipsoidal Height (h) is : $h = H + N$, where N is the Geoid Height or Geoid Undulation with respect to the Reference Ellipsoid. Orthometric Height is traditionally derived from geodetic leveling (using such techniques as optical leveling, trigonometrical leveling, barometric leveling).
Inter-Channel Bias	The difference in the code (or carrier) phases between two simultaneously simulated signals from the same satellite on different frequencies, excluding any effects from the propagation path or deliberately introduced errors, and after applying any corrections that are broadcast in the navigation message.
Inter-Frequency Bias	The difference in the code (or carrier) phases between two simultaneously simulated signals from the same satellite on different frequencies, excluding any effects from the propagation path or deliberately introduced errors, and after applying any corrections that are broadcast in the navigation message.
Inter-Sub-carrier Bias	The difference in the code (or carrier) phases between any two sub-carriers (e.g. I and Q) of the same signal.

Term	Description
Ionosphere, Ionospheric Delay	The Ionosphere is that band of atmosphere extending from about 50 to 1000 kilometres above the earth's surface in which the sun's ultraviolet radiation ionizes gas molecules which then lose an electron. These free electrons influence the propagation of microwave signals (speed, direction and polarization) as they pass through the layer. The Ionospheric Delay on GPS signals is frequency-dependent and hence impacts on the L1 and L2 signals by a different amount (unlike that within the Troposphere). A linear combination of pseudo-range or carrier phase observations on the L1 and L2 carrier waves can be created to almost entirely eliminate the Ionospheric Delay. The resulting observable is known as the Ionosphere-Free carrier phase (or pseudo-range). For single-frequency receivers it is not possible to account for this signal bias in this way. A broadcast model is contained within the transmitted Navigation Message, however, it is a relatively poor model (unlikely to account for more than 50% of the effect) as the Delay is very difficult to predict. The magnitude of the Ionospheric Delay is a function of the latitude of the receiver, the season, the time of day, and the level of solar activity. The Delay in the Zenith direction can be several tens of metres, increasing as the elevation angle of the satellite signal reduces (being 3-5 times greater than in the Zenith direction). The Delay is largely eliminated in Relative or Differential Positioning, however, the residual Ionospheric Delay increases as the baseline length increases and may be a significant source of error (especially in the height component) for very high precision GPS Geodesy. Even when using dual-frequency instrumentation, the Ionospheric Delay can still cause problems during the process of rapid Ambiguity Resolution when phase and range combinations other than the Ionosphere-Free one are used.
L1 Frequency 1575.42MHz	GPS carrier frequency which contains the C/A-Code, the encrypted P-Code (or Y-Code) and the Navigation Message. Commercial GPS navigation receivers can track only the L1 carrier to make pseudo-range (and sometime carrier phase and Doppler frequency) measurements.
Rice Factor	The ratio between the power of the direct component and the mean power of the Rayleigh faded component in Rician fading, expressed in dB. A Rice factor of $+\infty$ dB implies no fading, while $-\infty$ dB implies Rayleigh fading.
Satellite (or User) Location (or Trajectory)	The location (or trajectory) of the center of gravity of the satellite (or user).
Standard Keplerian Elements (almanac)	Those elements which describe the position of a satellite in a perfectly elliptical orbit and which comprise semi-major axis, eccentricity, inclination angle, longitude (or right ascension) of the ascending node (or at epoch), argument of perigee, and one of mean, true, and eccentric anomaly.
Sub-carrier	One of the separate modulated streams on a given frequency (either I and Q, or A, B and C).

THIS PAGE INTENTIONALLY LEFT BLANK.

Appendix C - Exporting, Editing and Importing Waypoints

The purpose of this appendix is to describe a method of adding custom waypoints to the GPSG-1000 without using the graphical users interface and touchscreen to enter waypoint data. Waypoint data will instead be entered on a PC, and then the custom data will be transferred to the GPSG-1000 using the file/waypoint/import feature.

Waypoints, as stored in the GPSG-1000, are a set of data that describe a point in 3D space, along with data to name/mark that location. Custom waypoints on the GPSG-1000 are stored in a comma separated variable file (CSV) which can be shared among GPSG-1000 units using the waypoint export and import functions. It is important to note that importing a custom waypoint file from another GPSG-1000 will result in the custom waypoints of the receiving unit to be overwritten. If the files from two different units need to be merged, it must be done external to the unit, and can be accomplished using the editing techniques that I will describe in this document.

Creating Custom Waypoints

Only Custom Waypoint data may be exported from the GPSG-1000. Once a Custom Waypoint is added to the GPSG-1000 it can then be exported to a USB drive and edited. To create a Custom Waypoint, select Waypoint from the main toolbar located at the left of the screen. The Waypoint screen appears (Figure C-1).

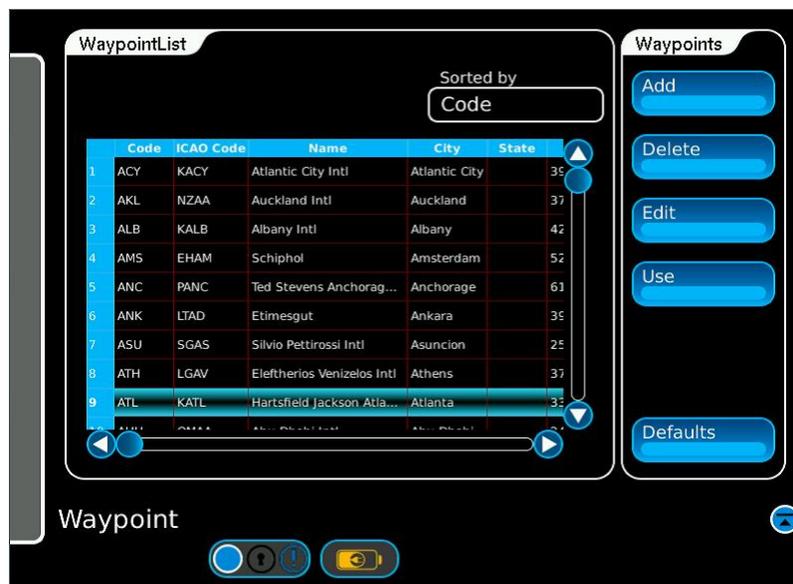


Fig. C-1 Waypoint Screen

Select the Add button, the Waypoint Edit screen appears (Figure C-2).



Fig. C-2 Waypoint Edit Screen

On the Waypoint Edit Screen select one of the lines from the table. For this exercise we will select ANC, line 7. Once you have highlighted the line, select Next. The data from the selected line will now populate the Waypoint Edit Screen (Figure C-3).

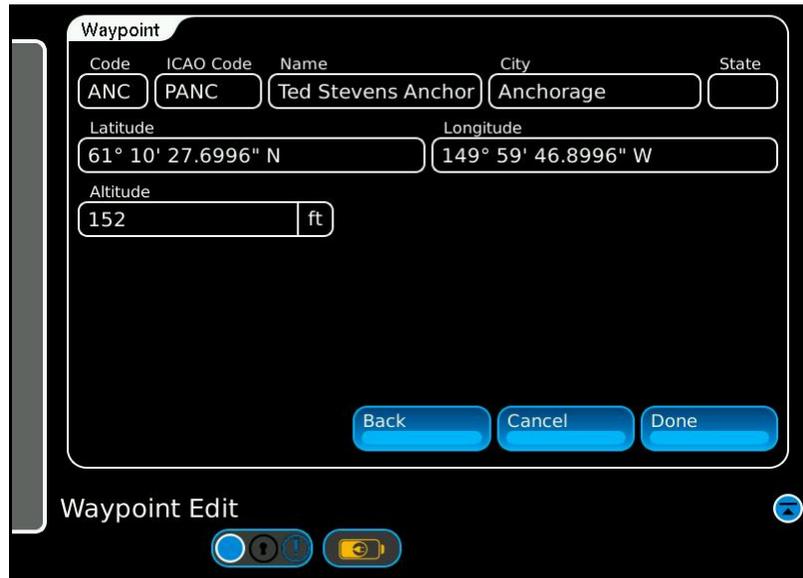


Fig. C-3 Waypoint Edit, Waypoint Data Screen

Select the Code field and enter a new code to identify the new Custom Waypoint. In this example we will use EXP1. Press Done, The new Custom Waypoint will be added to the Waypoint List (Figure C-4).



Fig. C-4 New Waypoint List

Exporting Waypoints

Exporting waypoints is done through the File/Waypoint page, to open the file screen first click on the main menu at the left side of the touchscreen, and select the 'File' button. On the file screen open the 'Waypoint' tab.

To export the custom waypoints, plug a compatible USB flash drive into one of the two USB ports located on the side of the box where the glare screen attaches, wait approximately 5 to 10 seconds for the unit to recognize the drive and then press the 'Export to USB' button on lower right of the Waypoint page (Figure C-5).



Fig. C-5 File Waypoints Screen

A green popup box will appear and confirm when the export has completed (Figure C-6).

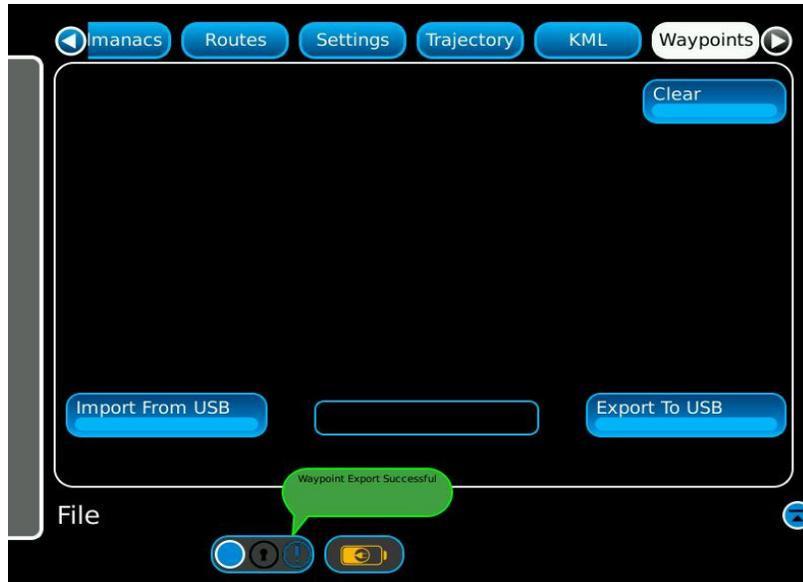


Fig. C-6 Waypoint Export Successful

Editing the Customer Waypoint File

Remove the USB flash drive from the GPSG-1000, and place the drive in a PC. The custom waypoint file will be located in the following directory /Instrument/Waypoint and will be named userairports.csv.

The Waypoint File may be opened in Excel or a Text type editor like Notepad++.

Excel Type Editor

The Waypoint information may be edited, copied, or new lines added. Ensure that each new Waypoint added has a unique identifying code in column D. Column J is added to the end of each Waypoint entry and set to "0", forcing a comma at the end of each row of the output file.

A	B	C	D	E	F	G	H	I	J
Ted Stevens Anchorage Intl	Anchorage		EXP1	PANC	61.174361	-149.996361	152	0	0

- Column A A unique name the user assigns to each user Waypoint.
- Column B City.
- Column C Country, not currently used.
- Column D Unique code to each user Waypoint. GPSG-1000 can sort Waypoints by this code.
- Column E CAO Code. A four-character code designating each airport around the world.
- Column F Latitude
- Column G Longitude
- Column H Altitude (in this case expressed in ft)
- Column I UTC offset, not currently used.
- Column J This column is added when the Waypoint file is edited to insert a comma at the end of the sentence. 0 should be entered here.

Text Type Editor

The Waypoint information may be edited, copied, or new lines added. The sentence terms are identical to the Excel type editor file, however, the line is already terminated with a comma.

```
Ted Stevens Anchorage Intl,Anchorage,,EXP1,PANC,61.174360999999998,-149.99636100000001,  
151.99999999999997,0,
```

Note: If Waypoint File contents exceeds a few thousand entries the loading and sorting functions in the GPSG-1000 will be slowed.

When editing is complete, save the file to the USB flash drive in the same directory location and with the same name from which it was originally opened.

Importing Waypoints

Importing waypoints is done through the File/Waypoint page, to open the file screen first click on the main menu at the left side of the touchscreen, and select the 'File' button. On the file screen open the 'Waypoint' tab (Figure C-7).

To import the custom waypoints, plug a compatible USB flash drive into one of the two USB ports located on the side of the box where the glare screen attaches, wait approximately 5 to 10 seconds for the unit to recognize the drive.



Fig. C-7 File Waypoints Screen

Press the Import From USB button on lower left of the Waypoint page. A pop-up box will appear with a warning that importing from the USB will overwrite the existing waypoints on the system. Press Yes to continue (Figure C-8.)

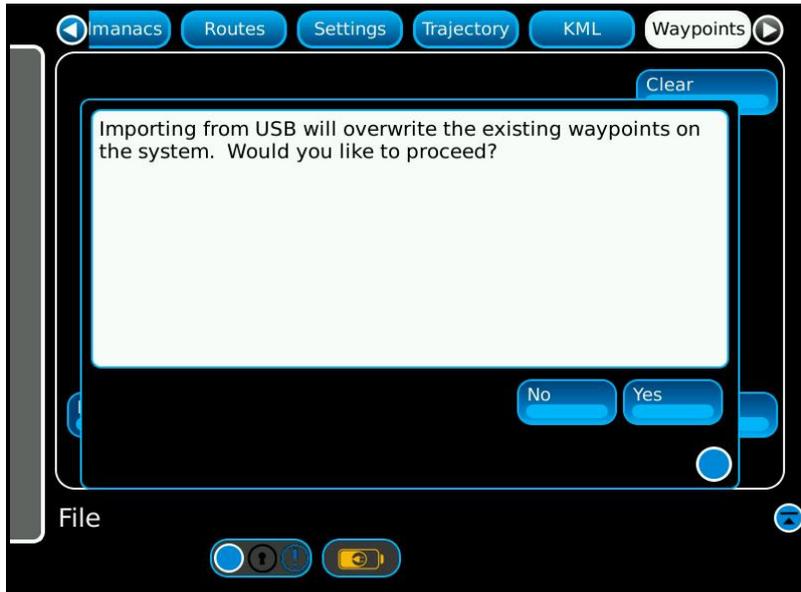


Fig. C-8 USB Import Warning Pop-up

A green popup box will appear and confirm when the import has been completed (Figure C-9).

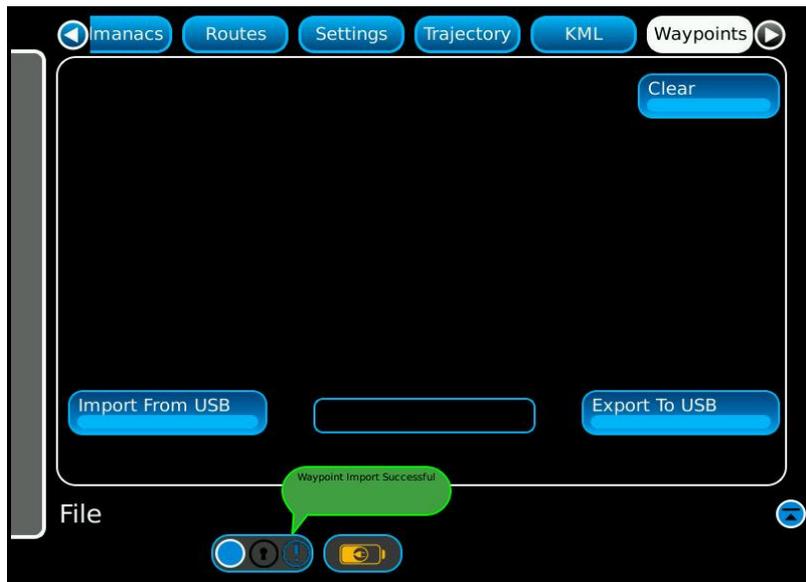


Fig. C-9 Waypoint Import Successful

The Waypoint imported to the GPSG-1000 will now be visible in the Waypoint Screen.

Appendix D - Exported and Imported File Formats

The GPSG-1000 has the ability to import and export a number of different file types for different uses. The file types include Almanac, KML, NMEA (Trajectory), Route, Settings and Waypoint. This appendix will attempt to explain the content of each of the file types that are able to be exported and imported onto the unit so the user can understand the content and format of each.

File Locations

Within the GPSG-1000, the various user files are stored on a static memory device, and with the exception of the load, store, manage, delete, import and export functions provided to the user through the UI, the user cannot further manipulate the files while they are contained within the unit. The user can however export the files to a USB drive where they can be accessed, edited and stored, and then using the import function of the GPST-1000, they can be reloaded onto the unit for use. When the various file types have been loaded onto a USB stick, the directories are created under the /Instrument directory which is located at the root of the USB device (Figure D-1).

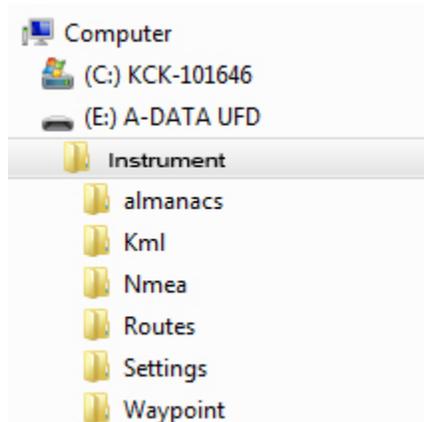


Fig. D-1 File Locations

Almanacs Files

The Almanacs directory contains almanac files in Yuma format (ICD-GPS-8.70 Rev A, Date Jun 15, 2011). The Almanacs files are either generated by the GPSG-1000 internal receiver downloads, or are downloaded from the United States Coast Guard repository website.

An example of the Almanac data file:

```
***** Week 799 almanac for PRN-01 *****
ID:                01
Health:            000
Eccentricity:      0.3730297089E-002
Time of Applicability(s): 61440.0000
Orbital Inclination(rad): 0.9613649345
Rate of Right Ascen(r/s): -0.7863184676E-008
SQRT(A) (m 1/2):   5153.619629
Right Ascen at Week(rad): 0.9558857469E+000
Argument of Perigee(rad): 0.444257464
Mean Anom(rad):    -0.1754657556E+001
Af0(s):            -0.1144409180E-004
Af1(s/s):          0.0000000000E+000
week:              799
```

Kml Files

The Kml directory contains files generated from the application GoogleEarth in Kml format on a PC, which have then been imported onto the GPSG-1000. The GPSG-1000 compiles the Kml files into Trajectory data files with a .gdt extension in CSV format.

Kml files are trajectory routes that are intended to follow a course laid out in GoogleEarth at a constant velocity. The files must have certain conditions; the altitude must be expressed in absolute terms, navigation points must be properly positioned for the speed and turning radius of the simulation. Therefore it is generally not suitable to convert recorded routes from a GPS receiver in to Kml files for simulation in the GPSG-1000. Recorded routes should be loaded to the GPSG-1000 as Nmea Files for playback.

The compiled .gdt files are in the following format:

```
Notes,Date,Time,Latitude,Longitude,Alt,Desc
$GDT,20000101,000144.00,38.9425699612859,-94.7561817577427,0.000000,3D,*16
$GDT,20000101,000145.00,38.9425695029864,-94.7561783124509,-0.000004,3D,*3F
$GDT,20000101,000146.00,38.9425681280874,-94.7561679765759,-0.000018,3D,*34
$GDT,20000101,000147.00,38.9425658365869,-94.7561507501185,-0.000039,3D,*39
$GDT,20000101,000148.00,38.9425626284821,-94.7561266330799,-0.000069,3D,*37
$GDT,20000101,000149.00,38.9425585037686,-94.7560956254621,-0.000106,3D,*35
$GDT,20000101,000150.00,38.9425534624409,-94.7560577272674,-0.000150,3D,*3E
$GDT,20000101,000151.00,38.9425475044924,-94.7560129384988,-0.000200,3D,*34
$GDT,20000101,000152.00,38.9425406299151,-94.7559612591597,-0.000254,3D,*3F
$GDT,20000101,000153.00,38.9425328387000,-94.7559026892542,-0.000312,3D,*3A
$GDT,20000101,000154.00,38.9425241308367,-94.7558372287867,-0.000371,3D,*34
$GDT,20000101,000155.00,38.9425145063137,-94.7557648777623,-0.000431,3D,*3F
$GDT,20000101,000156.00,38.9425039651181,-94.7556856361865,-0.000489,3D,*30
```

Nmea Files

The Nmea directory contains files with an NME extension that contain data in NMEA-0183 sentence format. The GPSG-1000 is able to use GGA, RMC and GSV sentences from these files. In general the NMEA-0183 files are created by the internal or an external GPS receiver.

Nmea file example:

```
$GPGGA,150923.000,3856.4506,N,09445.2627,W,1,07,1.1,332.2,M,-30.1,M,,0000*68
$GPGSV,3,1,11,29,65,303,50,05,63,046,52,26,36,124,45,02,31,082,49*73
$GPGSV,3,2,11,25,25,230,43,15,24,164,47,21,19,285,40,12,11,198,40*7B
$GPGSV,3,3,11,10,08,049,40,30,06,321,41,18,04,230,36*40
$GPRMC,150923.000,A,3856.4506,N,09445.2627,W,0.09,154.82,290113,,A*79
```

The sentence structure for each position sentence:

GGA

Essential fix data which provide 3D location and accuracy data.

```
$GPGGA,150923.000,3856.4506,N,09445.2627,W,1,07,1.1,332.2,M,-30.1,M,,0000*68
```

Where:

GGA	Global Positioning System Fix Data
150923.000	Fix taken at 12:35:19 UTC
3856.4506,N	Latitude
09445.2627,W	Longitude
1	Fix quality:
	0 = invalid
	1 = GPS fix (SPS)
	2 = DGPS fix
	3 = PPS fix
	4 = Real Time Kinematic
	5 = Float RTK
	6 = estimated (dead reckoning) (2.3 feature)
	7 = Manual input mode
	8 = Simulation mode
07	Number of satellites being tracked
1.1	Horizontal dilution of position
332.2,M	Altitude, Meters, above mean sea level
-30.1,M	Height of geoid (mean sea level) above WGS84 ellipsoid
(Empty field)	Time in seconds since last DGPS update
0000	DGPS station ID number
*68	Checksum data, always begins with *

GSV

Satellites in View shows data about the satellites that the unit might be able to find based on its viewing mask and almanac data.

```
$GPGSV,3,1,11,29,65,303,50,05,63,046,52,26,36,124,45,02,31,082,49*73
```

Where:

GSV	Satellites in view
3	Number of sentences for full data
1	Sentence 1 of 3
11	Number of satellites in view
29	Satellite PRN number
65	Elevation, degrees
303	Azimuth, degrees
50	SNR - higher is better
	Repeat PRN, Elevation, Azimuth and SNR for up to 4 satellites per sentence
*75	Checksum data, always begins with *

RMC

NMEA has its own version of essential gps pvt (position, velocity, time) data. It is called RMC, The Recommended Minimum, which will look similar to:

```
$GPRMC,150923.000,A,3856.4506,N,09445.2627,W,0.09,154.82,290113,,A*79
```

Where:

RMC	Recommended Minimum sentence C
150923.000	Fix taken at 12:35:19 UTC
A	Status A=active or V=Void.
3856.4506,N	Latitude
09445.2627,W	Longitude
0.09	Speed over the ground in knots
154.82	Track angle in degrees True
290113	Date - 23rd of March 1994
(Empty field),,	Magnetic Variation
A	NMEA 2.3 additional field
*79	Checksum data, always begins with *

Route Files

Route files are used to populate the route table on the Route page (Figure D-2)..



Fig. D-2 Route Page

The files are stored and exported from the GPSG-1000 in XML format. The beginning and end of each route file is designated by the text <Route>. The body of the route consists of a number of route points with the following contents. Please note that the route data shown in the example consists of six route points.

```
<Route>
  <Waypoint Longitude="-77.8842000000001" MaxAcceleration="0" MaxClimbRate="0"
Name="HESKU" Latitude="37.1498222222222" Altitude="1524" TargetSpeed="53.6446666666667"
TurningCircleRadius="108.5658611334349"/>
  <Waypoint Longitude="-78.8000527777778" MaxAcceleration="0" MaxClimbRate="0"
Name="RFLAT" Latitude="38.2002888888889" Altitude="1524" TargetSpeed="53.6446666666667"
TurningCircleRadius="131.3646919714563"/>
  <Waypoint Longitude="-78.8396333333332" MaxAcceleration="9.80000000000001"
MaxClimbRate="-3.048" Name="RIVKE" Latitude="38.2414916666667" Altitude="1249.68"
TargetSpeed="53.6446666666667" TurningCircleRadius="100"/>
  <Waypoint Longitude="-78.8831444444444" MaxAcceleration="9.80000000000001"
MaxClimbRate="-3.048" Name="BEEDY" Latitude="38.2867027777778" Altitude="944.88"
TargetSpeed="53.6446666666667" TurningCircleRadius="100"/>
  <Waypoint Longitude="-78.95743055" MaxAcceleration="9.80000000000001"
MaxClimbRate="-3.048" Name="RW33" Latitude="38.363725" Altitude="355.092"
TargetSpeed="53.6446666666667" TurningCircleRadius="131.3646919714563"/>
  <Waypoint Longitude="-79.1377222222222" MaxAcceleration="9.80000000000001"
MaxClimbRate="3.048" Name="MOL" Latitude="37.8637222222222" Altitude="1828.8"
TargetSpeed="75.9966111111111" TurningCircleRadius="183.4763053155051"/>
</Route>
```

The Route data variables are formatted as follows:

Waypoint Longitude is followed by the longitude value of the waypoint in DDD.DDDDDDDD format. Values in the western hemisphere are indicated by negative values, and values in the eastern hemisphere are indicated by positive values.

Max Acceleration is followed by the maximum acceleration value that the body in motion is allowed to achieve in the lateral and longitudinal axes as it travels from the current waypoint to the next. The acceleration value is expressed in m/s^2 .

Max Climb Rate is followed by the maximum climb or descent rate that the body in motion is allowed to achieve as it travels from the current waypoint to the next. The climb/descent rate is expressed in m/s.

Name is followed by the text indicating the name of the waypoint.

Latitude is followed by the latitude value of the waypoint in DD.DDDDDDDD format. Values in the southern hemisphere are indicated by negative values, and values in the northern hemisphere are indicated by positive values.

Target Speed is followed by the target speed of the body in motion as it passes through the waypoint. The target speed is expressed in m/s.

Turning Circle Radius is followed by the turning circle radius of the body in motion that defines the commanded path to be followed. The turning circle radius is expressed in meters.

Settings Files

The Settings file directory contains settings files generated from the GPSG-1000 File/Settings page. The Settings data is in XML format. Following is an example of the GPSG-1000 Power Up Settings. The Settings File can be edited and imported to other GPSG-1000 units to set a common start condition. Care must be taken to ensure settings parameters are compatible with the test set.

```
<!DOCTYPE GpsgPowerupConfig>
<GpsgPowerupConfig>
  <SimulationSetup>
    <SimulationMode>Gps</SimulationMode>
    <Carrier>L1_E1</Carrier>
    <SbasMode>Auto</SbasMode>
    <SimulationType>Static</SimulationType>
    <DigitalNoiseMode>Off</DigitalNoiseMode>
    <FadingMode>None</FadingMode>
    <PrnSignalType>Fixed</PrnSignalType>
    <PositionSource>User</PositionSource>
    <ClockSetting>User</ClockSetting>
    <UserDateTime>2011-08-05T21:12:16</UserDateTime>
    <UnitsType>Imperial</UnitsType>
    <LatLonFormat>DD°MM'SS.SS"</LatLonFormat>
    <RfPortSelection>Coupler</RfPortSelection>
    <RfLevel>-130</RfLevel>
    <RouteLooping>0</RouteLooping>
    <MotionModel type="Unlimited">
      <Pedestrian LateralAcceleration="2.94" Velocity="10.72896"
        LongitudinalAcceleration="2.94"/>
      <Automobile LateralAcceleration="9.800000000000001"
        Velocity="89.408"
        LongitudinalAcceleration="9.800000000000001"/>
      <Marine LateralAcceleration="6.86" Velocity="44.704"
        LongitudinalAcceleration="6.86"/>
      <LowPerfAircraft LateralAcceleration="19.6" Velocity="223.52"
        LongitudinalAcceleration="9.800000000000001"/>
      <HiPerfAircraft LateralAcceleration="88.2" Velocity="447.04"
        LongitudinalAcceleration="49"/>
      <Custom LateralAcceleration="19.6" Velocity="0.44704"
        LongitudinalAcceleration="9.800000000000001"/>
      <Unlimited LateralAcceleration="98" Velocity="514.096"
        LongitudinalAcceleration="98"/>
    </MotionModel>
  </SimulationSetup>
  <ChannelsSetup Gnss="12" Galileo="5" Gps="6" SingleSbas="0" Sbas="1"/>
  <IoSetup>
    <LossValues Splitter="0" Coupler="0" DirectCable="0" CouplerCable="0"/>
    <ExternalRefOutMode>Off</ExternalRefOutMode>
    <ReferenceSource>Internal</ReferenceSource>
    <TriggerMode>Auto</TriggerMode>
  </IoSetup>
  <DefaultStaticPoint Longitude="0" Latitude="0" Altitude="0"/>
  <DefaultFiles Trajectory="" Route="Default Route" Almanac=""/>
  <DiagnosticsSetup>
    <DiagnosticsMode>Off</DiagnosticsMode>
    <Frequency>1176.45 MHz</Frequency>
    <Amplitude>-100</Amplitude>
    <DopplerError>0</DopplerError>
  </DiagnosticsSetup>
</GpsgPowerupConfig>
```

Waypoint Files

The Waypoint file directory contains user entered custom waypoints created on the waypoint page. The Waypoint data is in CSV format. The Waypoint files will open in Excel.

Waypoint csv file example:

A	B	C	D	E	F	G	H	I	J
NY to RM 01	NA		TR01	NA	49.0875	-45.3539	7000	0	0
NY to RM 02	NA		TR02	NA	49.82806	-19.7547	7000	0	0

Where:

- Column A Unique name the user assigns to each user Waypoint.
- Column B City. In this case the Waypoint is not in a city.
- Column C Country, not currently used.
- Column D Unique code to each user Waypoint. GPST-1000 can sort Waypoints by this code.
- Column E CAO Code. A four-character code designating each airport around the world. In this case the Waypoint is not an airport.
- Column F Latitude
- Column G Longitude
- Column H Altitude (in this case expressed in ft)
- Column I UTC offset, not currently used.
- Column J This column is added when the Waypoint file is edited to insert a comma at the end of the sentence. 0 should be entered here.

Appendix E - Recording and Playing Trajectory Routes

Trajectory files recorded by GPS receivers or the GPSG-1000 and saved in the .gdt or .nme format may be played back in the GPSG-1000 for simulation and testing of GPS receivers. This appendix will detail the steps required to record a Trajectory route in the GPSG-1000 GPS RX and playback the file for simulation.

Files saved from other GPS receivers may have .nmea file extension. When transferred to the GPSG-1000 for playback they must be renamed with .nme file extension. See Application Note: GPSG-1000 File Properties. Once renamed and transferred to the GPSG-1000, they may then played in the same manner as files recorded by the GPSG-1000.

The GPSG-1000 GPS RX will record its position and route. Attach the included GPS RX antenna. From the Main Menu, select the down arrow (Figure E-1).



Fig. E-1 Main Menu

From the lower portion of the Main Menu, select GPS RX (Figure E-2).



Fig. E-2 Main Menu, Lower Section

The GPS RX page will display the current GPS position fix and the visible satellite (Figure E3).

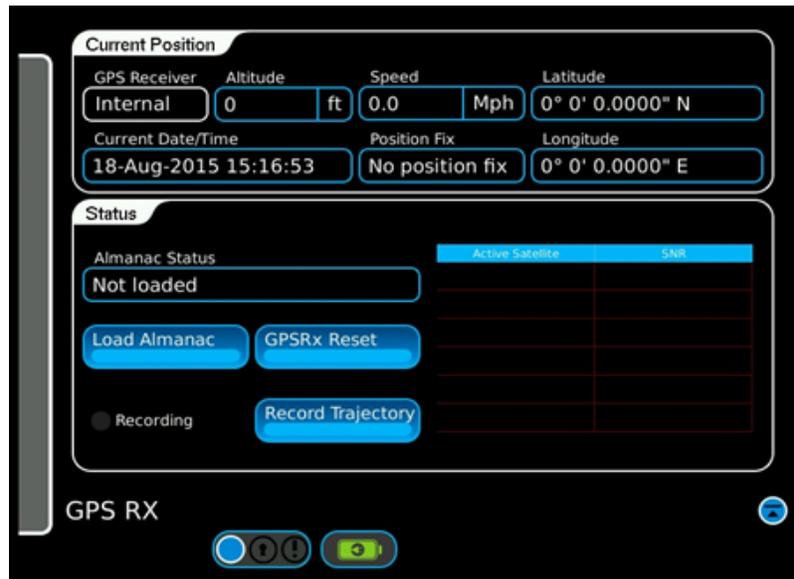


Fig. E-3 GPS RX Page

Wait for the GPS RX to acquire a 3d position fix. (Figure E-4).

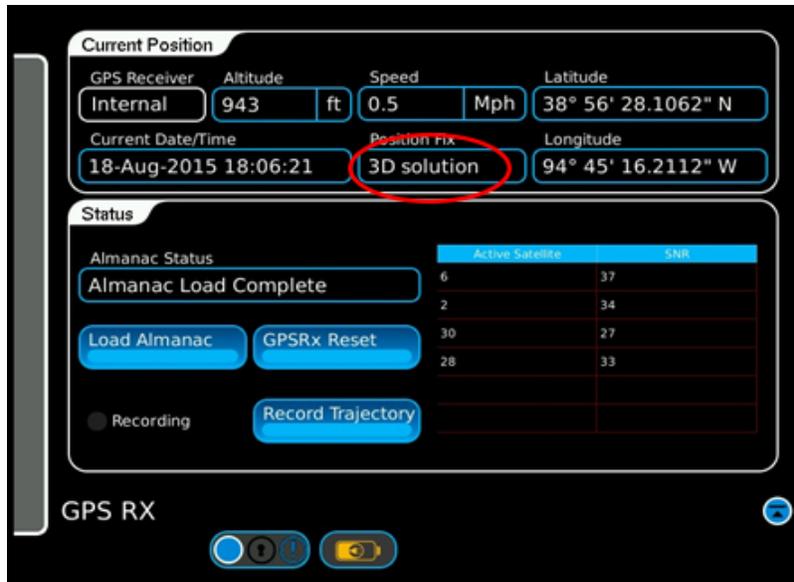


Fig. E-4 GPS RX Page with 3d Fix

Press the Record Trajectory button to start recording. The GPSG 1000 will continue to record until the Stop Recording button is pressed. Note the Current Date/Time field, the time is displayed as GMT (Figure E-5).

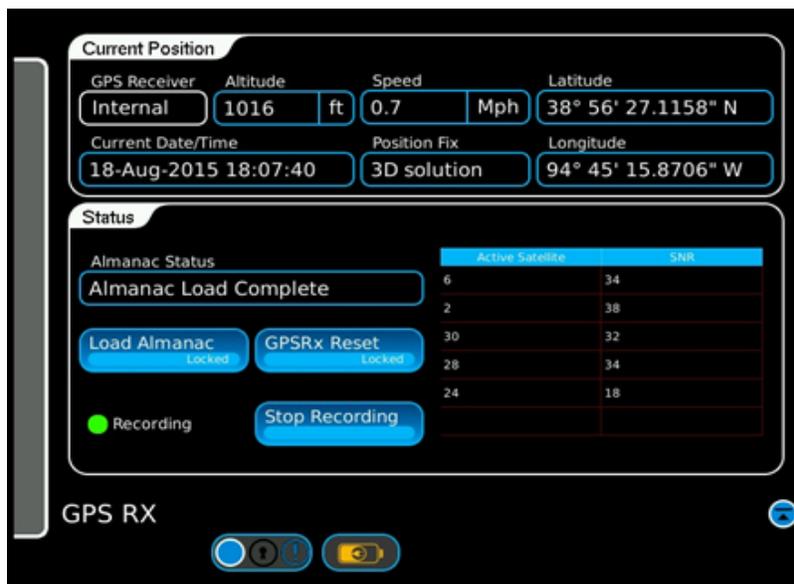


Fig. E-5 GPS RX Page, Recording Trajectory

The data will be stored in a file with the following naming convention:

MMDDYYYY_HHMMSS.mne.

The time recorded for the file name is the time the recording is stopped. To load the new Trajectory File for playback select File from the Main Menu and then Trajectory from the tabs at the top of the page. Press the Load button and select the new .nme file, press Open (Figure E-6).

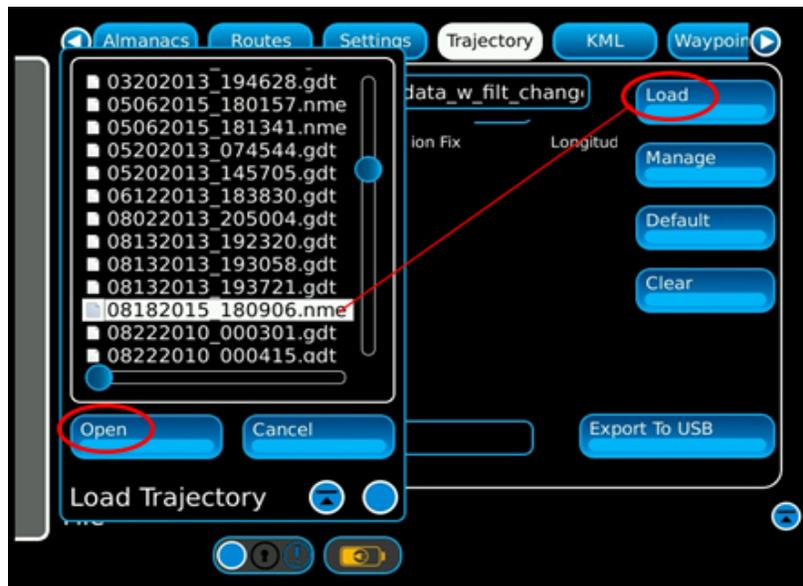


Fig. E-6 File Page, Trajectory File Saved

The new Trajectory file will appear in the Current Trajectory File widow (Figure E-7).



Fig. E-7 File Page, Trajectory Loaded

To run the Trajectory File simulation, select Setup from the Main Menu. In the GNSS window in the Simulation field select Trajectory. In the PRN Signal field select Traj File. Set the RF Level in the RF Output window to the desired level (Figure E-8).

The Trajectory File records the Signal to Noise Ratio of the received GPS signal. During playback the GPSG-1000 will adjust the RF Power Level to simulate the actual recorded S:N. For this feature to work the simulation must be played back with the same Almanac with which the recording was made. If the Trajectory File is played with a different Almanac the positional simulation will run, but, the Simulation screen will show a "Red" indicator for Traj Power and the RF Level will remain at the set level.

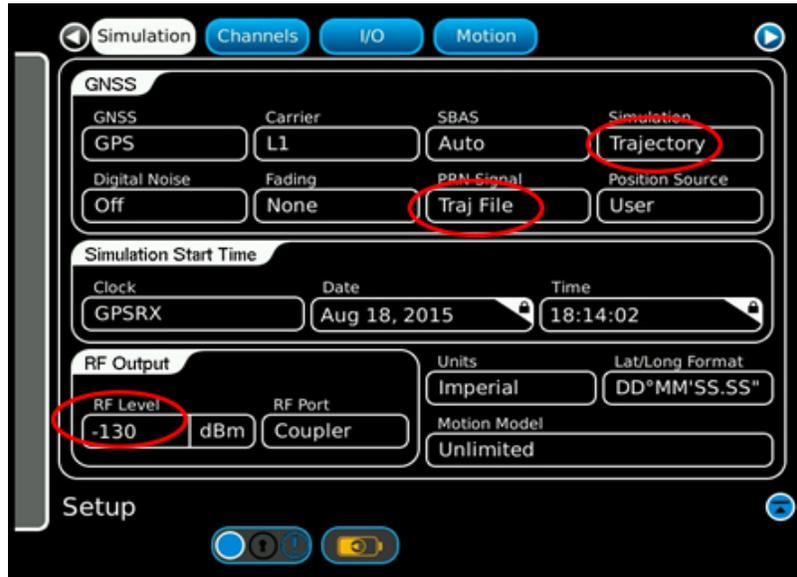


Fig. E-8 Setup Page, Trajectory Setup

Close the Setup page and select Simulation from the Main Menu. Press Run and the Trajectory Simulation will start (Figure E-9)

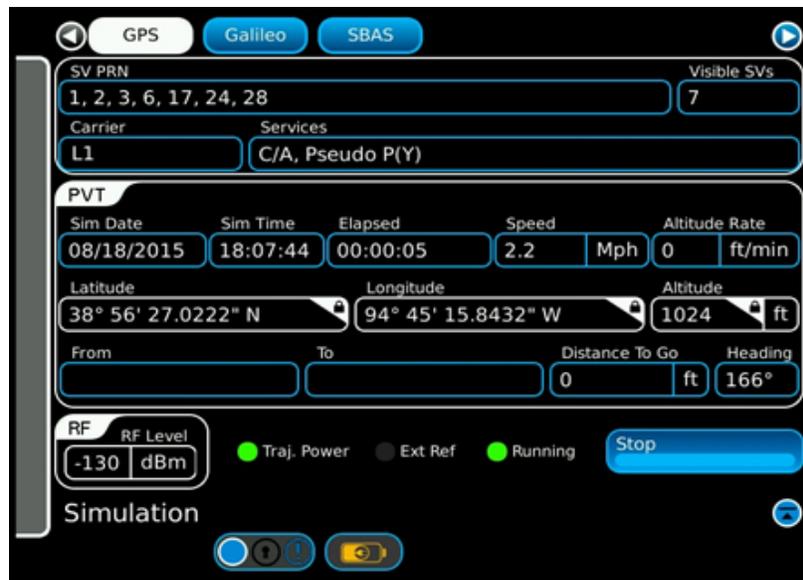


Fig. E-9 Simulation Page, Trajectory File Running

The Simulation will run until the end of the Trajectory File (Figure E-10).

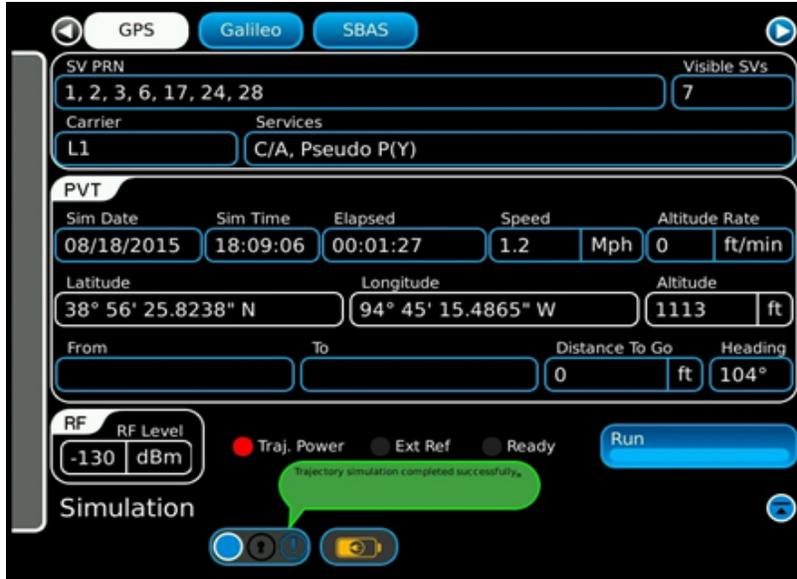


Fig. E-10 Trajectory Simulation Complete

Appendix F - GPSG-1000 USB Memory Device Format Compatibility

The GPSG-1000 uses USB Memory Devices as a utility to update software and to import and export almanac, route, and other files. Some types of USB Memory Devices have proven to be un-readable by the GPSG-1000 due to incompatible formatting.

The GPSG-1000 requires a USB Memory Device to be formatted as FAT32 or FAT16 only. It is also recommended that users have a dedicated USB Memory Device for the GPSG-1000 so that the directory structure does not get corrupted. The directory file structure is shown in Figure 1 below.

VIAVI Solutions recommends USB Memory Device P/N 67325, available for purchase from the VIAVI Solutions Customer Help Desk at 800-835-2350 or email avcomm.service@viavisolutions.com.

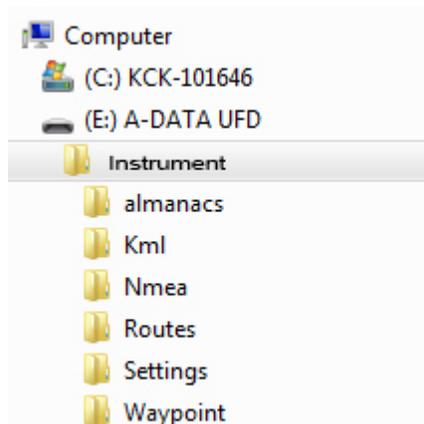
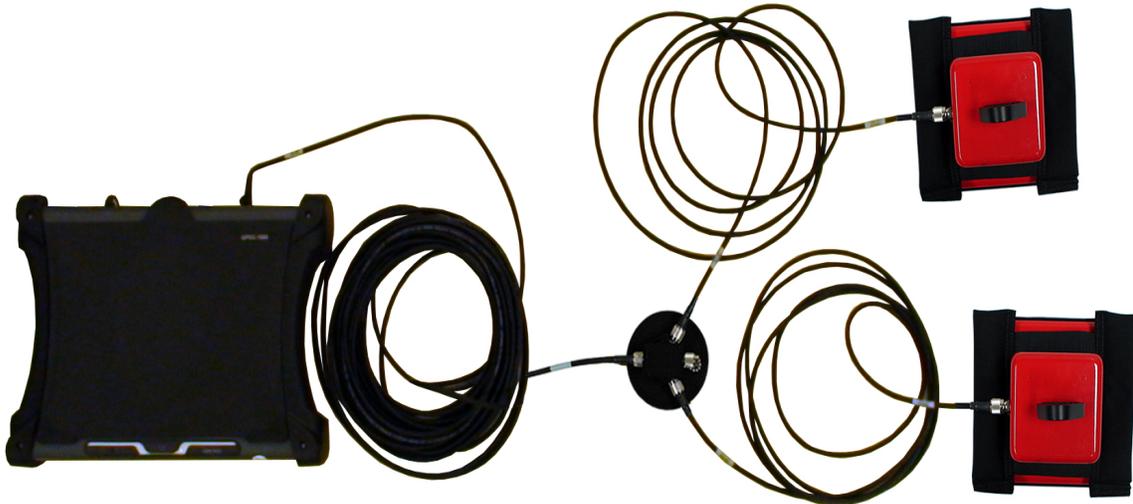


Fig. F-1 File Locations

THIS PAGE INTENTIONALLY LEFT BLANK.

Appendix G - Connecting Dual Antenna Coupler Kit

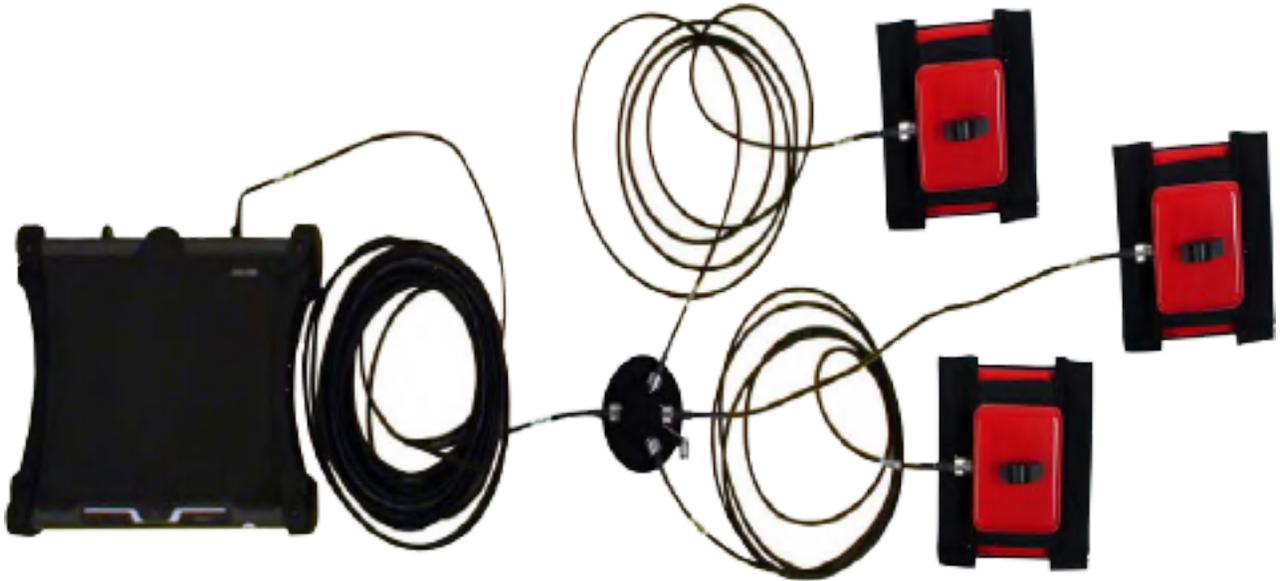


GPSG Dual Antenna Coupler Kit Connection

STEP	PROCEDURE
1.	Connect Coaxial Cable (TNC) (50 ft) (supplied with the GPSG-1000) between the GPS TX COUPLER Connector and the GPSG Splitter Common Port.
2.	Connect two Coaxial Cables (TNC) (12 ft) between the GPSG Splitter and two GPSG-1000 Antenna Couplers. (Use the GPSG-1000 Antenna Coupler and Shot Bag supplied with the GPSG-1000.)
3.	Ensure the Connector Termination is in place on the open GPSG Splitter connector.
4.	For Coupler Loss and Cable Loss values to enter in the GPSG-1000 I/O setup screen; calculate the average insertion loss of the couplers being used. Add to this value 9.5 dB for the splitter/combiner and enter this value as coupler loss. Calculate the average loss of the Coupler Cables in this Kit. Add the cable loss of the cable provided with the GPSG-1000 to the average of the two cables provided in this Kit and enter this value as cable loss.

THIS PAGE INTENTIONALLY LEFT BLANK.

Appendix H - Connecting Triple Antenna Coupler Kit



GPSG Triple Antenna Coupler Kit Connection

STEP	PROCEDURE
1.	Connect Coaxial Cable (TNC) (50 ft) (supplied with the GPSG-1000) between the GPS TX COUPLER Connector and the GPSG Splitter Common Port.
2.	Connect three Coaxial Cables (TNC) (12 ft) between the GPSG Splitter and three GPSG-1000 Antenna Couplers. (Use the GPSG-1000 Antenna Coupler and Shot Bag supplied with the GPSG-1000.)
3.	Enter Coupler Loss and Cable Loss values into in the GPSG-1000 I/O Setup Screen. Calculate the average insertion loss of the Couplers and enter as Coupler Loss. Calculate the average loss of the Coupler Cables in this Kit, add that value to the cable loss value for the Coupler Cable included in the GPSG-1000 Test Set and 9.5 dB for the splitter loss.

THIS PAGE INTENTIONALLY LEFT BLANK.

Appendix I - Direct Connecting to GPS Receivers

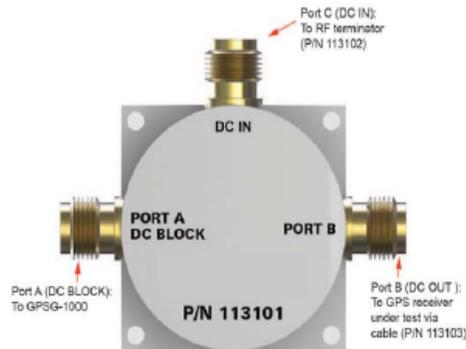
Hardware Requirements:

Antenna Load Simulators using the VIAVI GPSG-1000 and Optional Kit

Some GPS receivers require a resistive load be present on the antenna port of the receiver for proper operation. If a resistive load is not present, the receiver indicates an antenna fault and the system self-test indicates a failure.

The components within GPSG-optional kit provide a resistive load that is required by some GPS receivers when direct connecting the GPSG-1000 to the RF input of the receiver. This load prevents some GPS receivers from failing their internal self-tests.

The Bias-Tee and RF terminator provided within the GPSG-1000 optional kit simulates a 26 mA load in a 5 Vdc system. Other load values may be required depending on the needs of the individual GPS receiver under test. The content of the GPSG-1000 optional kit is not required if using the GPSG-1000 RF coupler to transmit GPS data to the antenna of the GPS receiver under test.



GPSG Dual Antenna Coupler Kit Connection

STEP	PROCEDURE
1.	Connect the RF terminator (P/N 113102) to Port C (DC IN) of the Bias-Tee (P/N 113101).
2.	Connect the TNC to SMA coaxial cable (P/N 113103) from Port B (DC OUT) of the Bias-Tee (P/N 113101) to the GPS antenna input connector of the receiver under test.
3.	Connect the GPSG-1000 to Port A (DC BLOCK) of the Bias-Tee (P/N 113101) using the TNC to TNC coaxial cable (supplied with the GPSG-1000).
4.	Add the loss factor of the TNC coaxial cable supplied with the GPSG-1000 with 0.3 dB (typical) for the Bias Tee loss and 0.95 (typical) for the Coax Assy (P/N 113103). Enter this value into the Direct Connect cable loss in the GPSG-1000 Setup I/O Window. If the supplied cables are <u>not</u> used, the cables used should be characterized and the values entered.
5.	Using the GPSG-1000 User's Manual as a reference, set up and begin a GNSS simulation on the GPSG-1000.

THIS PAGE INTENTIONALLY LEFT BLANK.

T

Test Set Functions	3-1
Calibration Function Window	3-30
Diagnostics Function Window	3-31
File Almanacs Function Window	3-32
File Routes Function Window	3-33
File Settings Function Window	3-34, 3-35, 3-36, 3-38
GPS RX Function Window	3-27
Maintenance Function Window	3-29
Route Edit Edit Window	3-21
Route Edit Stored Window	3-20
Route Function Window	3-18
Setup Channels Window	3-13
Setup I/O Window	3-14
Setup Motion Window	3-12
Setup Simulation Window	3-5
SV PRN Edit Window	3-16
SV PRN Selection Function Window	3-15
System Function Window	3-1, 3-15, 3-18, 3-23, 3-27, 3-39
Waypoint Edit Window	3-26
Waypoint Edit Stored Window	3-25
Waypoint Edit Window	5-8, 5-9
Waypoint Function Window	3-15, 3-23
Testing GPS/Galileo Receivers	
Antenna Coupler Installation	4-1, 5-5
GPS Receiver Communication	4-9
RAIM Testing and SV Geometry	4-17
Sensitivity	4-9
Acquisition Sensitivity	4-11
C/No Measurement Options	4-12
Signal Tracking Sensitivity	4-10
Setup	4-2, 4-4, 4-6
TTFF and Position Accuracy	4-12
Acquisition Cold Start	4-13
Acquisition Warm Start	4-14
Positional Accuracy	4-16
Reacquisition Hot Start	4-15
TTFF Accuracy	4-15

U

Upon Receipt	5-xi
Checking Equipment	5-xii
Standard Items	5-xiii, 5-xiv
Unpacking Test Set	5-xi
User Interface Components	
Function Keys	2-9
Function Window Icons	2-10
Function Windows	2-9
Launch Bar	2-8
Launch Bar Navigation	2-9



22165258 Rev. 501
July 2022
English

VIAVI Solutions

North America:	1.844.GO VIAVI / 1.844.468.4284
Latin America	+52 55 5543 6644
EMEA	+49 7121 862273
APAC	+1 512 201 6534
All Other Regions:	viavisolutions.com/contacts