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GPS-E1
Evaluation Kit for GPS-MS1 and GPS-PS1

– User's Manuals –

5th July 1999

GPS-E1 Evaluation Kit User’s Guide

About This Document

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Preface

The *GPS-E1 Evaluation Kit User's Guide* explains how to use your GPS-E1 Evaluation Unit to collect, display, and analyze GPS data.

How This Manual Is Organized

Chapter 1	"Introduction" describes the GPS-E1 Evaluation Kit.
Chapter 2	"Getting Started" describes the requirements to install the GPS-E1 Toolkit using Windows 95/98. In addition, it also explains how to connect the GPS receiver.
Chapter 3	"Quickstart" describes basic functions to get your unit running.
Chapter 4	"Setup" SiRFdemo menu functions.
Chapter 5	"View" SiRFdemo menu functions.
Chapter 6	"Action" SiRFdemo menu functions.
Chapter 7	"Navigation" SiRFdemo menu functions.
Chapter 8	"Poll" SiRFdemo menu functions.
Chapter 9	"SiRFstarI/LX Toolkit Software" Processing and analysis software.
Appendix A	"Evaluation Kit Specifications"
Appendix B	"File Formats"
Appendix C	"SiRF Binary Protocol Specification"
Appendix D	"NMEA Input/Output Messages"
Appendix E	"Datum Transformations of GPS Positions"
Appendix F	"Acronyms, Abbreviations, and Glossary"

Related Manuals

You can refer to the following data sheets:

- GPS-MS1 GPS Receiver Module Datasheet, μ-blox AG
- GPS-PS1 GPS Receiver Board Datasheet, μ-blox AG

These can be accessed online from `http://www.u-blox.ch`.

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http://www.u-blox.ch

Helpful Information When Contacting Technical Support

Receiver Serial Number:	…
Receiver Software Version:	…
SiRFdemo Version:	…

Chapter 1

Introduction

The goal of the GPS-E1 Evaluation Kit is to allow easy performance evaluation of the current generation of μ-blox OEM GPS receivers. The GPS module is either a GPS-MS1 (chip-sized 30.2mm x 29.5mm x 7.55mm) or a GPS-PS1 (credit-card sized 82.55 mm x 32.0 mm x 8.5 mm) board, mounted on an interface board encased in an aluminum housing (105 mm x 112.5 x 48mm).

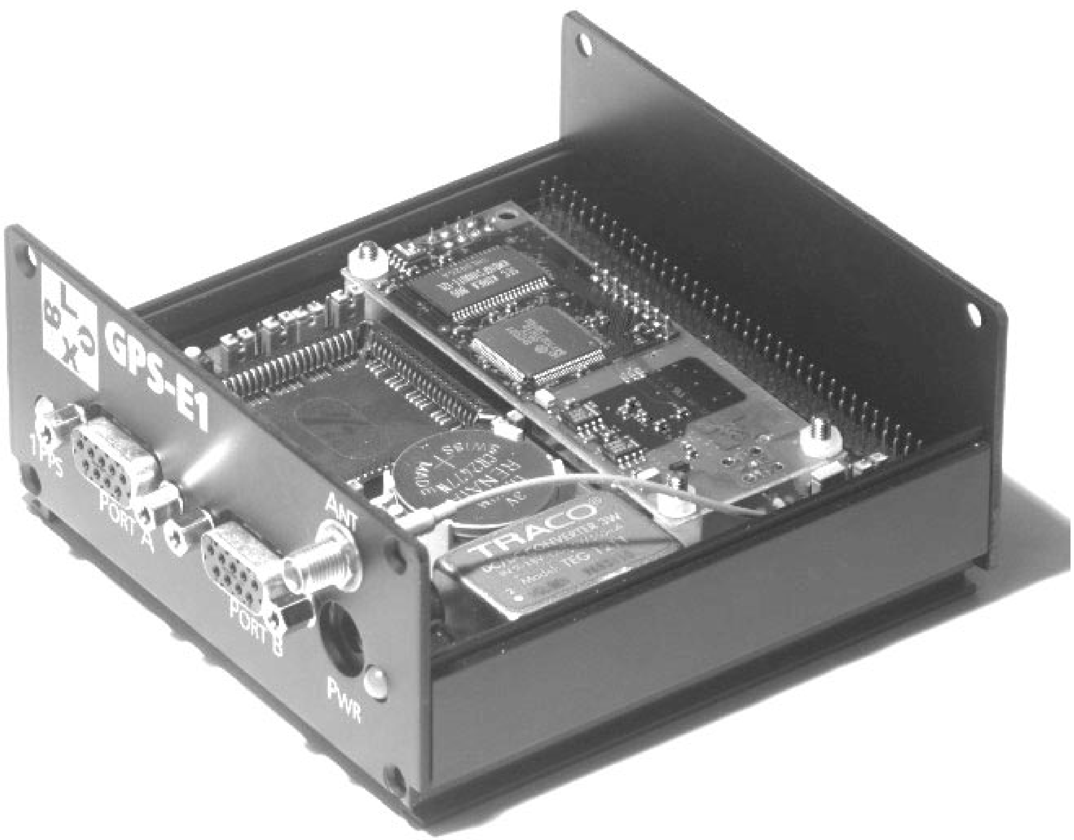


Figure 1.1: GPS-E1 Evaluation Kit, populated with a GPS-PS1 GPS receiver

The Evaluation Unit comes complete with:

- SMA (female) antenna connector
- Power jack, Power LED
- Two RS232 ports (DB9)
- 1PPS output LED

Under normal operating conditions the Evaluation Unit draws 180 mA @ 12 V max. Differential GPS (DGPS) corrections in the RTCM-104 format may be accepted via the uni-directional comm port B and are automatically applied (default) to the navigation solution. All other data I/O is performed via the bi-directional comm port A.

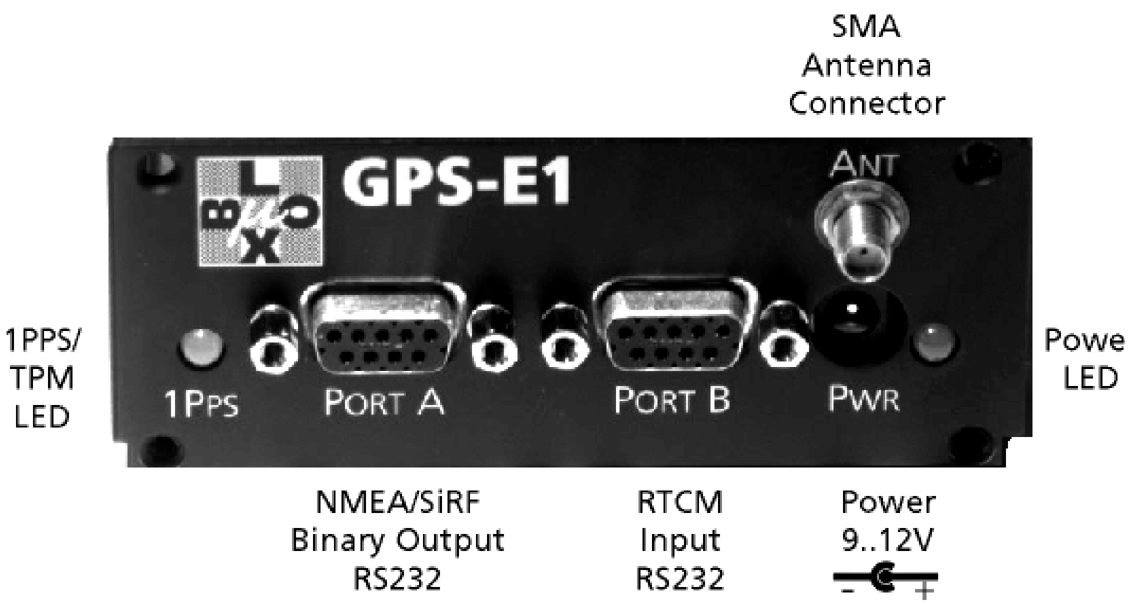


Figure 1.2: Evaluation Unit - Front

Selection between output data formats, SiRF binary (default) and NMEA protocol, can be made via the supplied software application (SiRFdemo) operating in Windows 95/98 or Windows NT 4.0. All aspects of GPS data (position, velocity, time, SVs tracking, etc.) can be monitored and logged under various test scenarios during the evaluation period. A software toolkit allows analysis of the collected data to investigate performance issues such as accuracy, road test position density and trajectory, satellite tracking, time to first fix, etc. All processed data is in ASCII format and can be ported into popular spreadsheets (i.e., MSExcel) for creating plots and statistics.

1.1 List of Contents

The GPS-E1 Evaluation Kit contains the following items:

- GPS receiver in aluminum housing
- Active antenna (5 meter cable, SMA male connector)
- 110/220 VAC power converter (max 700 mA output @ 12 V)
- PC interface data cable (modem cable)
- CD ROM containing SiRFstar1/LX Toolkit Software, Example Data, Source Code and Documentation in PDF Format.
- This manual, the GPS-E1 Evaluation Kit User's Guide

The user interface to the Evaluation Unit is provided by a full-duplex RS232-compliant serial port wired for direct connection to a PC running the SiRFdemo program and an RS232-compliant receive-only serial port wired for direct connection for GPS differential correction data input. A one-pulse-per-second output synchronized to the GPS second is also available.
If any of these items are missing, contact µ-blox AG sales at +41 1 632-7535 or at `sales@u-blox.ch`.

Chapter 2

Getting Started

This chapter describes the PC requirements and step-by-step instructions to install the μ-blox Tools using Windows 95/98 or Windows NT. In addition, it also explains how to connect the Evaluation Unit to your PC.

2.1 Requirements

PC, Pentium or better, with at least 16 MB RAM, running Windows 95/98 or Windows NT 4.0, with one available serial comm port (1, 2, 3 or 4).

2.2 Installing the Evaluation Kit Software

μ-setup will setup the software for the μ-blox product Evaluation Kit GPS-E1. Follow the steps to install the software on your computer.

1. Start Microsoft Windows 95/98 or Windows NT 4.0
2. Insert the CD into your CD drive.
3. You may select Run from the start menu and type `r:\u-setup.exe` where `r:\` is the drive letter of your CD-ROM drive, if μ-setup does not start automatically.
4. The μ-setup wizard will guide you through the setup process. Follow the instructions of the wizard.
5. Read the Software License Agreement. Press the PAGE DOWN key to see the rest of the Software License Agreement. You must accept all the terms of the License Agreement to install μ-blox products.

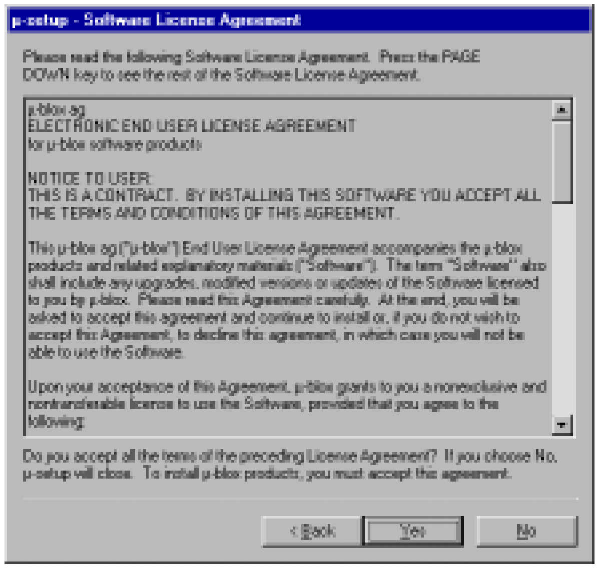


Figure 2.1: µ-setup - Software License Agreement

6. Select the µ-blox products and components desired.
7. You may change the location where you want to install the components.

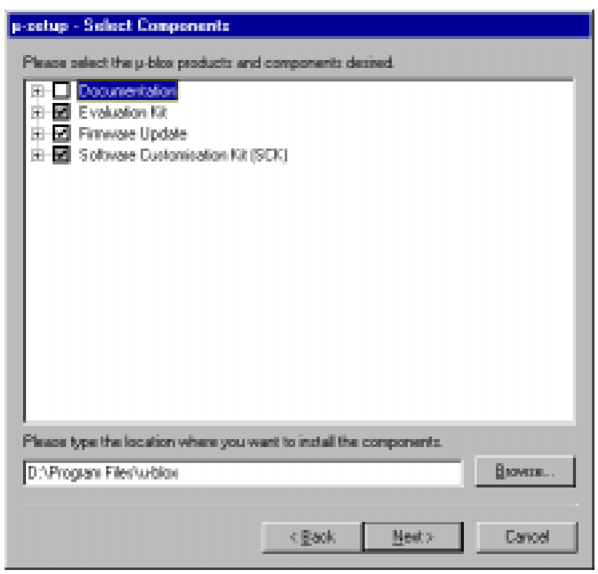


Figure 2.2: µ-setup - Select Components

8. µ-setup is now ready to complete the installation. µ-setup will start the setup process as soon as you press the *Finish* Button.
9. µ-setup will decrompress and copy the required files to your computer, updates the configuration and adds new links to the start menu.

10. Other setup programs may be lauched at the end of the installation process.
11. Please wait until the installation process has ended.
12. Press the *Close* button to exit µ-setup.

Note – *Uninstall of µ-blox products by µ-setup is currently not supported.*

All programs and shortcuts have been added in the Start menu under "Programs" → "µ-blox products".

2.3 Installing the GPS-E1 Evaluation Unit

To connect the different cables to the Evaluation Unit:

1. Connect the GPS antenna to the antenna input on the Evaluation Unit shown in Figure 2.3.

Note – *The antenna should be located where a clear view of the sky is available. However, to verify that the Evaluation Unit is working properly and the software is installed correctly, you do not need to connect the antenna.*

---

2. Connect one end of the serial cable to the appropriate communications port on your PC and the other end of the serial cable to the data output (Port A) on the Evaluation Unit, as shown in Figure 2.3.
3. Connect one end of the power cable to the unit and the other end to a power source.

Note – *The LED on the left side of the Evaluation Unit flashes depending on the operating mode. It visualizes either the 1PPS (1 Pulse per second aligned to UTC) signal or the trickle power state.*

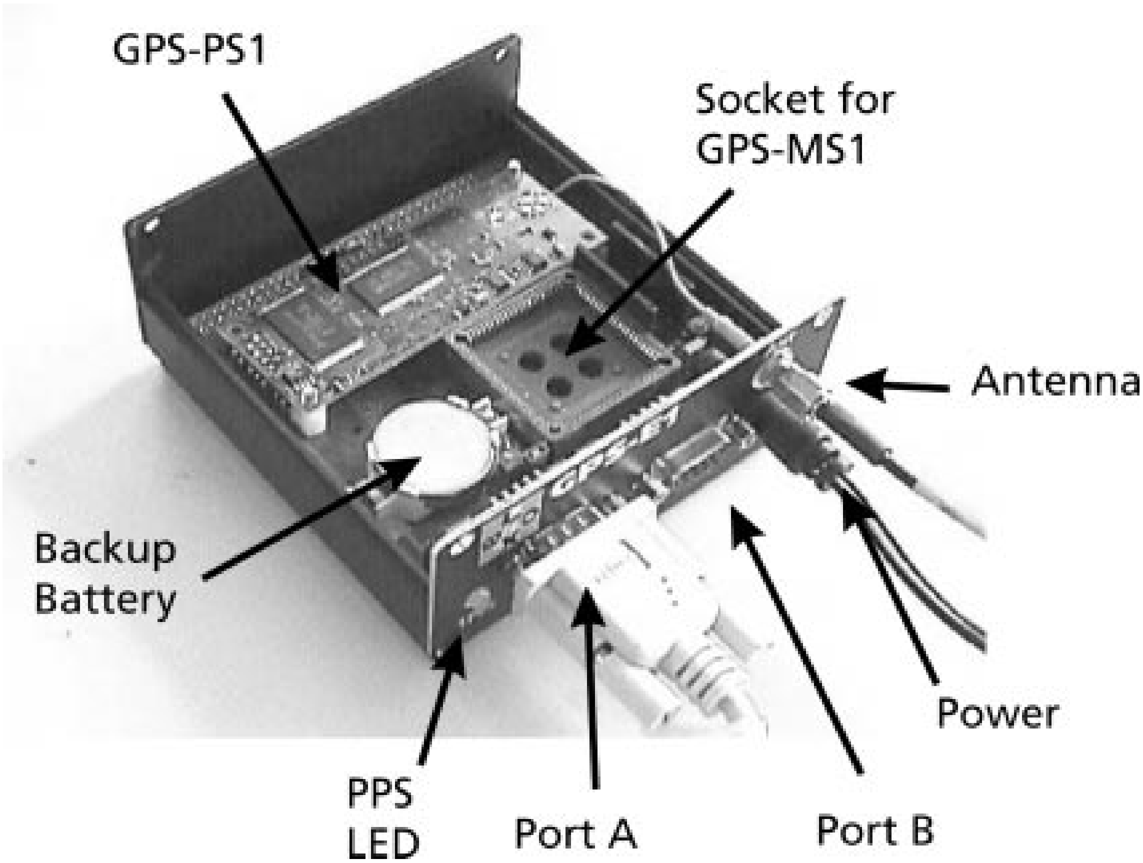


Figure 2.3: Evaluation Unit GPS-E1 Connectors

***Note** – The GPS-E1 Evaluation unit can be equipped with either a GPS-MS1* OR *a GPS-PS1. The Evaluation Unit has the mounting option for both, however only one receiver should be mounted at any time.*

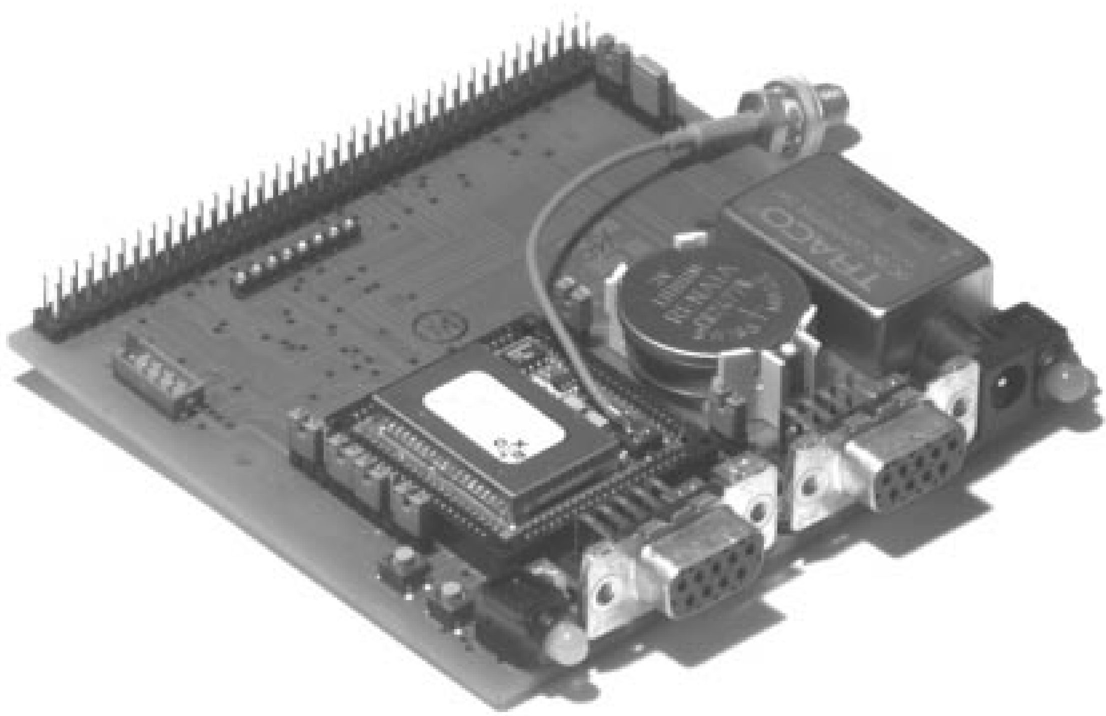
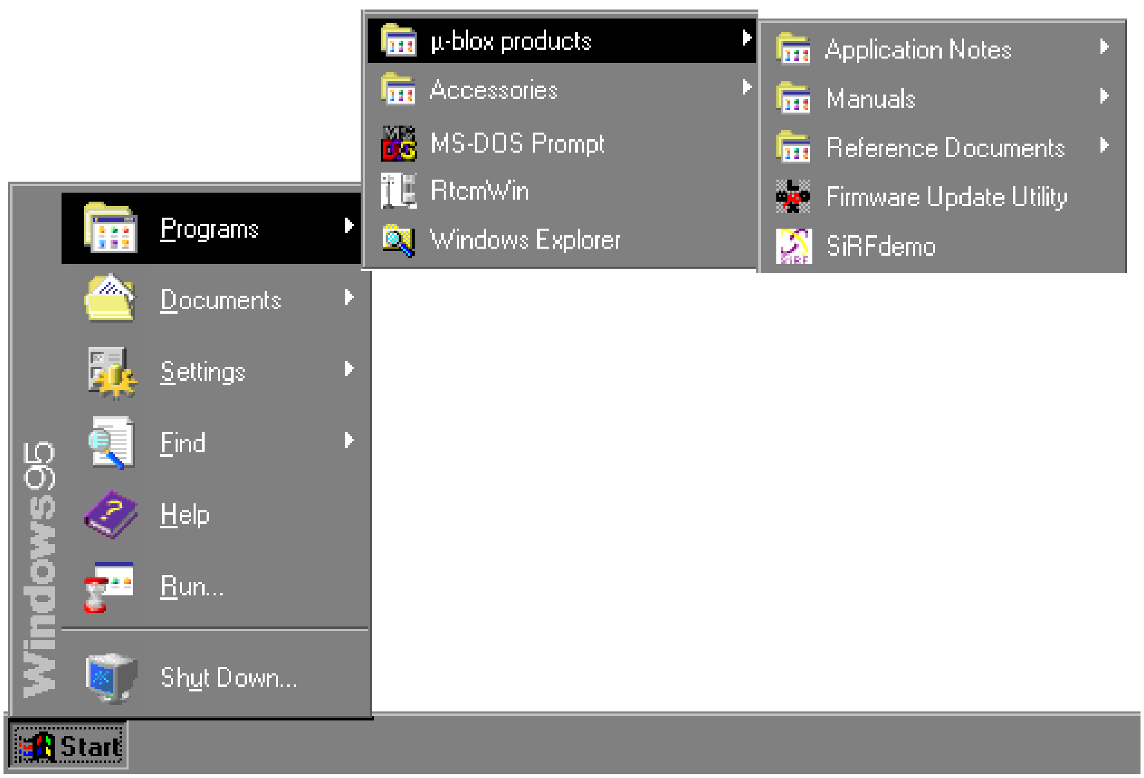


Figure 2.4: GPS-E1 Base Board, populated with a GPS-MS1 GPS receiver

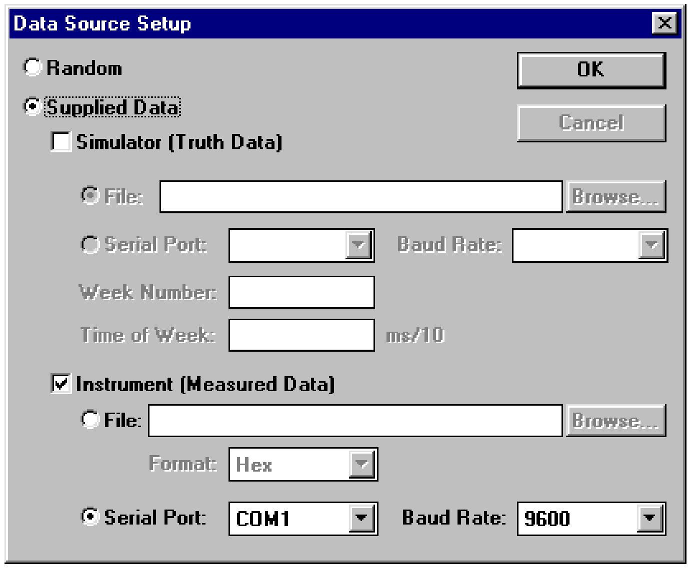
Chapter 3

Quickstart

This chapter describes how to run the SiRFdemo software.



1. Select SirfDemo from Start →Programs →μ-blox products. SiRFDemo is started and the Data Source Setup screen is displayed.



Note – *The Serial Port and Baud Rate apply to the host PC (i.e., not the Evaluation Unit).*

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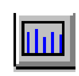
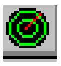
2. Click OK.

3. Click on the Signal Level View button or choose Signal Level from the View menu.



The 12-Channel Signal Level View screen displays the satellite number, status, azimuth, elevation, C/No, and last five seconds of measured signal levels.

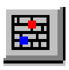
4. Click on the Tracking View button or choose Tracking from the View menu.



The Tracking View screen is displayed. This displays the satellites in a polar plot.

- Outer circle represents the horizon (Elevation=0 degrees)
- Inner circle represents 45 degrees
- Center point is directly overhead (Elevation=90 degrees)

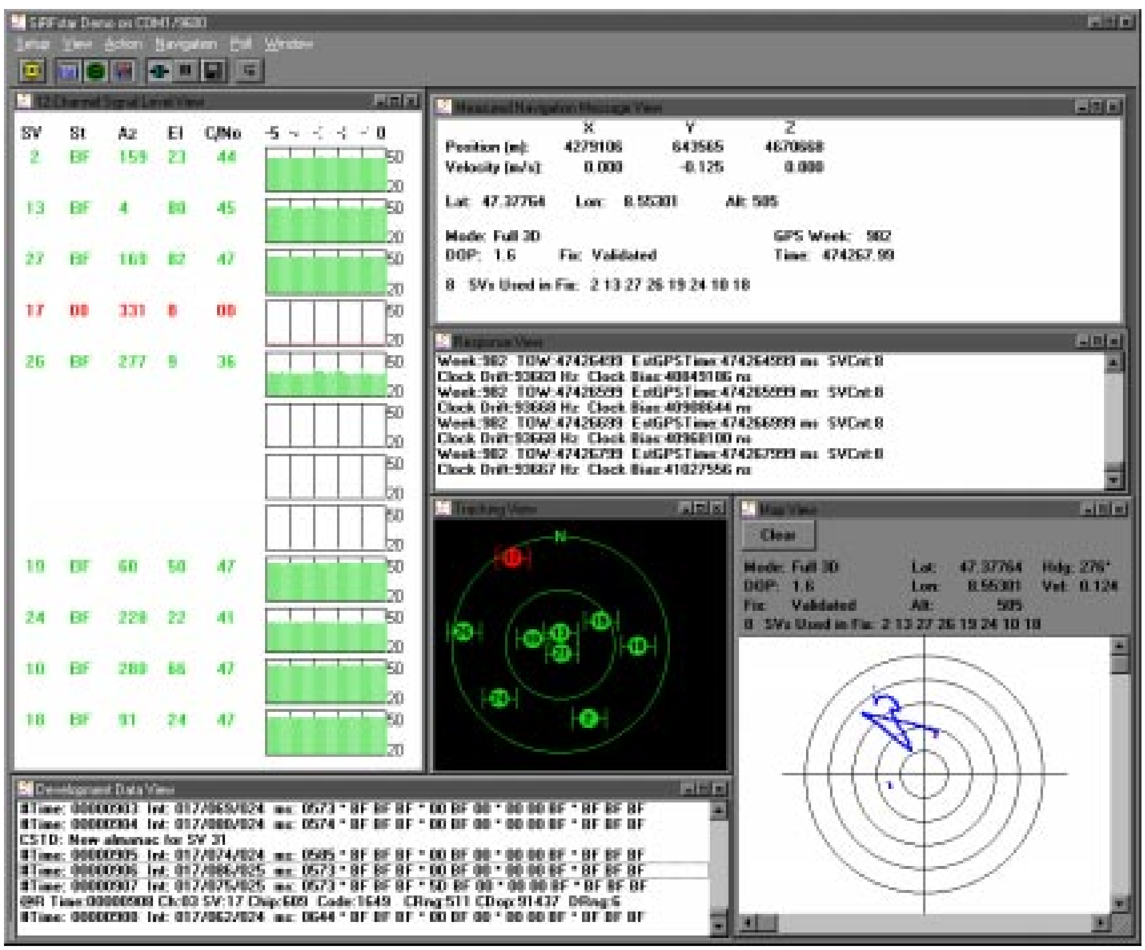
5. Click on the Map View button.



The Map View screen displays the position of the ground tracking.

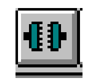
The red dot shows the last position solution. If you run Map View with a moving setup, the ground track is displayed in the Map View screen.

If no dot is shown, you must update the `.smp` file for your location.



Note – *To use the Map View track history portion of the screen, you must set up an appropriate SiRF Map Protocol file with a* `.smp` *extension. Refer to Appendix B for more details.*

6. Click the Connect/Disconnect button.

   A prompt is displayed asking if you want to open a log file.

7. Click No.

   If your receiver is properly connected (with antenna), the location and tracking status of the satellites are displayed on the Tracking View screen as follows:

   - The Tracking View screen displays the location of the satellites, their relative location in azimuth and elevation.
   - The 12-Channel Signal Level View screen displays the SV PRN, status, azimuth, elevation, and C/No for each satellite. The colors for the satellites are as follows:

     Green: Satellite with signal lock, used in navigation solution.

     Blue: Satellite with signal lock, not used in navigation solution.

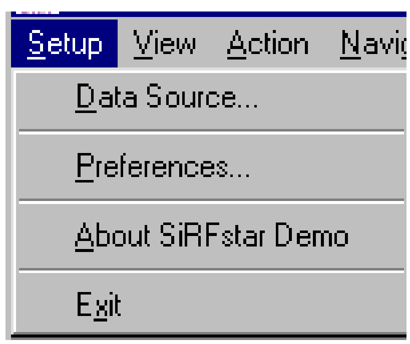
     Red: Satellite without signal lock.

Chapter 4

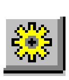
Setup

This chapter describes the SiRFdemo functions under the Setup menu:

Contents

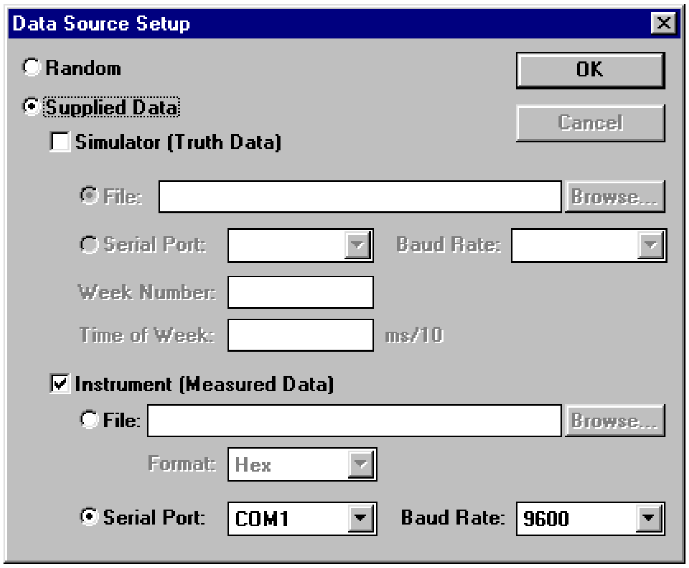


4.1 To Define the Data Source



1. Click the Data Source button or choose Data Source from the Setup menu.

   The Data Source Setup screen is displayed.



Note – *The Simulator (Truth Data) option is not yet implemented. The Serial Port and Baud Rate apply to the host PC (i.e., not the Evaluation Unit). To capture any information regarding your positions, the Evaluation Unit must be connected to the selected serial port on your PC. Do not use the File radio button. This option is not implemented at this time.*

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2. Click on Supplied Data if you want to run the SiRFdemo.

Option	Description
Random	Only uses randomly generated data. Use this option to verify that the SiRFdemo is running without the Evaluation Kit connected.
Supplied Data	Collects data on your positions.

3. Click on Instrument (Measured Data) if it is not already clicked on.

4. Select the comm port from the Serial Port pulldown menu to which the serial cable has been connected on your PC.

5. Select the appropriate baud rate from the Baud Rate pulldown menu (default baud rate is 19200).

6. Click the OK button to continue.

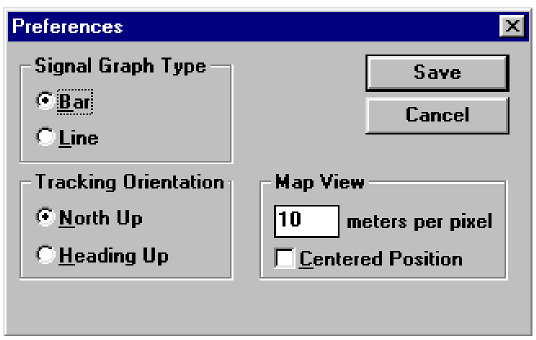
4.2 To Change Preferences

> ***Note –*** *These are basic settings that apply to the 12-Channel Signal Level View Screen, Tracking View Screen, and Map View Screen.*

---

1. Choose Preferences from the Setup pulldown menu.

   The Preferences screen is displayed.



2. Select the type of signal graph that you want to view on the 12-Channel Signal Level View screen.

Option	Description
Bar	Displays the data with vertical bars.
Line	Displays the data in a horizontal line.

3. Select the direction of the tracking orientation that you want to use in the Tracking View screen.

Option	Description
North Up	True north points to the top of the circle.
Heading Up	Used when driving. Current heading points to the top of the circle.

4. Type the meters per pixel that you want to display when viewing the map in Map View, this controls the scale of the map.

5. Click the check box if you want the Map View to be displayed with the current position at the map center.

6. Click the Save button to save the changes or the Cancel button to exit.

4.3 To Display Information About the SiRFstar Demo

1. Select About SiRFstar Demo from the Setup pulldown menu.
   This displays SiRFdemo software information.

4.4 To Exit the SiRFstar Demo

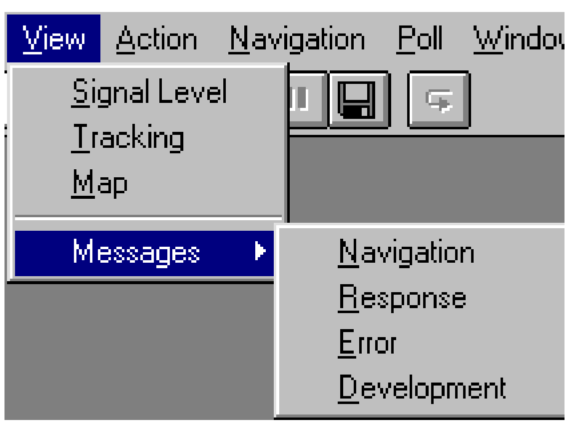
1. Select Exit from the Setup pulldown menu.
   This closes SiRFdemo software.

Chapter 5

View

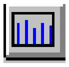
This chapter describes the SiRFdemo functions under the View menu:

Contents



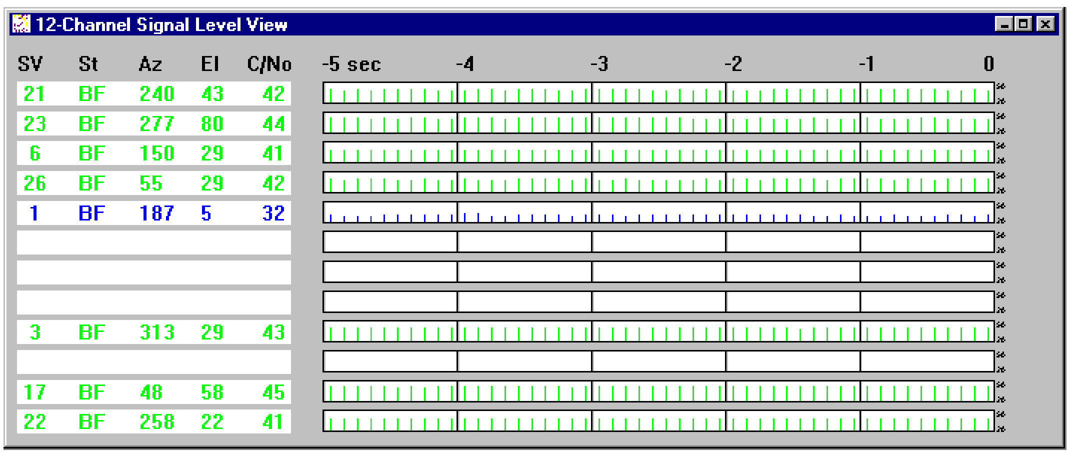
5.1 To Display the 12-Channel Signal Level View Screen

1. Click on the Signal Level View button or choose Signal Level from the View menu.



The 12-Channel Signal Level View screen displays the satellite number, status, azimuth, elevation, C/No, and last five seconds of signal measured strength.

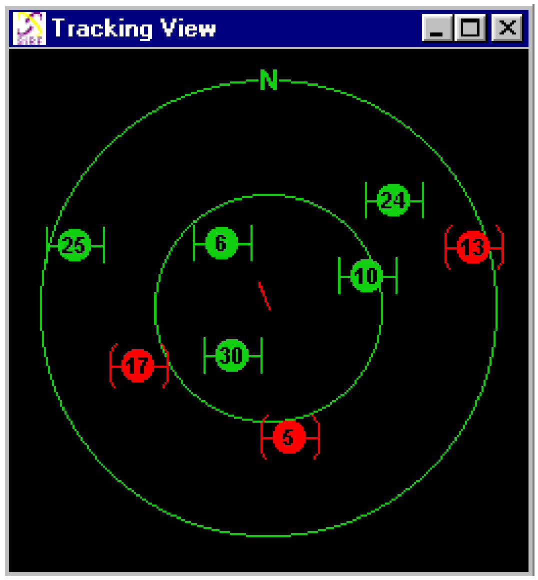
Note – *If you double-click on the 12-Channel Signal Level View screen, the Preferences screen is displayed, as described in Section 4.2. The Preferences screen enables you to modify the way information is displayed on the screen.*



Information Displayed	Description
Satellite Number (SV)	GPS satellite PRN number
Status (St)	Satellite status (see Table C.29 for more information)
Azimuth (Az)	Satellite azimuth (in degrees)
Elevation (El)	Satellite elevation (in degrees)
C/No	Signal level (in dB-Hz)
Signal Level (-5 sec)	5-second history

5.2 To Display the Tracking View Screen

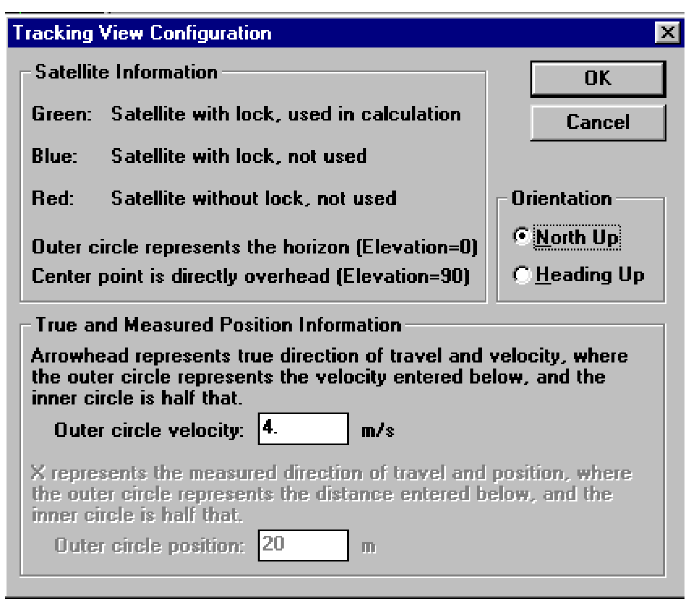
1. Click on the Tracking View button or choose Tracking from the View menu.



The Tracking View screen displays the satellites in a polar plot orientation.

5.3 To Display the Tracking View Configuration Screen

1. Double-click on the Tracking View screen to display the Tracking View Configuration screen.



2. Select the direction of the tracking orientation that you want to use.

Option	Description
North Up	True north points to the top of the circle.
Heading Up	This option can be used when driving. Current heading points to the top of the circle.

3. Type the Outer circle velocity (in m/sec).

4. Click the OK button to save the changes or the Cancel button to exit.

5.4 To Display the Map View Screen

Note – *To use the Map View track history screen, you must create a SiRF Map Protocol file (with a* `.smp` *extension). Provided with your software is a sample* `ring90.smp` *file that includes data for SiRF Technology, Inc.'s location. You can modify this file for your location. Go to Section B.1 in this manual for more information.*

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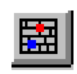
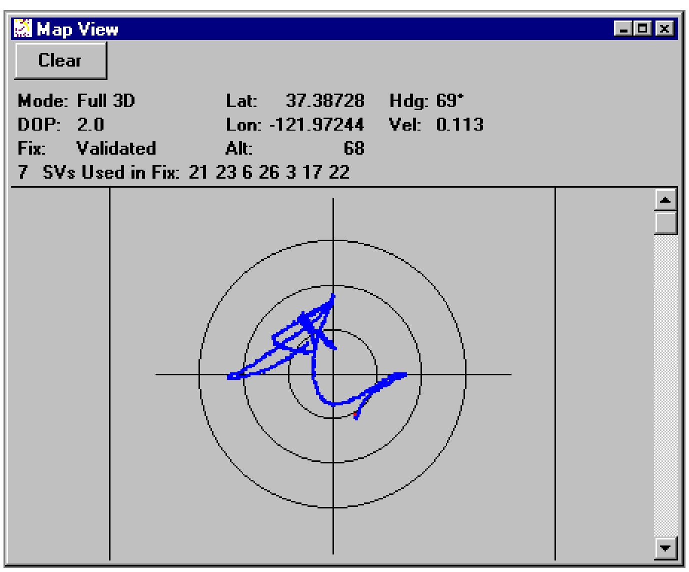
1. Click on the Map View button or choose Map from the View menu.

   The Map View screen is displayed.



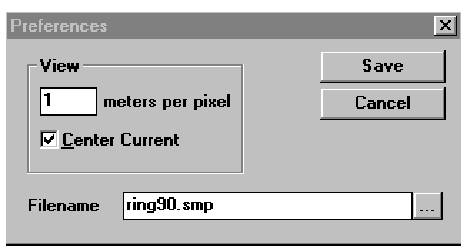


Note *– The red dot shows the current position while blue dots show previous positions.*

Note *– If you double-click on the Map View screen, the Preferences screen is displayed.*

5.5 To Change Preferences from the Map View

1. Double-click on the Map View screen to set specific preferences on the Map View screen.



2. Type the meters per pixel that you want to display when viewing the map in Map View. This value controls the map scale.

3. Click the Center Current check box if you want the Map View to be displayed in the centered position.

4. Type the Filename or browse.

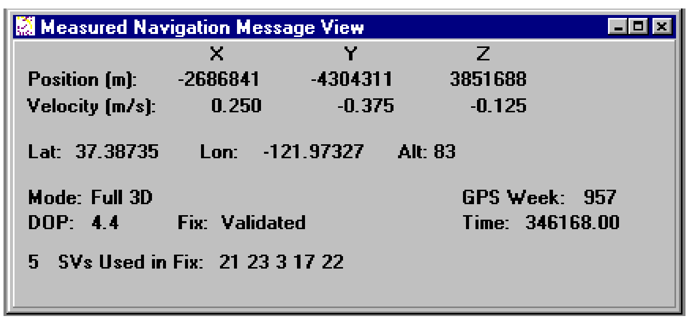
5. Click the Save button to save the changes or the Cancel button to exit.

***Note** – The Navigation, Response, Error, Development, and Messages options, are for viewing only. If you want to log data, choose Open a Log File from the Action menu. See Section 6.2.*

5.6 To Display the Measured Navigation Message View Screen

1. Choose Messages Navigation from the View menu.

   The Measured Navigation Message View screen is displayed.



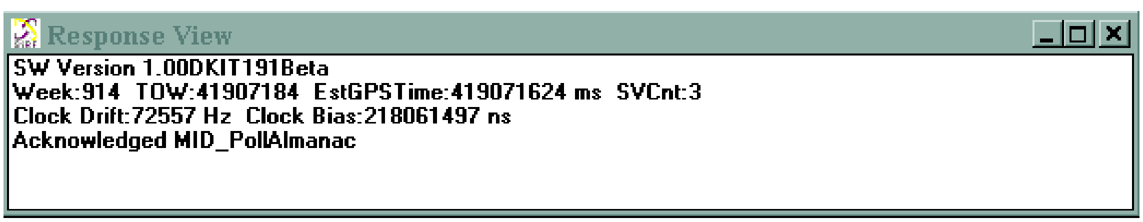
Information Displayed	Description
X, Y, Z positions	Coordinates of user's position in ECEF (meters)
Velocity	User's velocity in ECEF (m/s)
Latitude	User's latitude (decimal of degrees)
Longitude	User's longitude (decimal of degrees)
Altitude	User's altitude (meters)
Mode	Navigation solution type (see Table C.26 and Table C.27)
GPS Week	GPS week number
DOP	Dilution of Precision
Fix	Validated/unvalidated (see Table C.26 and Table C.27)
Time	Current GPS time (seconds)
Svs Used in Fix	Sv PRN used in solution

Note – *ECEF XYZ is converted geodetic latitude, longitude, and altitude based on the WGS84 ellipsoid parameters.*

5.7 To Display the Response View Screen

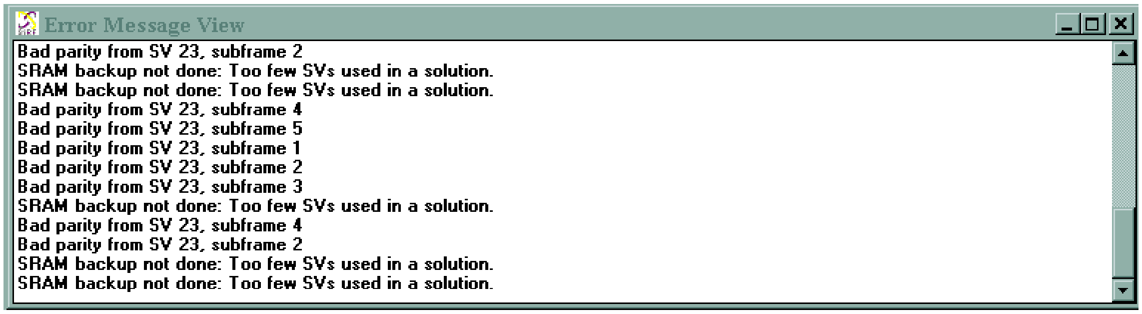
Note – *This option is used with the Poll menu. All responses to poll messages are displayed in the Response screen. See Section 8.*

1. Choose Messages Response from the View menu.



5.8 To Display the Error Message View Screen

1. Choose Messages Error from the View menu.

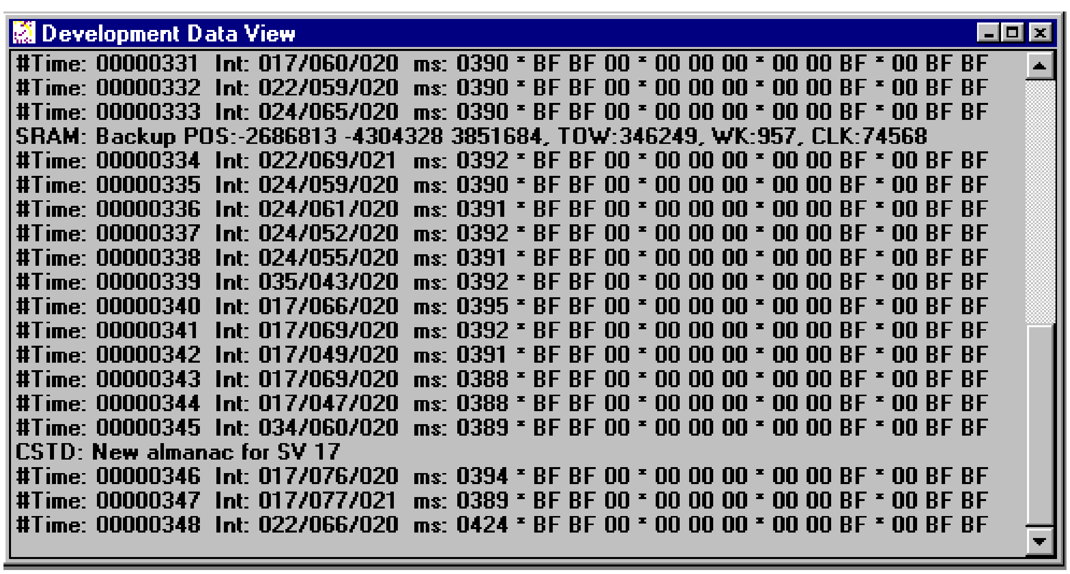


Note – *Error messages are generated automatically by the receiver under certain conditions. Many are caused by normal GPS operations (i.e., acquiring a low elevation satellite could result in a bad parity).*

5.9 To Display the Development Data View Screen

The Development Data View screen displays additional information about the receiver operation. The data is generated automatically by the Evaluation Unit.

1. Choose Messages Development from the View menu.



Note – *To view incoming development data the Enable Development Data checkbox must be enabled on the Receiver Initialization screen. See Section 6.4.*

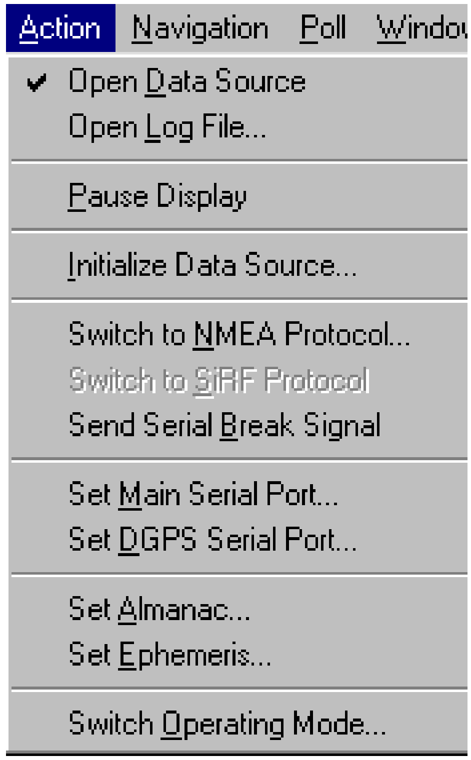
Chapter 6

Action

This chapter describes the SiRFdemo functions under the Action menu:

Contents

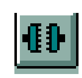
Note – *All values that appear in the dialogue boxes under this menu are* RECEIVER DEFAULT VALUES. *To determine the current settings of all Navigation Parameters refer to the Poll Menu in Chapter 8.*

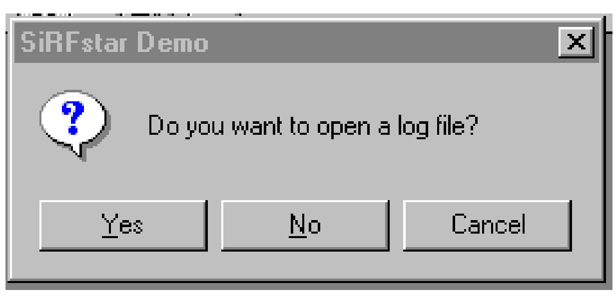


6.1 To Open Data Source

1. Click the Connect/Disconnect button or select Open Data Source from the Action menu.

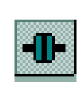
   A prompt is displayed asking if you want to open a log file.





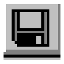
   - Clicking the Yes button displays the Log File Settings screen (see Section 6.2 for more information).
   - Clicking the No button will not open a log file.
   - Clicking the Cancel button aborts the connection.

2. Click the Connect/Disconnect button again or select Open Data Source from the Action menu to disconnect communication to the Evaluation Unit.

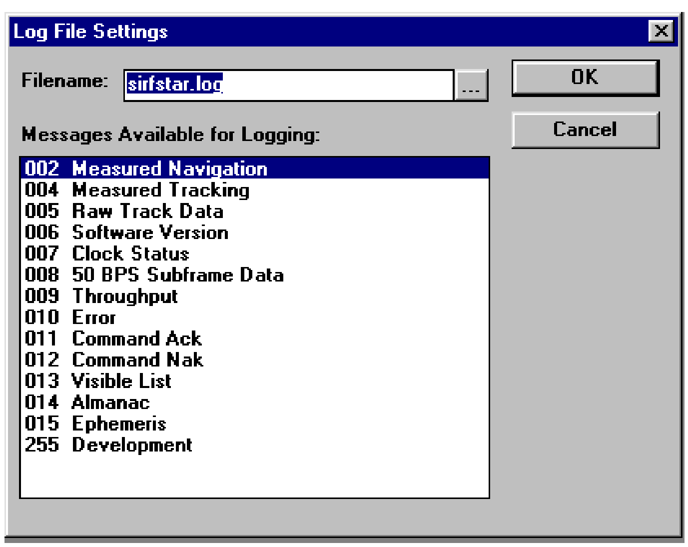


6.2 To Open a Log File

1. Click the Log File Settings button or choose Open Log File from the Action menu.



Note – `sirfstar.log` *is the default filename. Click the button on the right side of the filename field to browse for a file.*



Messages	Description
002 Measured Navigation	Time, position, velocity, ...
004 Measured Tracking	Satellite status and C/No
005 Raw Track Data	Satellite raw data measurements
006 SW Version	Software version of the Evaluation Kit
007 Clock Status	Receiver clock performance
008 50 BPS Subframe Data	Satellite ephemeris and almanac data
009 Throughput	CPU throughput usage
010 Error	Various error messages
011 Cmd Ack	Acknowledgment of received commands
012 Cmd Nak	Input message failures
013 Visible List	Satellite visibility list (based on current almanac)
014 Almanac	Satellite almanac data
015 Ephemeris	Satellite ephemeris data
017 Raw DGPS Data	Differential GPS corrections in RTCM format
255 Development	Various development information

2. Type or select the file name in which you want to save the settings.

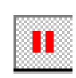
Note – *Only records that are selected are saved to file.*

---

3. Click the OK button to begin logging the selected messages or the Cancel button to abort opening a file.

6.3 To Pause the Display

1. Click the Pause button or choose Pause Display from the Action menu.

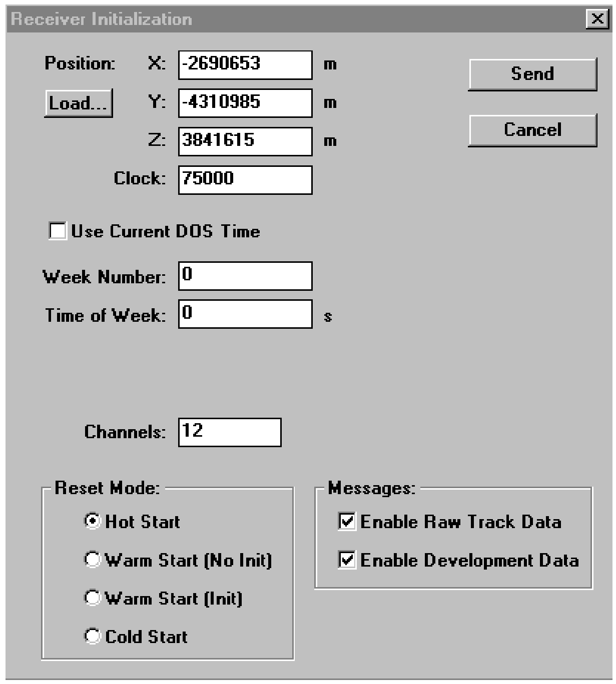


Note – *No data is logged while the display is paused.*

6.4 To Initialize Data Source

1. Click the reset button or choose Initialize Data Source from the Action menu.

The Receiver Initialization Setup screen is displayed.



2. Select type of Reset Mode by clicking on the radio button.

Option	Description
Hot Start	The Evaluation Unit restarts by using the values stored in the internal memory of the Evaluation Unit.
Warm Start (No Init)	This option has the same functionality as Hot Start except that it clears the ephemeris data and retains all other data.
Warm Start (Init)	This option clears all initialization data in the Evaluation Unit and subsequently reloads the data that is currently displayed in the Receiver Initialization Setup screen. Almanac is retained but ephemeris is cleared. You can load a predefined file by selecting a *.pos file (see Section B.2 for more information on loading positions X, Y, and Z).
Cold Start	This option clears all data that is currently stored in the internal memory of the Evaluation Unit including position, almanac, ephemeris, time, and clock drift.

Note – *If Warm Start (Init) is selected the user must supply the X, Y, and Z coordinates and the clock data. (Refer to Step 3 through Step 10 .) Otherwise go to Step 11.*

Note – *If Cold start is selected, all receiver settings will be reset to FACTORY DEFAULTS.*

---

3. Type or Load the X, Y, and Z coordinates by clicking the Load button to display the Specify a Name for the Position File screen to browse for a position file. A File Selection dialog is displayed.
4. Select the sample `Sirf.pos` configuration file.

Note – *See Appendix B.2 for more information on loading positions X, Y, and Z.*

---

5. Click the OK button to accept or the Cancel button to exit. The Receiver Initialization Setup screen is displayed again.
6. Type 96000 in the Clock field (typical clock drift value of the crystal in the Evaluation Unit).

Note – *If you type 0 in the Clock field, the Evaluation Unit uses its last stored value, or a default of 96000 if no prior stored value is available. Modifying the default clock offset can have serious impact on receiver performance, especially time to first fix.*

---

7. Click on or off the Use current DOS time check box. The default value is set to the current time.

Note – *It is recommended to use DOS time (it is assumed that the date and time on your computer are set correctly).*

---

8. Type the number of the week in the Week Number field.

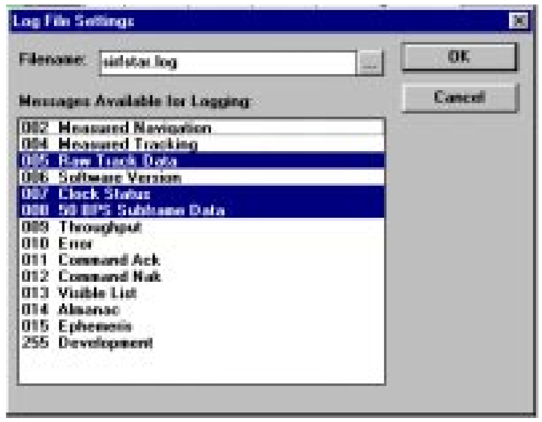
9. Type the time of the week in the Time of Week field.

10. Type number of channels in the Channel field. Not more than 12 and not less than 1.

11. Click on Enable Raw Track Data to Log Raw Track Data.

Note – *To log the Raw Track Data (005) or the Development Data (255) the records must be enabled by clicking in the respective boxes.*

Note – *005 [Raw Track] Data must also be high-lighted on the Log File Settings Screen.*



It is recommended to log records 007 [Clock Status] and 008 [50 BPS Subframe Data] with 005 [Raw Track Data] because they are enabled/disabled as a set of measurements.

---

12. Click on Enable Development Data to turn on message 255 for Development Data View.
13. Click the Send button to initialize or the Cancel button to exit.

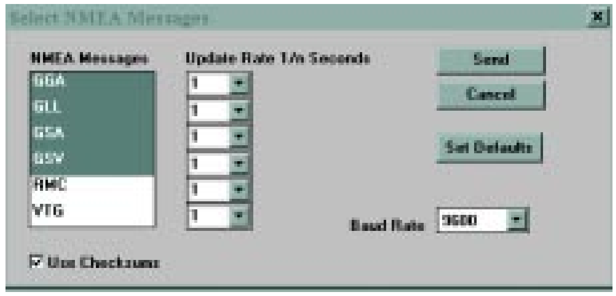
6.5 To Switch to NMEA Protocol

Note – *Switching to NMEA Protocol causes the Evaluation Unit to reset and send NMEA Messages.*

---

1. Choose Switch to NMEA Protocol from the Action menu.

   The Select NMEA Messages screen is displayed.



2. Select the NMEA Messages that you want to use:

Option	Description
GGA	Standard output message for detailed position information.
GLL	Older message for simple position information only.
GSA	List of satellites used in solution.
GSV	Detailed satellite information including signal strengths.
RMC	Combination message of position and velocity.
VTG	Standard output message for velocity.

3. Select the update rate for each NMEA message that you want to use from the Update Rate pulldown menu (1 record per second minimum to 1 record per 255 seconds maximum).

4. Select the baud rate that you want to use from the Baud Rate pulldown menu.

5. Click the OK button to save or the Cancel button to exit.

Note – *NMEA is regarded as a message 255 and can be viewed in the Development Data screen. It can also be logged by using the same technique as a SiRF binary file. Select 255-Development in the Log File Settings screen and Enable Development Data must be checked on in the Messages field of the Receiver Initialization screen.*

6.6 To Switch to SiRF Protocol (from NMEA Protocol)

1. Choose Switch to SiRF Protocol from the Action menu to return to SiRF binary protocol.

Note – For more detailed information see Appendix C.

6.7 To Send Serial Break

Note – Applies to previous software versions only (maintained for backwards compatibility).

6.8 To Synchronize Protocol and Baud Rate

All receiver settings are preserved over power cycles in a battery backed SRAM. It can occur that the computer in use may change or communication parameters may change. Other users of the Evaluation Unit may not be aware of the last settings. This option will attempt to communicate with the evaluation unit using all possible baud rates and both NMEA and SiRF binary protocols. When communication is established with the unit it will be set to SiRF binary protocol at a baud rate of 9600.

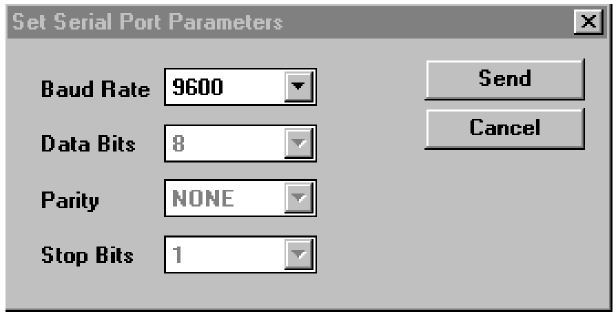
Note – The RS232 settings (i.e. parity, stop bits....) are left at current settings

---

6.9 To Set the Main Serial Port

1. Choose Set Main Serial Port from the Action menu.

   The Set Serial Port Parameters screen is displayed.



2. Select the baud rate, data bits, parity, and stop bits that you want to use for the serial port parameters from each pulldown menu.

***Note** – Only Baud Rate is changeable.*

---

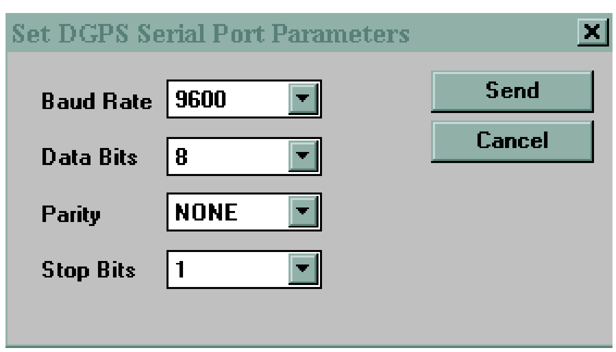
3. Click the Send button to accept or the Cancel button to exit.

   Clicking the Send button resets the Evaluation Unit and computer's serial port to start communicating with the new parameters.

6.10 To Set the DGPS Serial Port Parameters

1. Choose Set DGPS Serial Port from the Action menu.

   The Set DGPS Serial Port Parameters screen is displayed.



2. Select the baud rate, data bits, parity, and stop bits that you want to use for the DGPS serial port parameters from each pulldown menu.
3. Click the Send button to accept or the Cancel button to exit.

Clicking the Send button resets the Evaluation Unit and attempts to accept DGPS information from serial port B (RTCM input).

Note – *Differential correction data source must be configured separately.*

6.11 To Upload an Almanac to the Evaluation Unit

The Almanac file must be in the same format as polled from the Evaluation Unit.

1. Choose Set Almanac from the Action menu.

   The "Specify Almanac Data Filename To Load" screen is displayed.

2. Specify the file you want to use.

3. Click the OK button to accept or the Cancel button to exit.

Note – *To download an Almanac from the Evaluation Unit see Chapter 8.4.*

6.12 To Upload an Ephemeris to the Evaluation Unit

The Ephemeris file must be in the same format as polled from the Evaluation Unit.

1. Choose Set Ephemeris from the Action menu.

   The "Specify Ephemeris Data Filename To Load" screen is displayed.

2. Specify the file you want to use.

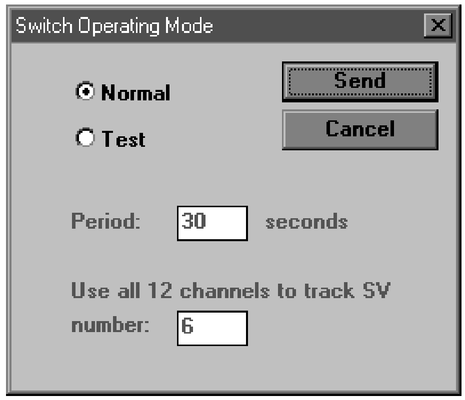
3. Click the OK button to accept or the Cancel button to exit.

Note – *To download an Ephemeris from the Evaluation Unit see Chapter 8.5.*

6.13 To Switch Operating Mode

1. Choose Switch Operating Mode the Action menu.

   The Switch Operating Mode screen is displayed.



2. Select "Test" if you wish to track a specific satellite on all channels. Satellite and tracking period must be specified.
3. Select Normal (default) to track all available satellites.
4. Send the command to the Evaluation Unit.

6.14 To Switch Trickle Power Parameters

Starting with firmware version 1.3, functionality is added for low-power receiver operation. There are two modes of low-power operation:

- TricklePower – In TricklePower mode, the power to the μ-blox receiver is cycled periodically, so that it operates only a fraction of the time.
- Push-to-Fix – In Push-to-Fix mode, the receiver is generally off, but turns on frequently enough to collect ephemeris and maintain real time clock calibration so that, upon user request, a position fix can be provided quickly after power-up.

6.14.1 TricklePower

In this mode, the power to the μ-blox receiver is cycled regularly, according to two user-specified parameters: Update Rate and OnTime.
During TricklePower operation, the receiver receives the GPS signal for OnTime (in milliseconds), calculates a position fix and is then then powered off for a specified number of milliseconds as determined by the update rate.This cycle repeats indefinitely.

The real time clock (RTC) portion of the receiver continues operation at all times, and is used to generate the interrupt that turns everything back on. The microprocessor on which the code executes is not explicitly powered down. After the OnPeriod has elapsed, the processor continues operating long enough to complete its navigation tasks, then puts itself in sleep mode until it is reawakened by the RTC-generated interrupt.

The recommended parameter values are:

- OnPeriod = 300ms
- Update Rate = 1 second

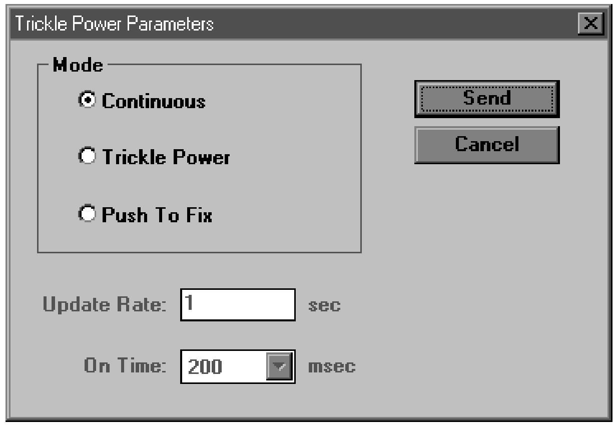
Note –
There are Trickle Power Mode limitations on the allowable OnPeriod/Update Rate combinations. See Table C.22 for supported/unsupported settings.

6.14.2 Push-to-Fix

For applications where a position fix is required on demand (i.e., not continuous) then the Push-to-Fix mode is the most appropriate mode of operation for power sensitive situations. In this mode, the receiver turns on periodically (approximately every 30 minutes) to update ephemeris records and calibrate the clocks. When all internal updating tasks are complete, the unit powers itself off (except for RTC) and schedules the next wake up period. When the receiver is power cycled externally, a navigation solution will be available to the user in 3 seconds.

6.14.3 To enable trickle power mode

1. Select Set Trickle Power Parameters from the Action Menu
   The Trickle Power Parameters screen is displayed



2. Select low power mode.

Note – *If you select Trickle Power you must also input the update rate (number of seconds between fixes, minimum is 1 second) and On Time (range 300-900 ms).*

Note – *Maximum duty cycle in Trickle Power mode is 50 percent (i.e., at 1 Hz data rate maximum on-time is 500 ms.*

---

3. Click Send to activate selection.

Note – *For more information, see the Trickle Power Mode application note, available from µ-blox.*

Chapter 7

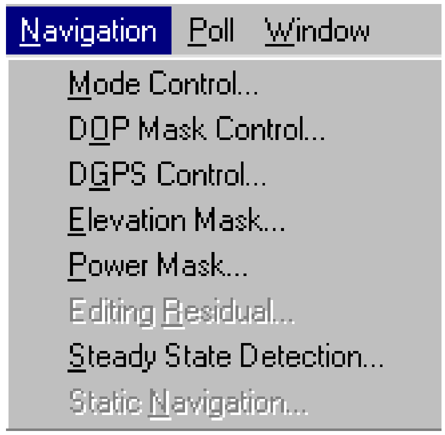
Navigation

This chapter describes how to modify the operational parameters of the evaluation unit. The evaluation unit is shipped with a set of defaults that provide optimized operation over a variety of applications. However, your application may have specific requirements that need modification of the operation of the Evaluation Unit to provide improved performance. The navigation control parameters which can be adjusted via the serial port from the SiRFdemo and their effects are explained in this chapter.

This chapter describes the SiRFdemo functions under the Navigation menu:

Contents

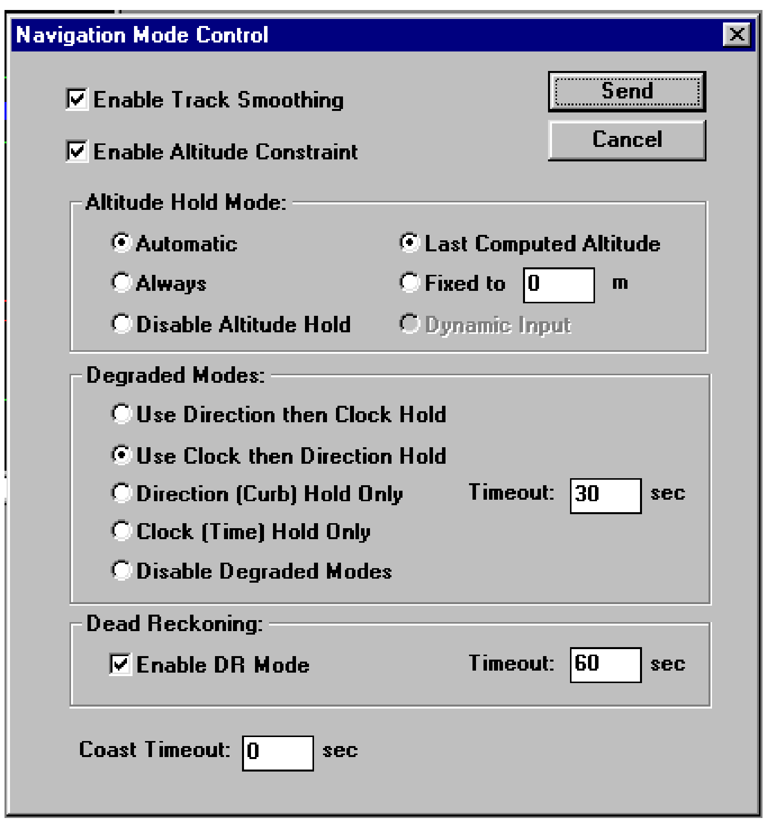
Note – *All values in the dialog boxes are the default settings, which may not be the current settings. Current settings are output in the Development Data screen during startup or reset.*



7.1 To Set Navigation Mode Control

1. Choose Mode Control from the Navigation menu.

   The Navigation Mode Control screen is displayed.



2. Select the option(s) that you want to use.

Option	Description	Default
Enable Track Smoothing	Enables data smoothing	On
Enable Altitude Constraint	Clamp altitude variation to 10% of horizontal to create a smoother ground track.	On
Altitude Hold Mode:		
Automatic	Switch automatically to 2D if only three satellites are used, 3D if four satellites or more are used.	On
Always	Stay in 2D regardless of number of satellites in solution.	Off
Disable Altitude Hold	Only do 3D, if less than four satellites, no navigation.	Off
Last Computed Altitude	In hold mode, use last computed altitude.	Off
Fixed to	In hold mode, use entered value (meters)	Off
Dynamic Input	User can input new value via serial port. Not currently implemented.	Off
Degraded Modes:		
Use Direction then Clock Hold	In two satellite mode use direction hold, one satellite is in clock hold.	Off
Use Clock then Direction Hold	In two satellite mode use clock hold, one satellite is in direction hold.	On
Direction (Curb) Hold Only	Never use clock hold, must have two satellites in direction hold.	Off
Clock (Time) Hold Only	Never use direction hold, must have two satellites in clock hold.	Off
Disable Degraded Modes	No output if less than three satellites.	Off
Timeout	Mode is disabled at timeout value.	30 sec
Dead Reckoning:		
Enable Dead Reckoning Mode	Outputs position updated with last velocity for specified time period.	On
Timeout	Mode is disabled at timeout value.	60 sec
Coast Timeout	Delay mode switch by specified time.	0 sec

Note – *3D mode is always enabled and cannot be changed.*

3. Type the Timeout(s) that you want to use.
4. Click the Send button to accept or the Cancel button to exit.

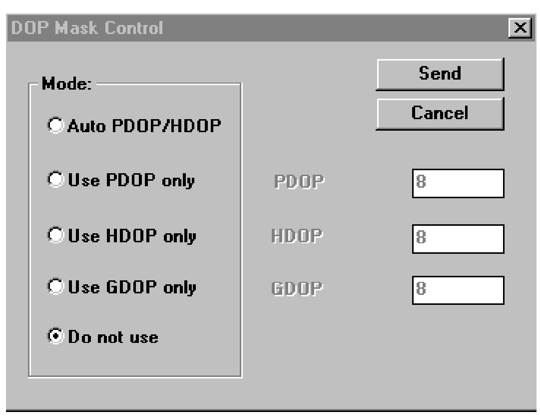
7.2 To Set the DOP Mask Control

This mask enables you to control the output of the receiver such that positions computed with a high DOP (dilution of precision) are not updated. When the DOP mask is exceeded, the position message status changes to DOP mask exceeded and the position does not update. You can select the modes and the associated values can be entered in the fields adjacent to the radio button for each mode.

Note – *At this time, the mask is implemented based only on PDOP. The other options are not currently implemented.*

1. Choose DOP Mask Control from the Navigation menu.

   The DOP Mask Control screen is displayed.



2. Select the Mode that you want to use.

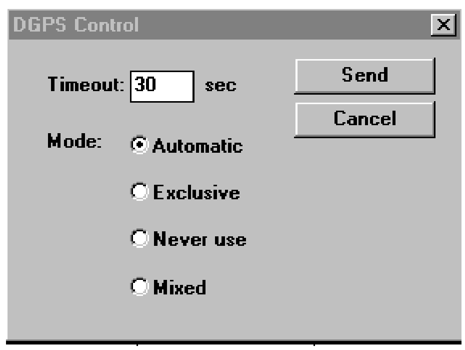
Option	Description	Default
Auto PDOP/HDOP	PDOP in use if more than four satellites, HDOP if three satellites.	Off
Use PDOP only	PDOP mask always in use.	Off
Use HDOP only	HDOP mask always in use.	Off
Use GDOP only	GDOP mask always in use.	Off
Do not use	No mask in use, update regardless of DOP (default).	On

3. Click the Send button to accept or the Cancel button to exit.

7.3 To Set the DGPS Control

1. Choose DGPS Control from the Navigation menu.

   The DGPS Control screen is displayed.



2. Select the Mode that you want to use.

Option	Description	Default
Automatic	Use differential corrections when they are available, otherwise compute a nondifferential solution.	On
Exclusive	Only compute a differential solution. If no corrections are available no solution is output.	Off
Never use	Only compute a nondifferential solution (even if corrections are valid).	Off

3. Type the Timeout that you want to use.

Note – *Any received differential corrections older than the timeout value are not applied.*

4. Click the Send button to accept or the Cancel button to exit.

Note – *Automatic Mode: The Automatic Mode of operation reports a valid position that is either deferentially corrected (all valid DGPS corrections applied) or a non-deferentially corrected solution with all valid satellites used in the solution. Conditions leading to a solution are described in the table below.*

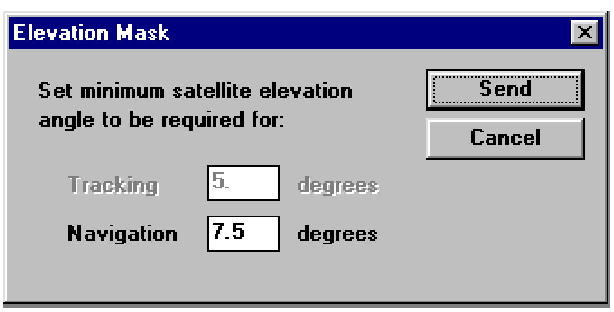
Valid SVs	Valid DGPS Correction	Reported Position Mode
>= 4 Svs	>= 4 valid corrections	DGPS
>=4	<=3	>=4 SV (NON DGPS)
<=3	<=3 valid corrections	DGPS

Table 7.1: DGPS Automatic Mode

7.4 To Set the Elevation Mask

1. Choose Elevation Mask from the Navigation menu.

   The Elevation Mask screen is displayed.



Note – *Minimum satellite elevation angle for satellites to be tracked is not currently implemented (default is 5 degrees).*

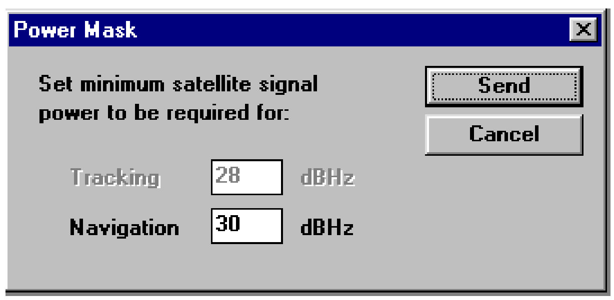
---

2. Type the minimum satellite elevation angle for satellites to be used in navigation solution. (The default is 7.5 degrees.)
3. Click the Send button to accept or the Cancel button to exit.

7.5 To Set the Power Mask

1. Choose Power Mask from the Navigation menu.

   The Power Mask screen is displayed.



Note – *Minimum satellite signal power for satellites to be tracked is not currently implemented (default is 28 dBHz).*

---

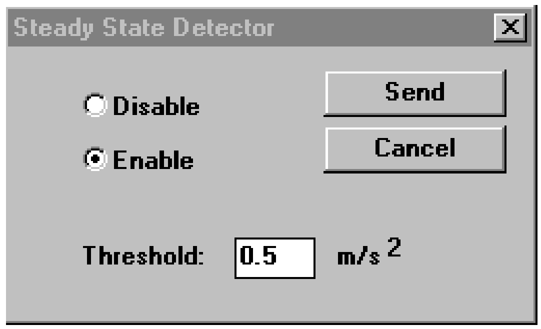
2. Type minimum satellite signal power for satellites to be used in navigation solution.
3. Click the Send button to accept or the Cancel button to exit.

7.6 To Enable/Disable the Steady State Detection

The steady state detection allows the navigating algorithms to decrease the noise in the position output when the acceleration is below the threshold. This reduces the position wander caused by Selective Availability (SA) and improved positions especially in stationary applications.

1. Choose Steady State Detection from the Navigation menu.

   The Steady State Detector screen is displayed.



2. Select the option that you want to use.
3. Type the Threshold if applicable.
4. Click the Send button to accept or the Cancel button to exit.

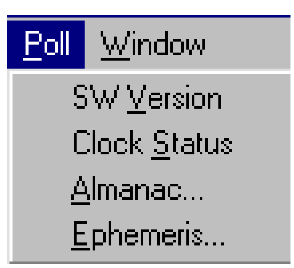
Chapter 8

Poll

This chapter describes how to request the following information. All responses are displayed in the Response View screen or saved in a file.

This chapter describes the SiRFdemo functions under the Poll menu:

Contents



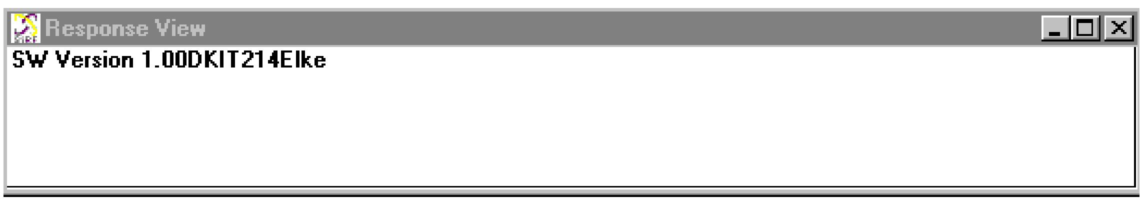
8.1 To Poll The Software Version

Note – *The software version is composed of the software version number, a four-letter kit identifier, and a build number. This software version refers to the Evaluation Unit. Use this information when calling μ-blox Technology technical support.*

---

1. Choose SW Version from the Poll menu.

   The Response View screen is displayed with the software version.

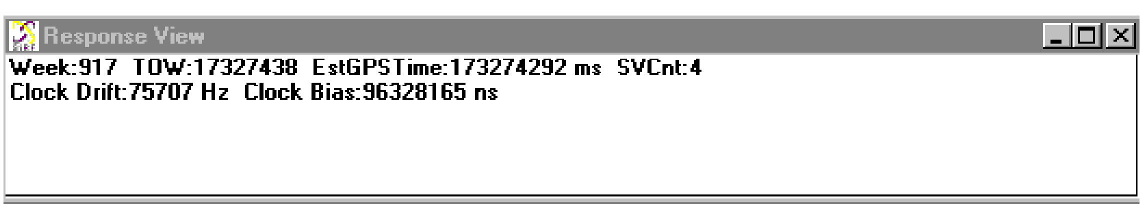


8.2 To Poll the Clock Status

The Clock Status displays the receiver clock performance.

1. Choose Clock Status from the Poll menu.

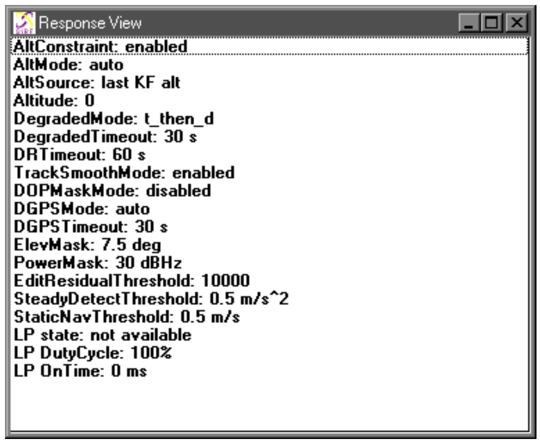
   The Response View screen is displayed with the clock status.



8.3 To Poll Navigation Parameters

All of the user settings under the Action and Navigation menus can be polled for their current status and settings.

1. Select Navigation Parameters from the Poll menu.
   The current settings will be displayed in the response view window.



8.4 To Download an Almanac from the Evaluation Unit

1. Choose Almanac from the Poll menu.

   The "Specify Almanac Data Filename To Load" screen is displayed.

Note – *To log the almanac see Section 6.2 on page 41.*

---

2. Specify the file name in which to save the almanac information.
3. Click the OK button to save or the Cancel button to exit.

Note – *Clicking the OK button saves the data to file when received. A message box is displayed to confirm completion.*

8.5 To Download Ephemeris Data from the Evaluation Unit

1. Choose Ephemeris from the Poll menu.
   The "Specify Ephemeris Data Filename To Load" screen is displayed.
2. Specify the file name that you want to save the ephemeris information to.
3. Click the OK button to save or the Cancel button to exit.

Note – *Clicking the OK button saves the data to file when received. A message box is displayed to confirm completion.*

Chapter 9

SiRFstarI/LX Toolkit Software

This chapter describes how to use the programs supplied in the toolkit. Following are the programs that have been installed in the subdirectories `SiRFTool` and `SiRFDemo`:

Subdirectory SiRFDemo		
`SiRFdemo.exe`	(Windows)	Controls Evaluation Unit functions
`ring90.smp`		Contains a sample map file for SiRFDemo
`SiRF.pos`		Contains a sample initialization file for SiRFDemo

Subdirectory SiRFTool		
`summary.exe`	(DOS)	Summarizes data
`SiRFsig.exe`	(DOS)	Analyzes signal characteristics
`parser.exe`	(DOS)	Separates all data types
`conv.exe`	(DOS)	Converts between ECEF XYZ and WGS 84
`fixanal.exe`	(DOS)	Calculates TTFF statistics
`cksum.exe`	(DOS)	Calculates checksum value
`datum.exe`	(DOS)	Converts between GPS datums
`calcpsr.exe`	(DOS)	Computes GPS measurement data and EPH parameters

Example data that has been logged with a SiRFdemo is provided to familiarize the client with the processing procedures and features of the supplied software. This will permit easier performance evaluation of the receiver.

Note – *In order to facilitate operation of the command-line based tools, we recommend that you copy them over to a directory, which is in your* `$PATH` *variable, or that you modify* `$PATH` *in* `C:\AUTOEXEC.BAT` *to point to the SiRFTool directory.*

9.1 Software Operation

For each program, instructions for operation and options are described.

9.2 SiRFdemo

Refer to Chapters 3 through 8 for details on the SiRFdemo.

9.3 Summary

`Summary.exe` is a DOS-based program that processes logged data collected with SiRFdemo. It uses message type 002 data (see Table C.25) for all position, velocity and tracking statistics. Many processing options can be selected via command line input. All output files maintain the basename of the log file (i.e., `basename.ext`).

Note – *See example data files* `station.gps` *and* `roadtest.gps`*.*

Command-line options

Switch	Action
-o	Creates navigation data output file with extension *.out.
-o-	Does NOT create navigation data output file with extension *.out.
-c:n	Prints the worst line out of every n lines to *.out file.
-s	Specifies the case when test was stationary.
-s-	Specifies the case when test was not stationary (i.e., road test).
-n:username	Indicates tester's name (where username is the person who did the testing).
-p:ident	Specifies hardware platform identifier (i.e., data collection device).
-d	Processes only DGPS-corrected position fixes.
-i:n	Indicates the number of fixes to ignore, where n is a number of initial fixes to be ignored.
-a	Processes all data, regardless of any reset strings.
-x:coord	Specifies a coordinate where coord is an ECEF reference X coordinate in meters.
-y:coord	Specifies a coordinate where coord is an ECEF reference Y coordinate in meters.
-z:coord	Specifies a coordinate where coord is an ECEF reference Z coordinate in meters.

***Note** – If you enter summary at the DOS prompt, you will be prompted for minimum input information.*

9.3.1 Running Summary

After you start Summary, you are prompted for your name and the platform on which you are running. These prompts are repeated in the output file to help you identify the test. As data is being processed, two numbers are displayed on your screen. The first number is the total number of lines read from the data file. The second number is the number of the line currently being processed. Although these numbers are not updated continuously, they indicate that the program is running.

9.3.2 Initial Position Message

Because the Summary Program converts to ENU (East, North, Up), it must have an XYZ starting point. This message is automatically saved by the Evaluation Unit on reset and is logged by the SiRFdemo as long as message type 255 (Development Data) is highlighted in the message box in the log file heading from the Define Data Sources screen.

If it is not, you can cut and paste the message in the `*.log` file from another file that contains the data or simply type the contents of the message using a text editor. The only lines that the Summary Program looks for are line 1 (Version) and line 4 (POS), as shown below:

```
Version 00.33 built at 14:38:27 Oct 19 1996 using fxp
TOW: 384074
WK:  876
POS: -3955124 3355588  3699664
CLK: 62779
CHNL:12
```

If you have a log file containing type 2 messages without a Version header, the first message two coordinates are interpreted as initial position reference point.

This `summary.exe` file then produces the following output

- A histogram of position and velocity data for stationary test evaluation.
- A file that has converted XYZ format of position and velocity to ENU format.

The output data files are listed in ASCII format. Therefore, you can import the data into a Microsoft Excel spreadsheet or any other spreadsheet programs for further plotting (an example macro is provided on Disk 3: Macro).

Two new files are created and displayed in your current directory:

- `*.sum` - Statistical information.
- `*.out` - Position, velocity, and tracking information.

9.3.3 Summary File: *.sum

The summary output file (`*.sum`) includes the following parts:

- Header information to identify the test
- Statistical measurements of data
- A histogram

9.3.4 Header Information

The first part of the `summary.exe` file is the header information that identifies the test, as shown here:

Header Name	Description
Tester's name	George
HW platform:	cc102
Software:	Version 0.11
Processed on	Fri Nov 15 14:12:11 1996
GPS Time	WeekNo 879, TOW 329520
Total Number of Samples	166

9.3.5 Statistical Measurements of Data

The second part of the `summary.exe` file consists of statistical measurements of data. The table has the following columns:

- Labels
- Position East (in meters)
- Position North (in meters)
- Position Up (in meters)
- Velocity East (in meters/second)
- Velocity North (in meters/second)
- Velocity Up (in meters/second)

9.3.6 Statistical Measurements

Labels	Position East	Position North	Position Up	Velocity East	Velocity North	Velocity Up
Maximum:	4.24	3.91	32.3	0.238	0.631	0.898
Line #	842	833	2398	2460	2389	1640
Minimum:	-28.7	-35.1	-2.11	-0.186	-0.179	-0.843
Line #	2186	1913	842	957	1396	2487
Mean:	-13.9	-17	15.3	-0.0115	0.153	0.48
Standard Deviation:	7.58	9.04	9.53	0.0886	0.172	0.201
Max-Min:	33	39	34.5	0.424	0.81	1.74

Line numbers are included in the log file where each maximum and minimum value occurs. This process is helpful when debugging and searching for unusual events. You can import this position into a Microsoft Excel spreadsheet using spaces as column delimiters.

9.3.7 Histogram

The third part of the `summary.exe` file is the histogram. It also uses the same six columns (Pe, Pn, Pu, Ve, Vn, Vu). The bin sizes are listed on the left. The position range is +/- 500 m in 20-meter bins and the velocity has a range of +25 m/s in 1 m/s bins. The numbers reported in each bin are listed as a percentage. You can obtain the number of values in a bin by multiplying the total number of samples list on the last line of part 1. Any points outside this range are listed as Bad Fix with a line number.

9.3.8 Summary Output File (*.out)

The `*.out` file has 14 columns that can be imported into a Microsoft Excel spreadsheet using spaces as delimiters. The file format is as in Table 9.1:

9.4 Porting Data into the Excel Macro

The provided templates are designed to paste data directly from a `*.out` file.

***Note –** See example macro* `Msanfran.xls`*.*

To port data into the Excel macro:

1. Open a new template.

Label	Description
GPS Time:	Seconds into the GPS week
Latitude:	WGS 84 Geodetic Latitude in degrees
Longitude:	WGS 84 Geodetic Longitude in degrees
Position East:	LTP delta Easting in meters from initial coordinate
Position North:	LTP delta Northing in meters from initial coordinate
Position Up:	LTP delta height in meters from initial coordinate
Velocity East:	LTP velocity in meters/seconds in the east (-) west (+) direction
Velocity North:	LTP velocity in meters/seconds in the north (+) south (-) direction
Velocity Up:	LTP velocity in meters/seconds in the up (+) down (-) direction
DOP:	Dilution of Precision
Svs in view:	Almanac calculation of visible satellites
Svs tracked:	Number of satellites in track at this time
Svs in Solution:	Number of satellites used in the navigation solution at this time
Pos Mode:	Position status (see Table C.26). -99 implies that the position is un-validated

Table 9.1: Output File Format

2. Select Save As from the File menu.
3. Name the file Plot.
4. Open the `*.out` file. This is the source file. (Two files are open simultaneously, plot and source, although you can view only one at a time.) Excel prompts you about how to import the data.
   (a) Choose delimited, then next.
   (b) Choose delimited by spaces, then next.
   (c) If the first column contains only blanks cells, mark the bubble to delete it.
   (d) Select finish. Excel will read the data into a new work sheet.
5. Mark (highlight) and copy (copy button, or File - Copy, or Ctrl-C) all the data rows (first data row to bottom of the sheet) and columns (A-N).
6. Move to the Plot file (Windows button, then click on the plot file's name).
7. Click on the top left data cell in the plot file (A13).
8. Paste the data into the plot file. (Paste button, or File - Paste, or Ctrl-V.)
9. Trim or copy the bottom of the spread sheet to remove any leftover template data and to insure the computed items are present for every data row. (See specific instructions below.)
10. Enter the documentation for the run in column B rows 2 through 8.
11. Save the file, you are ready to plot and analyze.

9.4.1 How to Trim the Data File

You must trim the Plot file to match the number of data rows in the data file in the following cases:

- The template has more data than the plot file
- The plot file has more data than the template.

If the Plot file has more data than the template, perform the following steps:

1. Go to the bottom of column N (the first computed column). Notice there is more data in columns A-N than there is in the computed columns, O - ??. Assume there are DDDD rows of data and CCCC rows of computed columns.
2. Mark and Copy the last row of computed items (row CCCC, columns O-??).
3. Mark and paste rows CCCC+1 through DDDD so that there are computed items for every data row.
4. Extend each series to the new value (i.e., the length of column).

If the template has more data rows than the Data file, perform the following steps:

1. Go to the last row containing data copied from the Data file. Assume this is row DDDD.
2. Mark all the rows that are "extras", left over from the template.
   (a) Click the left tab for row DDDD+1.
   (b) Go to the end of the file.
   (c) Hold down the Shift key.
   (d) Click the left tab for the last row.
3. Delete the extra data by pressing the Delete key or by selecting Delete from the Edit menu.

9.5 SiRFsig

The SiRFsig DOS-based program analyzes the performance of an antenna as well as the conditions of the satellite observation environment. SiRFsig uses data message code 004 (Measured Tracking) and 002 (Measure Navigation) in its plotting routines and development data.

***Note** – See example data file* `station.gps`.

9.5.1 Procedure

Before running the SiRFsig program, you need to collect a data file using the desired antenna.

Note – *You must collect the 002 (Measured Navigation), 004 (Measured Tracking) data records and have development data enabled.*

Note – *SiRFsig expects that the data file will have a* `*.gps` *extension.*

---

1. At the prompt, type: `sirfsig filename`

   Example: Data file name is `station.gps` so you would enter:

   ```
   sirfsig station
   ```

2. SiRFsig parses the data file and extracts the information required for plotting. To terminate the program while parsing, press the ESC key.

3. Thirteen screens correspond to the function keys for viewing. Screen #1 (F1 key) is automatically displayed after the program has finished parsing. If you want to display any other screen, press the function key that corresponds to the number of that screen.

   Note – *You must press the F2 key to complete the calculation for the statistics required for screen 7.*

   ---

4. Select the F10 key to exit the program when the main menu is displayed.

***Note** – If you run SiRFsig with the same data file again and the data has already been successfully parsed, then you are asked if you want to re-parse the data. You have 10seconds to reply (press any key), otherwise the data is re-parsed.*

9.5.2 Auxiliary Options

Screen 3 - C/No Vs Time	1. Enter specific satellite number 2. Enter 'a' to view each satellite consecutively 3. Enter 's' to display Smoothed SV C/No data 4. Select 'r' to display Raw SV C/No data
Screen 4 - C/No Vs Elevation	1. Enter specific satellite number
Screen 5 - Antenna Profile	1. Another data profile may be compared by selecting 'o' and entering the file name. The data must have been previously parsed.
Screen 7 - Bin Statistics	1. Press F7 to view next page of bin statistics.
Screen 8 - Position Trajectory	1. To change scale distance of rings press F2. Enter radius in meters. 2. Enter filter selection (F5,F6,F7). 3. To return to main menu press F12.
Screen 9 - Altitude Variation	1. To change scale distance press F2. Enter distance in meters. 2. Enter filter selection (F5,F6,F7). 3. To return to main menu press F12.
Screen 10 - Distance Variation F2. Enter distance in meters.	1. To change scale distance press
	2. Enter overlay selection (F8). 3. Enter filter selection (F5,F6,F7). 4. Press F12 to return to main menu. Statistics: Maximum, minimum and average horizontal distance variation (meters). Standard deviation of horizontal variation (meters). Number of positions and percentage per each container category.

To Exit Program - Press F10 when main menu options appear on the screen.

9.5.3 Processing Options

If you have several data files processing or the files are very large, you may want to process the data using a batch file approach. To do so, you need to add the p option to the command line:

Example: `sirfsig station p`

Then the data is parsed and the program returns to the DOS prompt. If you create a batch file of several data files, they are processed consecutively.

Example: Create a file called `process.bat` that contains the following lines:

```
sirfsig data1 p
sirfsig data2 p
```

Run `process.bat` at the command line and all data files will be processed. To view the data file in graphic form, run SiRFsig without the p option.

9.5.4 Data Files

SiRFsig creates the following files with a common basename:

File	Description
*.###	Where the ### represents the Sv number (i.e., .002 is satellite #2)
*.bin	Text file containing the bin statistics (F7 option)
*.avg	Text file containing the average values (for program use only)
*.pos	Text file of time tagged positions in XYZ coordinates (F8 option)
*.vel	Text file of time tagged velocity in XYZ (not implemented yet)
*.svs	Text file containing satellite-specific data (F6 option)

All file formats are described in Appendix B.

9.5.5 Screen Descriptions

Screen 1 - C/No Pattern (F1) – Figure 9.1

This screen depicts the measured C/No pattern in terms of 72 azimuth/ elevation bins. Dimensions of the bins are 45 degrees in Azimuth and 10 degrees in Elevation. The value shown in each bin is the average C/No value based on all satellite measurements in that bin. Where the value is 0 (zero), no data was collected. The patterns created by the adopted color scheme and the average C/No values may be used to investigate the antenna characteristics (assuming a clear horizon) or the observation environment (assuming multipath surfaces or blockages).

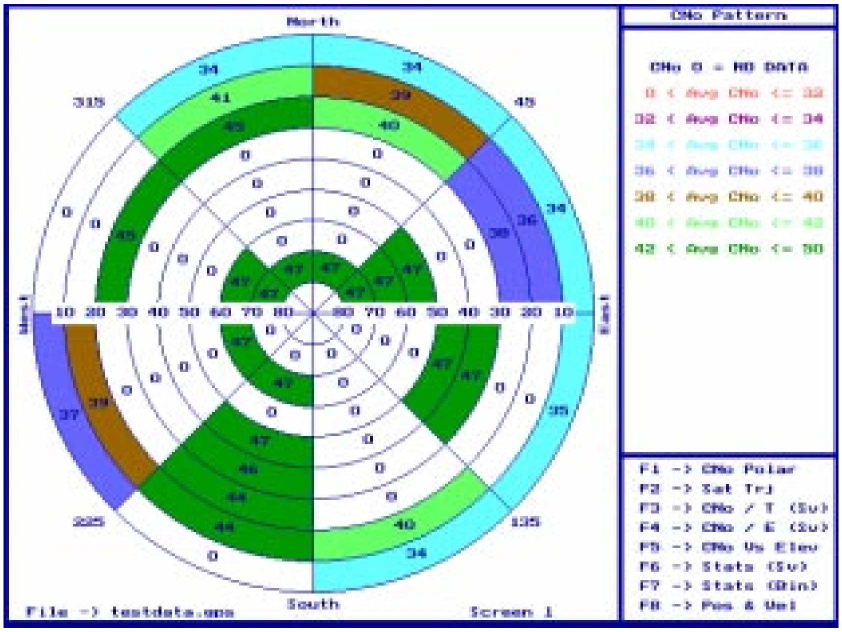


Figure 9.1: C/No Pattern

Screen 2 - Satellite Trajectory (F2) – Figure 9.2

The Azimuth/Elevation plot depicts the measured trajectory of each satellite over time in the data session. The outer ring represents the horizon (0 degrees elevation) and the middle of the ring is the zenith (90 degrees elevation). The top of the plot is north (0 degrees), bottom is South (180 degrees), West is Left (270 degrees) and East is right (90 degrees). Satellites tracked, maximum and minimum elevation angles can be found in the rightmost column on the screen. Any breaks in the trajectory are an indication of missing data.

Screen 3 - Satellite Specific C/No Values (F3) – Figure 9.3

This plot depicts the measured C/No values (Y axis) versus GPS Time (X axis). C/No values may range from >= 28db to <= 50db. The time window is the entire data session not just the time the satellites was tracked. Measured C/No values are plotted with some statistical information in the header of the plot. A Smoothing Factor (SF) may be used to look for data trends. The value of the smoothing factor implies the number of previous C/No values averaged to predict data at that point. All data is equally weighted. The C/No line plot is a good indication of satellites signal behavior. Signal reaction to increased atmosphere (i.e., rising or setting) and multipath should be discernible.

Screen 4 - Satellite Specific C/No Values (F4) – Figure 9.4

This plot depicts the measured C/No values (Y axis) versus Elevation Angle (X axis). C/No values may range from >= 28db to <= 50db. Measured C/No values are plotted

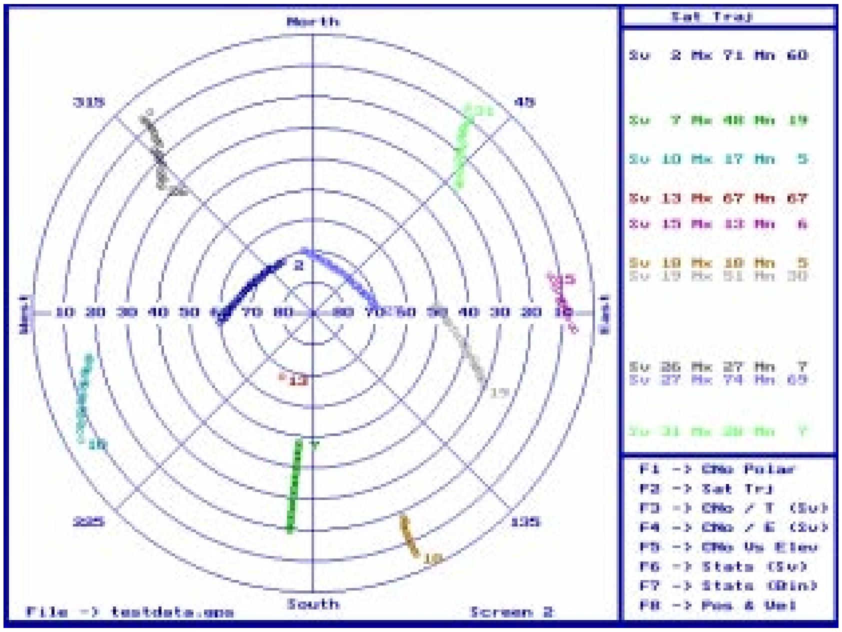


Figure 9.2: Satellite Trajectory

with some statistical information in the header of the plot. The C/No scatter plot is a good indication of satellites signal behavior.

Screen 5 - Antenna Profile (F5) – Figure 9.5

The three lines represented on this plot are Max reading, average reading and minimum reading. The x-axis represents elevation in 10 degree increments and the y-axis represents C/No values from 28db to 50db. The value plotted at each junction (i.e., C/No for 0-10 degrees) represents the average value independent of azimuth. It is the average value based on the populated bins from screen 1, in the appropriate degree range (i.e., 0-10). Subsequent points are computed for each elevation bin. All values are azimuth independent.

Screen 6 - Satellite Dependent Statistics (F6) – Figure 9.6

Table contains up to 32 rows representing the 32 satellites by PRN.
Each line contains:

- Satellite number
- Mean: the average of all C/No values of the satellite
- Std-Dev: the standard deviation
- Max: the maximum C/No value
- Min: the minimum C/No value

Figure 9.3: C/No Values (Y axis) Versus GPS Time (X axis)

- Range: the difference from the Max.- Min. C/No values
- Data: the number of fixes collected during the test session

Screen 7 - Bin Statistics (F7) – Figure 9.7

This table shows the associated statistics for each azimuth/elevation bin for the 72 bins. Data is on four pages with each page displayed when F7 is hit. Each bin section contains the average, standard deviation, maximum and minimum C/No values of all the satellites passing through each Azimuth elevation section.

Position and Velocity (F8)

Selecting F8 displays a submenu for position and velocity plotting and statistics.

Note – *Velocity data is not yet implemented.*

To return to the main menu press F10.

Figure 9.4: C/No Values (Y axis) Versus Elevation Angle (X axis)

Screen 8 - Horizontal Trajectory (F1) – Figure 9.8

The plot is a scatter diagram based on data type 002 (position data). The rings are scalable and depict the receivers position error with respect to the average position of the data set. The average ECEF XYZ position was computed during the parsing stage. All position differences are with respect to the average coordinate which is the centre of the plot. The rings are scalable (F2) by redefining the radius of the outside ring. Associated statistics for each ring are found on the sidebar.

Screen 9 - Altitude Variation (F3) – Figure 9.9

The line plot is data type 002 (position data). The ECEF Coordinates are converted to latitude, longitude and height data based on the WGS84 ellipsoid. The Altitude variation is determined by the difference between the measured altitude at a certain epoch and the average altitude determined during parsing. The containers are scalable (F2) and have the associated statistics in the side bar.

Screen 10 - Distance Variation (F4) – Figure 9.10

This line plot shows the distance variation from the average coordinate. The containers are scalable (F2) and have the associated statistics in the side bar.

DOP Filter (F5)

The Dop filter eliminates any positions greater than the DOP value specified from being plotted and are reported as rejected positions in the statistics.

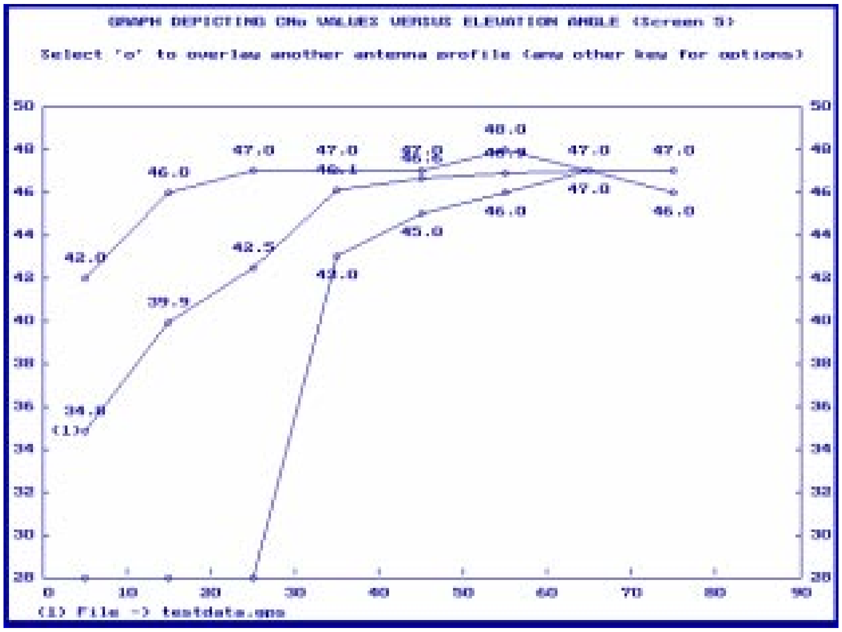


Figure 9.5: Antenna Profile

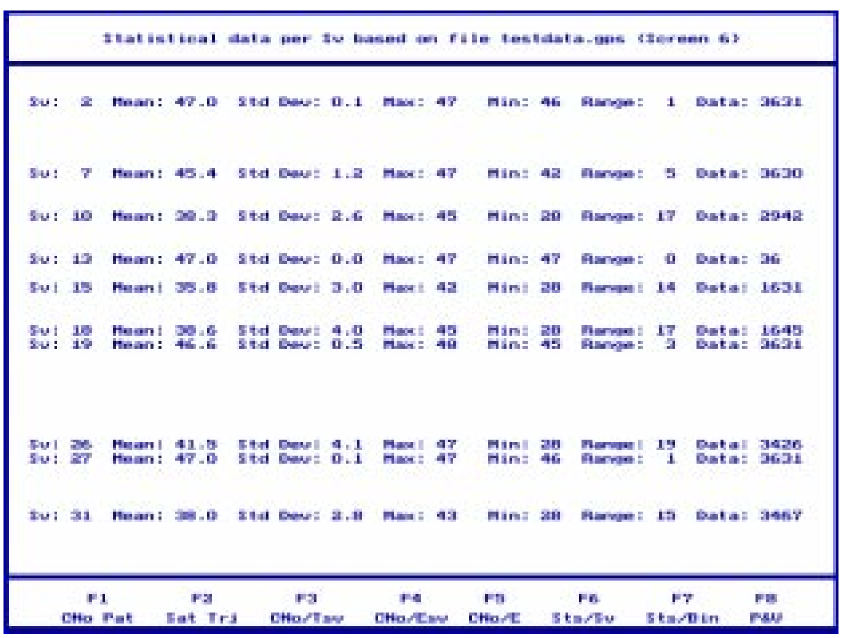
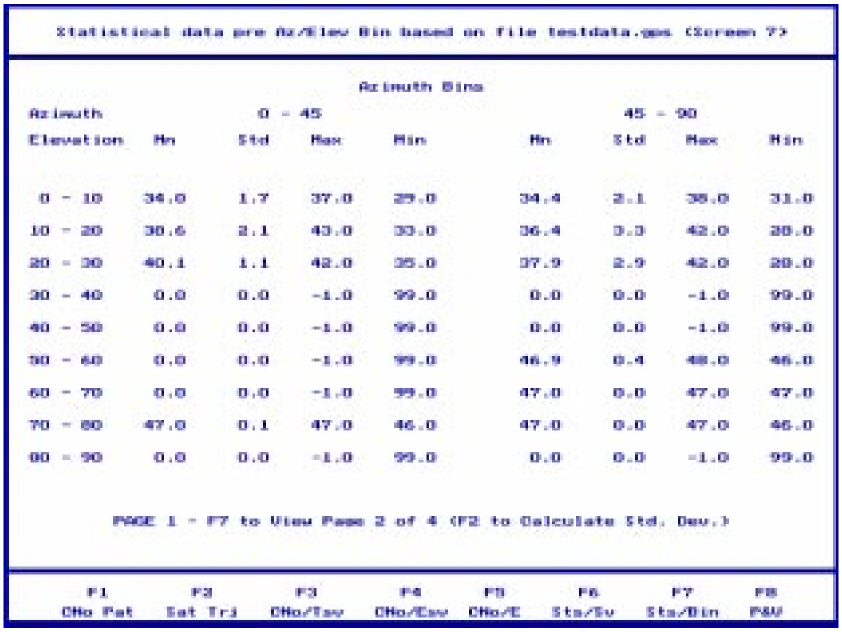


Figure 9.6: Sv Statistics



Azimuth	0 - 45				45 - 90			
Elevation	Mn	Std	Max	Min	Mn	Std	Max	Min
0 - 10	34.0	1.7	37.0	29.0	34.4	2.1	38.0	31.0
10 - 20	38.6	2.1	43.0	33.0	36.4	3.3	42.0	28.0
20 - 30	40.1	1.1	42.0	35.0	37.9	2.9	42.0	28.0
30 - 40	0.0	0.0	-1.0	99.0	0.0	0.0	-1.0	99.0
40 - 50	0.0	0.0	-1.0	99.0	0.0	0.0	-1.0	99.0
50 - 60	0.0	0.0	-1.0	99.0	46.9	0.4	48.0	46.0
60 - 70	0.0	0.0	-1.0	99.0	47.0	0.0	47.0	47.0
70 - 80	47.0	0.1	47.0	46.0	47.0	0.0	47.0	46.0
80 - 90	0.0	0.0	-1.0	99.0	0.0	0.0	-1.0	99.0

Figure 9.7: Bin Statistics

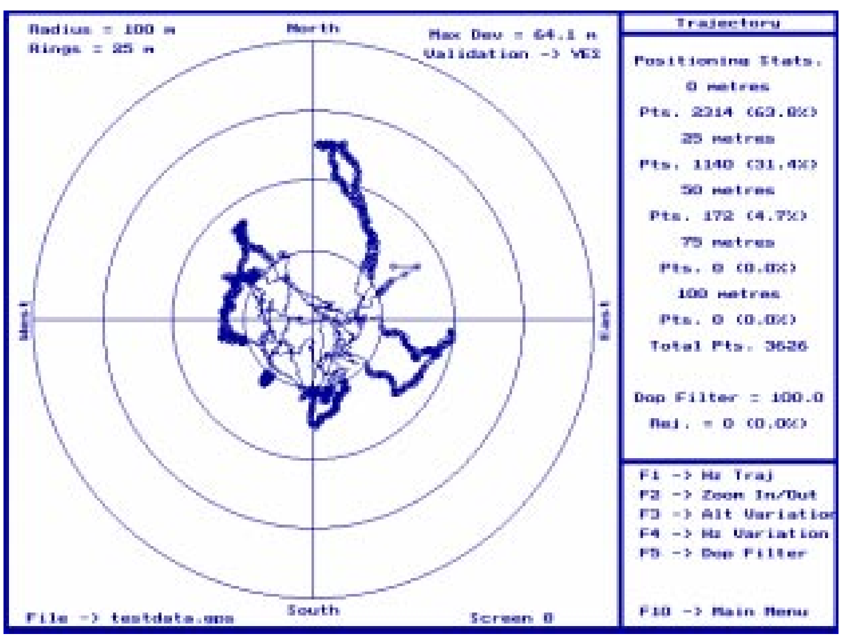


Figure 9.8: Position Trajectory

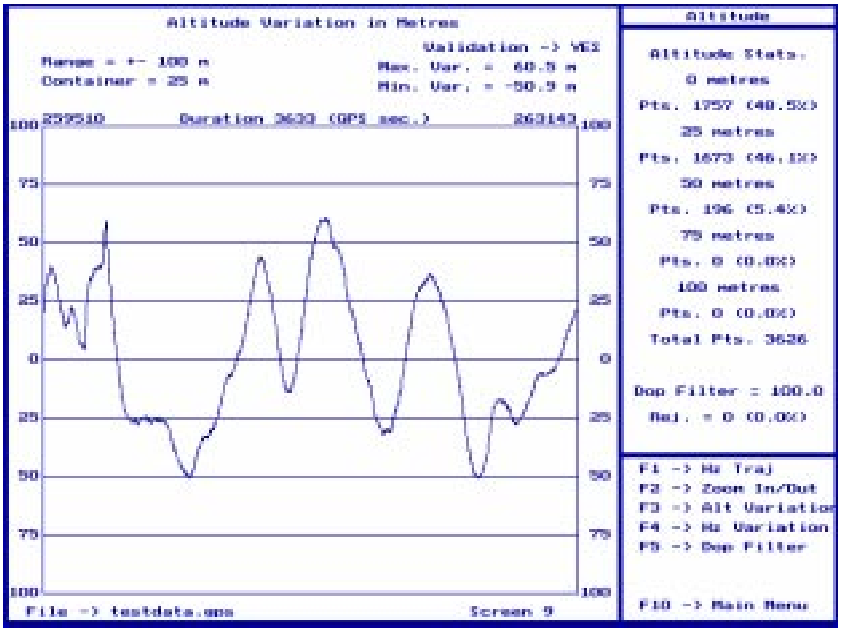


Figure 9.9: Altitude Variation

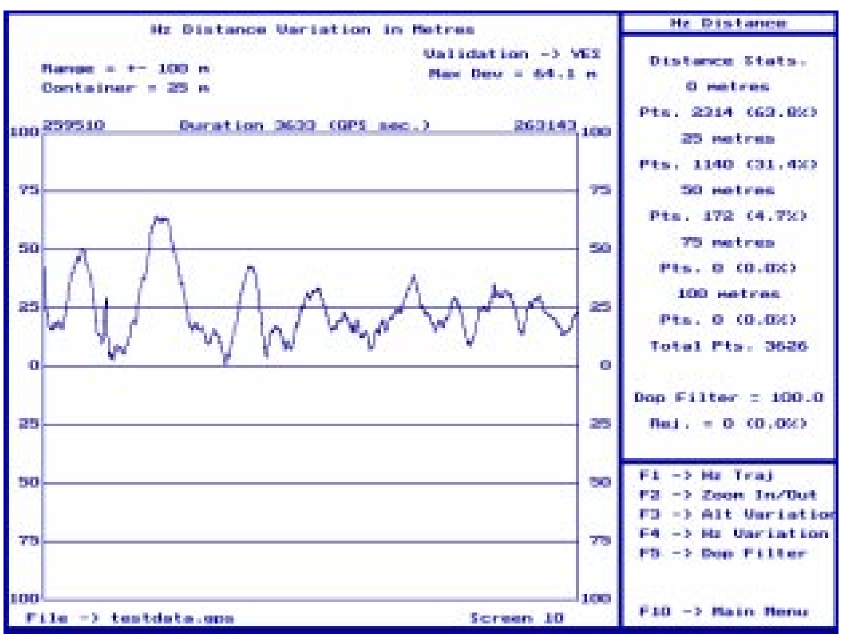


Figure 9.10: Distance Variation

9.6 Parser

This DOS-based utility scans through the data file collected with SiRFdemo and breaks out specific data strings to separate files. The following is a description of the parsed files:

File Type	Description
`*.clk`	Clock data (message 007)
`*.dbg`	Development data (message 255)
`*.dgp`	Differential GPS position data (002)
`*.nav`	Position, velocity (message 002 with the 2 stripped from the string)
`*.spc`	Spec check message (output by receiver during acquisition)
`*.trk`	Tracker development messages
`*.raw`	Raw track (message 005) plus 50 BPS data (message 008)

All data formats are unchanged from SiRF binary protocol.

9.6.1 Using Parser

Parser is a command-line utility that expects a data file collected with SiRFdemo. The following command options are available:

Option	Description
/re	Constructs missing version header from log.
/rm	Builds header without extract init from log (raw file need to be edited manually to add init).
/t	Trims data before the version header.
/s	Searches for header in log file; if found, trims data before it; if not found, extracts data and rebuilds header.
/p	Prompts user for processing options.
/d	Specifies default parser option.

Note – *See example data file* `roadtest.gps`*.*

9.7 Conv

`Conv.exe` is a DOS-based utility that lets you convert ECEF XYZ coordinate systems (used by GPS) to WGS 84 Geodetic (GEO) coordinate systems (latitude, longitude, altitude) compatible with mapping projections. Conversion can be performed in both directions.

9.7.1 Command-Line Options

Command-line options are available for converting ECEF XYZ to WGS84 Latitude, Longitude, and Height.

```
To convert from XYZ to GEO, use the following command-line options:

-h      Help - displays all command-line options

GEO to XYZ

-Lat    Latitude in degrees range -90.0 .. 90.0
-Lon    Longitude in degrees range -180.0 .. 180.0
-Alt    Value in meters

XYZ to GEO

-X      Value in meters
-Y      Value in meters
-Z      Value in meters
```

9.8 Fixanal

File `fixanal.exe` is a DOS program used to process logged data from SiRFdemo log files. As input, it uses data from messages of 'debug type 255' and it can produce a text file containing the following types of output:

- Detailed listing of every position fix timing, including times it took receiver to acquire first satellite, lock on three satellites and produce a position fix.
- Statistical summary of the above data.
- Detailed per-channel time analysis of all stages of satellite acquisition, meaning time to acquire, time to bit sync, time to frame sync, time to acquire ephemeris (if not already available), and total acquisition time (i.e., the sum of all mentioned times).

Note *– See example data file* `hotstart.gps`*.*

Note – *Fixanal.exe keys on specific Development Data Messages. Ensure that this is turned on for data collection. Refer to "Initialize Data Source" for details.*

9.8.1 Usage

After using SiRFdemo to create a log file `filename.log`, you should copy file `fixanal.exe` to the same directory where your log file is located, and then type `fixanal` at the DOS prompt. Follow the screen prompts, and if you opt for all the default options offered, one new file,`filename.fix`, is created in your current directory. It contains all the position fix statistical information.

9.8.2 Input Files

The log files must contain the following items for fixanal to work properly:

- Logged data of debug message type – It can contain other logged message types as well. The `fixanal` program ignores them. Also, `fixanal` must be run on a log file, not an output file from parser (e.g., `filename.nav`). This is because it expects to see the debug message type indicator. You can edit the log file to isolate certain sections except as noted below.
- Initial position message – Because `fixanal` uses these lines to determine parameters of the subsequent logging session. The lines that `fixanal` will look for are line 1 (showing software version), line 2 (describing the start mode), and line 7 (showing the number of channels used). A sample is presented below:

```
Version 00.33 built at 14:38:27 Oct 19 1996 using fxp
Receiver is initializing in Warm Start mode ...
TOW: 384074
WK:  876
POS: -3955124 3355588  3699664
CLK: 62779
CHNL:12+
```

9.8.3 Operation

After beginning the program, enter the names of the input and output files and specify output options. If you opt for default answers, the output file contains all available statistical reports. Enter your name to more easily identify the test report. This begins the processing of the data. As the data is processed, two numbers are displayed on the screen. The first is the total number of lines read from the file, the second is the number processed. These are not updated continually, but are displayed to show that the program is running. The program returns to the DOS prompt when finished.

9.8.4 Command-Line Options

Option	Description
-log:in_name	Use the input log file name (default extension is `.log`).
-out:out_name	Send output to the output file name. By default, it is the same as `in_name` but with the extension `.fix`
-sum	Provide an overall performance analysis summary.
-sum-	Turn off the above performance analysis option.
-det	Create a detailed listing of every position fix statistics.
-det-	Turn off the above detailed listing option.
-chan	Include per channel tracker performance analysis.
-chan-	Turn off the above channel tracker option.
-cold	Specify cold start performance analysis.
-cold-	Turn off the above cold start performance option.
-n:username	Specify tester's name.
-z	Ignore zero results when doing statistics (default).
-z-	Do not ignore zero results.
-p	Prompt for all parameters not specified.

9.8.5 Fixanal Output File (*.fix)

The `fixanal` output file (`*.fix`) has five parts. The first is the header information for identifying the test:

```
First Fix Analysis Sheet for Log File test2.log
Software Version 00.38 built at 16:39:33 Nov 12 1996 using flp
Number of Channels Used: 8
```

The second part includes statistical measures of every position fix recorded within the file. Following is a sample:

```
Session   1: Hot  Start 1.99  InitAcq  1.80   TT3Locked   6.29  TTFF   26.29 sec
Session   2: Hot  Start 1.99  InitAcq  1.80   TT3Locked  11.29  TTFF   27.29 sec
Session   3: Warm Start 1.99  InitAcq  1.80   TT3Locked  27.29  TTFF   40.29 sec
Session   4: Cold Start 1.99  InitAcq  2.70   TT3Locked  46.19  TTFF   81.19 sec
Session   5: Cold Start 1.99  InitAcq  2.70   TT3Locked   8.19  TTFF   96.19 sec
Session   6: Cold Start 1.99  InitAcq  2.70   TT3Locked  49.19  TTFF   84.19 sec
```

This portion can be imported into MSExcel or other spreadsheet program using spaces as column delimiters.
The third part of the file consists statistical analysis results based on the Time To First Fix data listed in the previous section. All results are expressed in seconds as units of measure.

```
Statistics:
Start       InitAcq          TT3Locked        TTFF
Ave:  1.99  Ave:    13.61   Ave:       37.23  Ave:   43.90 sec
Max:  1.99  Max:    38.30   Max:       80.59  Max:   93.19 sec
Min:  1.99  Min:     2.70   Min:        8.19  Min:   21.19 sec
```

The fourth part of the output file is a table of timing information obtained by analyzing each receiver channel separately. As physical channels are allocated to satellites by the satellite elevation from the horizon, and in descending order, variation of performance results across channels will be significant.

```
Ch   Acqire       Lock         Bitsync      Framesync    Ephemeris     Total
 #   Ave Max Min  Ave Max Min  Ave Max Min  Ave Max Min  Ave Max Min   Ave Max Min
------------------------------------------------------------------------------
 1    1.0   1   1  0.0   0   0 14.0 196   2 16.9 136  13 24.5 221  11  56.1 256  31
 2   71.1 269   2  0.0   0   0  3.0  72   2 15.8  31  13 22.4 124  11 110.0 276  31
 3   87.2 308   4  0.0   0   0  3.1  28   2 16.1  99  13 22.4  44   6 124.9 284  36
 4   71.6 266   2  0.0   0   0  3.0  18   2 15.9  36  13 23.1 211  11 111.6 276  36
 5   94.3 275   6  0.0   0   0  3.3  93   2 15.8  42  13 22.9 145   5 133.0 268  47
 6   93.6 266   2  0.0   0   0  3.2  21   2 15.7  31  13 22.1  97  11 131.8 287  36
 7   98.5 284   2  0.0   0   0  3.3 105   2 16.5 121  13 25.7 147  11 140.8 297  47
 8   89.2 282   8  0.0   0   0  3.2  30   2 16.2  87  13 22.6 191  11 126.7 298  41
------------------------------------------------------------------------------
Sum 73.4 308   1  0.0   0   0  4.7 196   2 16.1 136  13 23.2 221   5 114.8 298  31
```

9.9 Cksum

The purpose of `cksum.exe` is to read a file containing NMEA sentences and calculate the correct NMEA checksum. You can use the checksum to verify operation of NMEA output sentences or to generate a checksum for an NMEA input message.
Example:
Create a text file containing an NMEA input sentence such as an input NMEA query message and determine the proper checksum.

```
type query0.txt
$PSRF103,00,01,00,01*xx
cksum query0.txt
INPUT FILE: query0.txt
inline:$PSRF103,00,01,00,01*xx
cksum:25
```

The correct checksum for this message is 25. You can use Procomm or a similar terminal program to send the message. CK.C can be compiled using any compiler capable of generating DOS programs, and is simple to modify for your own unique uses.

9.10 Datum

This is a sample program to convert between GPS reference datums. Source code is supplied in C. See Appendix E, "Datum Transformation of GPS Positions" for datum formulation and transformation parameters.

To run the program either enter the file name as a command line argument (i.e., datum station) or enter the file name when prompted by the program (expected extension is *.gps). This is a user application example only.

9.11 Calcpsr

This is a sample program to convert the raw track data message (005) into GPS measurement data (i.e., pseudo-range, carrier phase...) for use in post processing. The Ephemeris data (if collected) is also decoded. To run the program either enter the file name as a command line argument (i.e., `calcpsr station`) or enter the file name when prompted by the program (expected extension is *.gps). This is a user application example only.

Appendix A

Evaluation Kit Specifications

This appendix describes the:

- GPS Receiver
- Physical Specifications
- Environmental Specifications
- Electrical Specifications
- Serial Ports

Note – *This manual only documents GPS-E1 boards with hardware Revision 12/98. If you own an older board, please get in touch with our support staff for updated documentation*

A.1 GPS Receiver

- 12 channels all-in-view tracking.
- Full-duplex serial port for navigation messages and control.
- Battery back-up switch-over circuit maintains real-time clock and position/almanac/ephemeris data in static RAM in the absence of external power.
- Flash EPROM-based program storage permits code updates from a PC via serial port B.
- Accurate one-pulse-per-second output signal.

A.2 Base Board

- Accepts 9 to 18 VDC input power.
- Internal battery for backup of real-time clock and static RAM.
- Provides RS232 level conversion for the serial ports.
- Contains a green LED that visualizes 1 PPS output.
- Contains a red LED that indicates power.

A.3 Physical Specifications

A.3.1 Receiver Dimensions

GPS-MS1 30mm x 30mm x 7.7mm

GPS-PS1 82.5mm x 32mm x 8.5mm

A.3.2 Enclosure Dimensions

105 mm x 112.5 x 48mm

A.4 Environmental Specifications

- Storage temperature -40 to +85 deg. C
- Operating temperature -40 to +85 deg. C.

A.5 Electrical Specifications GPS Receiver

See datasheets for GPS-MS1 and GPS-PS1 for electrical specification

A.6 Electrical Specifications GPS-E1 Base Board

A.6.1 Front Panel connectors

- Power input +9 to +18 VDC @ 200 mA max.
- 2 RS-232C-compliant serial ports.
- Female SMA Connector for GPS antenna.
- On-board customer-specific connectors and jumpers

Pin # and Name	Description
Pin 2 [Rx data]	Transmit data from the GPS receiver
Pin 3 [Tx data]	Receive data to the GPS receiver
Pin 5 [GND]	Connected to signal ground
1,4,6,7,8,9	Not connected

Table A.1: Serial Port A Pinout Descriptions

Pin # and Name	Description
Pin 2 [Rx data]	Transmit data from the GPS receiver
Pin 3 [Tx data]	Receive data to the GPS receiver
Pin 5 [GND]	Connected to signal ground
1,4,6,7,8,9	Not connected

Table A.2: Serial Port B Pinout Descriptions

A.6.2 Serial Ports

The serial ports consist of port A, which is used for navigation messages and control, and port B which is used as a receive only RTCM differential GPS correction input. Both ports are DB9-style female connectors wired as a null-modem. Port A is located on the front panel adjacent to the 1 PPS LED. Port B is located on the front panel next to the antenna input SMA connector. Connection to either port is accomplished via the included serial cable which is configured to connect directly to an IBM PC-style serial port. Following is the pin assignment for these ports.

Tables A.1 and A.2 describe the female DB9-style connector that is wired for direct connection to a serial port. Signal names in brackets [ ] are the RS232-standard names for the pin.

A.6.3 Antenna

The GPS patch antenna is cabled to the receiver through a female SMA connector located on the front panel of the GPS receiver. The center pin carries 4.75V DC bias voltage, suitable for most 4.5 - 5V active antennas.

A.6.4 Power

A female 2.1 mm circular connector on the front panel of the GPS receiver connects external power from the included AC adapter or a cigarette lighter adapter. The center conductor of this connector is the positive supply connection. The outer conductor is connected to circuitry ground. Connecting directly to a power source higher than +18 VDC can result in permanent damage to the Evaluation Unit.

A.7 Additional Connectors and Jumpers

The GPS-E1 Baseboard contains connectors for user-specific applications. Please refer to figure A.1 and the following tables for pinout and jumper options.

Pin #	Type	Function
1	O	Tx_B
2	I	VCC 5V
3	O	Tx_A
4	I	V Bat 3.3V
5	I	Rx_A
6	O	TIMEMARK
7	I	Rx_B
8	I	GND

Table A.3: J11/A - GPS-PS1 Connector

Pin #	Type	Function
2	O/(I)	RESET
1,3,4,5,6		reserved
7	O	VCC 3.3V
8	I	TEST_I

Table A.4: J11/B - GPS-PS1 Optional Connector

Pin	Type	Name	Pin	Type	Name	Pin	Type	Name
1	I	Vcc	15	I	RX_3	29	I	RX_1
2	I	Gnd	16	O	TX_2	30	O	TX_0
3	I/O	GPIO_11	17	I	RX_2	31	I	RX_0
4	I/O	GPIO_10	18	I	LP_A	32	I/O	GPIO_7
5	I/O	GPIO_9	19	I	Vcc	33	I/O	GPIO_6
6	I/O	GPIO_8	20	I	Vant	34	I/O	GPIO_5
7	I	NMI	21	I	Gnd	35	I/O	GPIO_4
8	I/O	RESET_N	22	I	Gnd	36	I/O	GPIO_3
9	I	TEST_I	23	I	Vcc	37	I/O	GPIO_2
10	O	TEST_O	24	I	TEST_D	38	I/O	GPIO_1
11	O	WAKEUP_N	25	I	Vbat	39	I/O	GPIO_0
12	O	WAKEUP	26	I/O	SCK1	40	I/O	CPU_CLK
13	I/O	1PPS	27	I/O	SCK0	41	I	Gnd
14	O	TX_3	28	O	TX_1	42	I	Vcc

Table A.5: J6 - GPS-MS1 Socket

A.7.1 GPS-E1 Board Features

Designator	Description
JB1	Serial Port A, Used for NMEA/SiRF Binary In/Output
JB2	Serial Port B, Used for RTCM In and Firmware Update
J1	Power Supply Connector
D1	1PPS / TPM Activity LED
D2	Power LED
S1	Reset Pushbutton
S2	Firmware Update Pushbutton
J6	Socket for GPS-MS1
J11	Mounting Area for GPS-PS1
J5	General Purpose I/Os[a]
U8	Backup Battery
U2	Power Regulator

Table A.6: GPS-E1 12/98 Board Features

[a] See table A.8 for Signal Names

A.7.2 GPS-E1 Jumper Settings

#	Positions	Default	Purpose	
J2	1-2		Antenna Voltage Off	
	2-3	×	Antenna Voltage On	
J3	open		Antenna Supply[a]	
	1-2	×		
J4	open		Backup Battery Supply[a]	
	1-2	×		
J7	1-2		Continuous Mode	
	2-3	×	Trickle Power Mode[b]	
J8	1-2	×	Trickle Power Mode[c]	
	2-3		Continuous Mode	
J9	1-2		(reserved)	Leave at factory default!
	2-3	×		
J10	open		Power GPS-MS1[a]	
	1-2	×		
J12	open		Power GPS-PS1[a]	
	1-2	×		

Table A.7: Jumper Options Hardware Revision 12/98

[a] By replacing this jumper with an ampere meter, one can measure the current draw
[b] GPS-MS1: This connects WAKEUP_N to NMI
[c] GPS-MS1: This connects WAKEUP_N to LP_A

#	Signal Name	#	Signal Name
71	GPIO_0	35	NMI
69	GPIO_1	33	1PPS
67	GPIO_2	31	SCK1
65	GPIO_3	29	SCK0
63	GPIO_4	27	TXD[a]
61	GPIO_5	25	RXD[b]
59	GPIO_6	23	TXC[c]
57	GPIO_7	21	RXC[d]
55	GPIO_8	19	TX3
53	GPIO_9	17	RX3
51	GPIO_10	15	TX2
49	GPIO_11	13	RX2
47	TEST_I	11	TX1
45	TEST_0	9	RX1
43	WAKEUP	7	TX0
41	WAKEUP_N	5	RX0
39	RESET	3	3.3V
37	CPU_CLK	1	5.0V
All even numbered pins are connected to Ground			

Table A.8: I/O Signals on J5

[a] RS232-level equivalent of TX3
[b] RS232-level equivalent of RX3
[c] RS232-level equivalent of TX2
[d] RS232-level equivalent of RX2

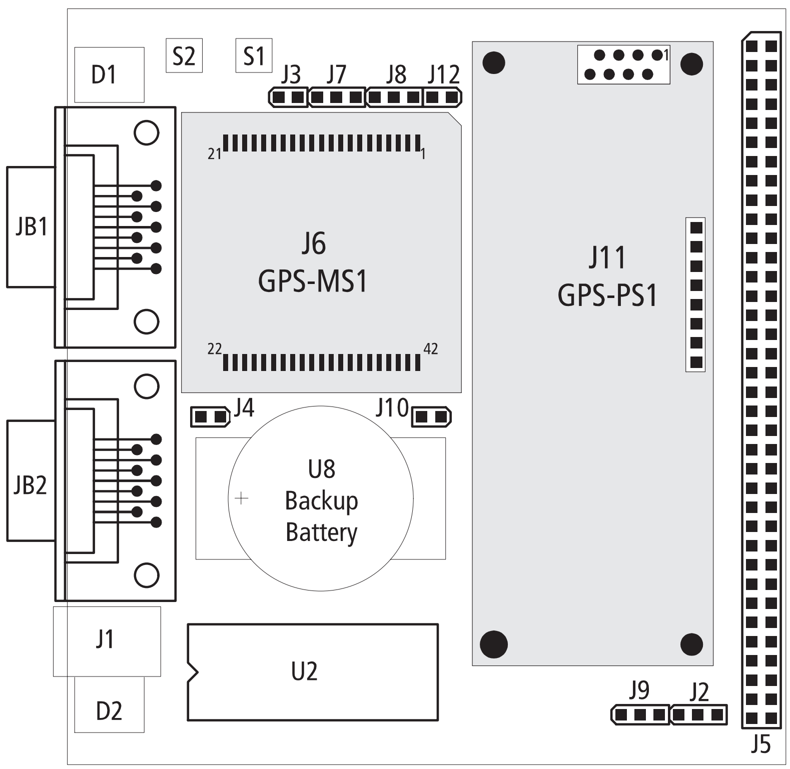
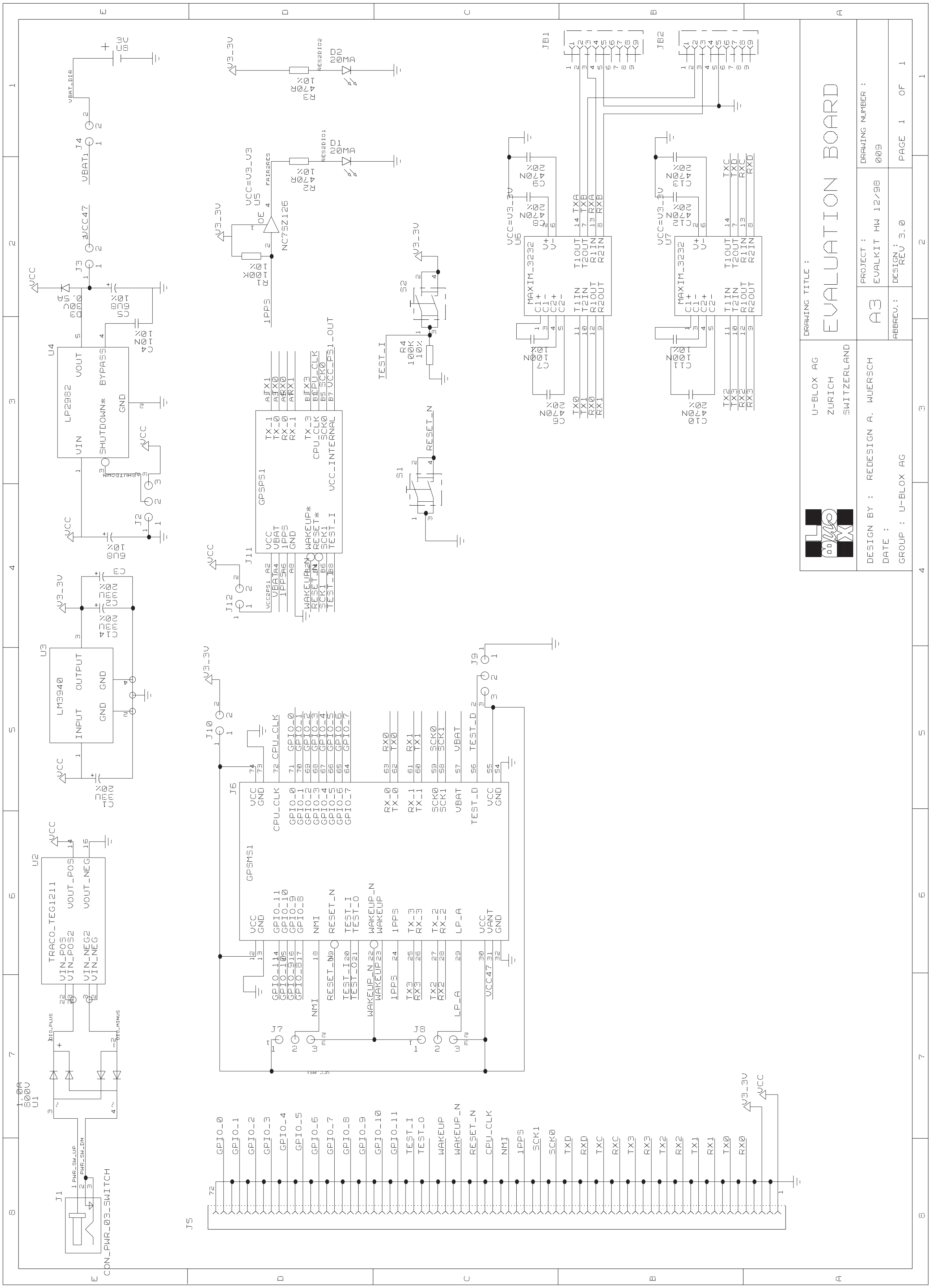


Figure A.1: GPS-E1 Jumper Locations, H/W Revision 12/98


DRAWING TITLE :
EVALUATION BOARD
U-BLOX AG
ZURICH
SWITZERLAND
DESIGN BY : REDESIGN A. WUERSCH
DATE :
GROUP : U-BLOX AG
PROJECT :
EVALKIT HW 12/98
DRAWING NUMBER :
009
A3
ABBREV.:
DESIGN :
REV 3.0
PAGE 1 OF 1

Appendix B

File Formats

This appendix describes the formats of files. It includes information on the following:

Contents

B.1 Modifying the Sample ring90.smp File

To modify the sample `ring90.smp` file:

1. Open the sample `ring90.smp` file in the SiRFdemo folder using a text editor.

```
;     Current version
V,2,0
;     SiRF in Santa Clara
O,37.37185,-121.99704
;     Map extent (height, width) in meters
E,300,300
;     Rings: 30, 60 and 90 radii in meters
C,0,0,30
C,0,0,60
C,0,0,90
;     cross-hair lines
L,-120,0,120,0
L,0,-120,0,120
```

Figure B.1 depicts the Map View screen with the `ring90.smp` file loaded.

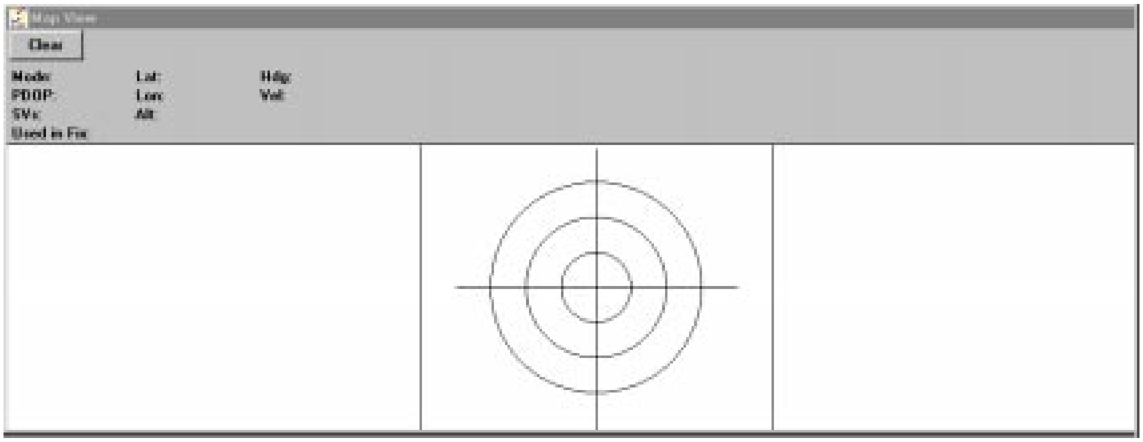


Figure B.1: Map View Screen with ring90.smp Sample File Loaded

---

Note – *The Map View screen shown in this chapter uses the default values set in the sample* `ring90.smp` *file. You can modify all of the configuration values in the sample* `ring90.smp` *file.*

You can modify the values for the Map View screen, as shown below.

```
;   Current version
V,2,0
;   SiRF in Santa Clara
O,37.3875113,-121.9723228
;   Map extent (height, width)
E,400,400
;   Rings: 20, 40 ... 100m radii
C,0,0,20
C,0,0,40
C,0,0,60
C,0,0,80
C,0,0,100
;   cross-hair lines
L,-120,0,120,0
L,0,-120,0,120
```

The file is then saved as `ring100.smp`. The Map View screen changes are shown in Figure B.2. It depicts the Map View screen with the `ring100.smp` file loaded.

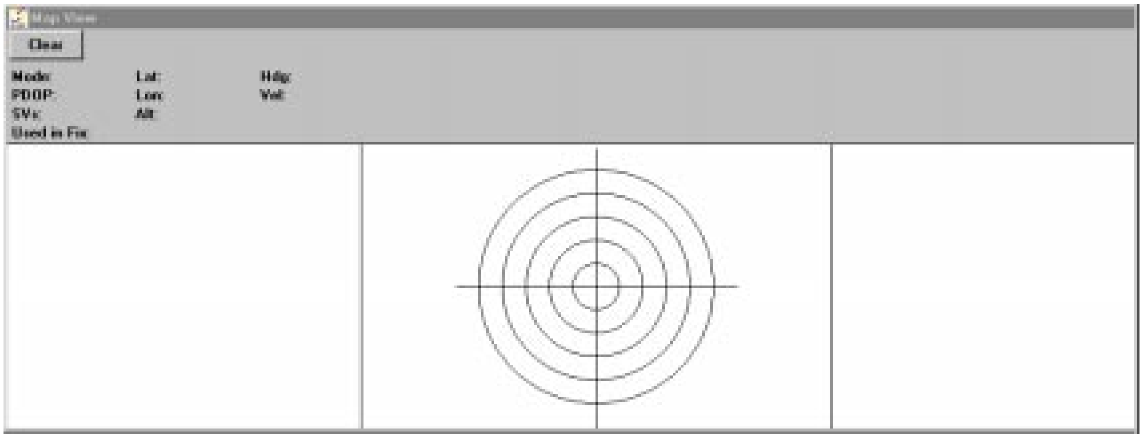


Figure B.2: Map View Screen with ring100.smp Sample File Loaded

B.2 Modifying the Sample Sirf.pos File

To modify the `Sirf.pos` file:

1. Open the sample `Sirf.pos` file in the SiRFdemo folder using a text editor. The sample X, Y, Z positions are displayed.

```
-2686718
-4304272
3851636
0
```

2. Use the configuration values displayed on the Measured Navigation Message View screen after communication has been connected to the Evaluation Unit as your new X, Y, and Z coordinates.

3. Modify the X, Y, Z positions in the `Sirf.pos` file with the new configuration values displayed on the Measured Navigation Message View screen.

```
-2690721
-4310924
3841682
0
```

B.3 Description of SiRFsig File Formats

SiRFsig produces the following files for plotting and statistics:

- `*.avg`
- `*.pos`

- *.vel
- *.###
- *.svs
- *.bin

Following are descriptions of each type of file.

B.3.1 *.avg File

*.avg is the average data file used to calculate statistics. It is created during parsing and used if data is reviewed without re-parsing the datafile.

Format

Lines 0-32 are satellite data. All fields are 0 if Sv. is not tracked.

Sv	Avg C/No	Number of Seconds Tracked
0	0.00	0
0	0.00	0
2	47.00	3631
0	0.00	0
0	0.00	0
0	0.00	0
0	0.00	0
7	45.44	3630
..	....	...
..	....	...
31	38.02	3467
0	0.00	0

Bin Data for Polar Plots

Bins are in a matrix of [8][8] with each bin defined by an azimuth range and elevation range. Bin[0][0] is AZ 0-45 and El. 0-10 degrees, Bin[0][1] is Az 0-45, El 10-20 degrees. Bins azimuths are in steps of 45 degrees in a clockwise direction, elevation bins are in 10 degree steps starting at the horizon (0 degrees) and finishing at the zenith (90 degrees).

Bin	Bin	Avg. C/No	# of Data	Max C/No	Min C/No
0	0	34.04	444	37.00	29.00
0	1	38.58	1638	43.00	33.00
..	..	..	..	..	..
0	8	0.00	0	-1.00	99.00
..	.	..	..	..	..
..	..	..	..	..	..
7	0	34.12	429	37.00	28.00
7	1	40.59	1638	46.00	35.00
..	..	..	..	..	..
7	8	0.00	0	-1.00	99.00

This is the start and end time of the data session in GPS seconds into the week.

Start	End
259510.24	263143.18

This is the average position of the receiver in ECEF XYZ coordinates.

X	Y	Z
-2686753.9	-4304226.9	3851670.2

B.3.2 *.pos File

`*.pos` is the time tagged position file in ECEF XYZ parsed from record 002 (measured navigation data) of SiRFdemo.

GPS Time	X	Y	Z
259510.24	-2686738.0	-4304253.0	3851706.0
259511.24	-2686738.0	-4304253.0	3851706.0
259512.24	-2686738.0	-4304253.0	3851706.0

B.3.3 *.vel File

`*.vel` is the time tagged position file in ECEF Vx, Vy, Vz parsed from record 002 (measured navigation data) of SiRFdemo.

GPS Time	Vx	Vy	Vz
259510.24	-0.2	0.0	0.0
259511.24	-0.2	0.0	0.0
259512.24	-0.2	0.0	0.0

B.3.4 *.### File

`*.###` is the satellite specific data for each Sv tracked where ### is the SV PRN number. This data is parsed from record 004 (measured tracker data) from SiRFdemo (i.e., Satellite data for Sv. Number 22 will be in file `*.022`).

GPS Time	Az	El.	Avg. C/No
256707.11	297	35	44
256708.11	297	35	45
256709.11	297	35	45

B.3.5 *.svs File

`*.svs` contains statistics that are generated each time the program processes a data file on a per satellite basis.

Statistical data file: *.svs

Statistical data per Sv based on file.

Sv	Mean	Std Dev	Max	Min	Range	Data
2	47.0	0.1	47	46	1	7262
7	45.4	1.2	47	42	5	7260
10	8.3	2.6	45	28	17	5884
13	47.0	0.0	47	47	0	72
15	35.8	3.0	42	28	14	3262
18	38.6	4.0	45	28	17	3290
19	46.6	0.5	48	45	3	7262
26	41.5	4.1	47	28	19	6852
27	47.0	0.1	47	46	1	7262
31	38.0	2.8	43	28	15	6934

B.3.6 *.bin File

The `*.bin` file contains statistics that are generated each time the program processes a data file on a per bin basis as defined by the C/No polar plot.

Statistical data file: *.bin

Azimuth	0-45				45-90			
Elevation	Mn	Std	Max	Min	Mn	Std	Max	Min
0 - 10	34.0	0.0	37.0	29.0	34.4	0.0	38.0	31.0
10 - 20	38.6	0.0	43.0	33.0	36.4	0.0	42.0	28.0
....								
80 - 90	0.0	0.0	-1.0	99.0	0.0	0.0	-1.0	99.0

Azimuth	90-135				135-180			
Elevation	Mn	Std	Max	Min	Mn	Std	Max	Min
.....	.....	.....	.....	.....	.....	.....	.....	.....

Azimuth	180-225				225-270			
Elevation	Mn	Std	Max	Min	Mn	Std	Max	Min
.....	.....	.....	.....	.....	.....	.....	.....	.....

Azimuth	270-315				315-360			
Elevation	Mn	Std	Max	Min	Mn	Std	Max	Min
.....	.....	.....	.....	.....	.....	.....	.....	.....

Appendix C

SiRF Binary Protocol Specification

The serial communication protocol is designed to include:

- Reliable transport of messages
- Ease of implementation
- Efficient implementation
- Independence from payload

Contents

C.1 Protocol Layers

C.1.1 Transport Message

Start Sequence	Payload Length	Payload	Message Checksum	End Sequence
0xA0 0xA2	Two-bytes (15-bits)	Up to 2^{10} -1 (<1023)	Two-bytes (15-bits)	0xB0,0xB3

C.1.2 Transport

The transport layer of the protocol encapsulates a GPS message in two start characters and two stop characters. The values are chosen to be easily identifiable and such that they are unlikely to occur frequently in the data. In addition, the transport layer prefixes the message with a two-byte (15-bit) message length and a two-byte (15-bit) check sum. The values of the start and stop characters and the choice of a 15-bit values for length and check sum are designed such that both message length and check sum can not alias with either the stop or start code.

C.1.3 Message Validation

The validation layer is of part of the transport, but operates independently. The byte count refers to the payload byte length. Likewise, the check sum is a sum on the payload.

C.1.4 Payload Length

The payload length is transmitted high order byte first followed by the low byte. This is the so-called big-endian order.

High Byte	Low Byte
0x00 …0x7F	0x00 …0xFF

Even though the protocol has a maximum length of (2^{15}-1) bytes practical considerations require the SiRF GPS module implementation to limit this value to a smaller number. Likewise, the SiRF receiving programs (e.g., SiRFdemo) may limit the actual size to something less than this maximum.

C.1.5 Payload Data

The payload data follows the payload length. It contains the number of bytes specified by the payload length. The payload data may contain any 8-bit value.
Where multi-byte values are in the payload data neither the alignment nor the byte order are defined as part of the transport although SiRF payloads will use the big-endian order. It should be noted that some processors do not allow arbitrary byte alignment of multi-byte data and therefore care should be used when reading data delivered as payload data.

C.1.6 Checksum

The check sum is transmitted high order byte first followed by the low byte. This is the so-called big-endian order.

High Byte	Low Byte
0x00 …0x7F	0x00 …0xFF

The check sum is 15-bit checksum of the bytes in the payload data. The following pseudo code defines the algorithm used.

```
1: Let message to be the array of bytes to
                 be sent by the transport.
2: Let msgLen be the number of bytes in the
           message array to be transmitted.
3: Index = first
4: checkSum = 0
```

```
while index < msgLen
    checkSum = checkSum + message[index]
    index = index + 1
checkSum = checkSum AND (2^15-1).
```

C.2 Input Messages for SiRF Binary Protocol

Note – *All input messages are sent in BINARY format.*

The following table lists the message list for the SiRF input messages.

Hex	ASCII	Name
0 x 80	128	Initialize Data Source
0 x 81	129	Switch to NMEA Protocol
0 x 82	130	Set Almanac (upload)
0 x 84	132	Software Version (Poll)
0 x 86	134	Set Main Serial Port
0 x 88	136	Mode Control
0 x 89	137	DOP Mask Control
0 x 8A	138	DGPS Control
0 x 8B	139	Elevation Mask
0 x 8C	140	Power Mask
0 x 8D	141	Editing Residual
0 x 8E	142	Steady-State Detection
0 x 8F	143	Static Navigation
0 x 90	144	Clock Status (Poll)
0 x 91	145	Set DGPS Serial Port
0 x 92	146	Almanac (Poll)
0 x 93	147	Ephemeris (Poll)
0 x 95	149	Set Ephemeris (Upload)
0 x 96	150	Switch Operating Mode
0 x 97	151	Set Trickle Power Mode
0 x 98	152	Navigation Parameters (Poll)

C.2.1 Initialize Data Source - Message I.D. 128

Table C.1 contains the input values for the following example:
Warm start the receiver with the following initialization data: ECEF XYZ (-2686727 m, -4304282 m, 3851642 m), Clock Offset (75,000Hz), Time of Week

(86,400s), Week Number (924), and Channels (12). Raw track data enabled, Debug data enabled.
Example:

```
A0A20019 --Start Sequence and Payload Length
80FFD700F9FFBE5266003AC57A000124F80083D600039C0C33 -- Payload
0A91B0B3 -- Message Checksum and End Sequence
```

			Binary (Hex)		
Name	Bytes	Scale	Example	Units	Description
Message ID	1		80		ASCII 128
ECEF X	4		FFD700F9	meters	
ECEF Y	4		FFBE5266	meters	
ECEF Z	4		003AC57A	meters	
Clock Offset	4		000124F8	Hz	
Time of Week	4	*100	0083D600	seconds	
Week Number	2		039C		
Channels	1		0C		Range 1-12
Reset Config.	1		33		See table C.2
Payload Length	25 bytes				

Table C.1: Initialize Data Source

Bit	Description
0	Data valid flag – set warm/hot start
1	Clear ephemeris – set warm start
2	Clear memory – set cold start
3	Reserved (must be 0)
4	Enable raw track data (YES=1, NO=0)
5	Enable debug data (YES=1, NO=0)
6	Reserved (must be 0)
7	Reserved (must be 0)

Table C.2: Reset Configuration Bitmap

Note – *If Raw Track Data is ENABLED then additionally message I.D. 0x05 (ASCII 5 - Raw Track Data), message I.D. 0x08 (ASCII 8 - 50BPS data), and message I.D. 0x07 (ASCII 7 - Clock Status) are transmitted. All messages are sent at 1 Hz.*

C.2.2 Switch To NMEA Protocol - Message I.D. 129

Table C.3 contains the input values for the following example:
Request the following NMEA data at 4800 baud:

```
GGA - ON at 1 sec, GLL - OFF, GSA - ON at 5 sec,
GSV - ON at 5 sec, RMC-OFF, VTG-OFF
```

Example:

`A0A20018` -- Start Sequence and Payload Length
`810201010001050105010001000100010001000112C0` -- Payload
`016AB0B3` -- Message Checksum and End Sequence

Name	Bytes	Binary (Hex) Scale	Binary (Hex) Example	Units	Description
Message ID	1		81		ASCII 129
Mode	1		02		
GGA Message [a]	1		01	1/s	See Chapter D for format.
Checksum [b]	1		01		
GLL Message	1		00	1/s	See Chapter D for format.
Checksum	1		01		
GSA Message	1		05	1/s	See Chapter D for format.
Checksum	1		01		
GSV Message	1		05	1/s	See Chapter D for format.
Checksum	1		01		
RMC Message	1		00	1/s	See Chapter D for format.
Checksum:	1		01		
VTG Message	1		00	1/s	See Chapter D for format.
Checksum	1		01		
Unused Field	1		00		Recommended value.
Unused Field	1		01		Recommended value.
Unused Field	1		00		Recommended value.
Unused Field	1		01		Recommended value.
Unused Field	1		00		Recommended value.
Unused Field	1		01		Recommended value.
Unused Field	1		00		Recommended value.
Unused Field	1		01		Recommended value.
Baud Rate	2		12C0		38400,19200,9600,4800
Payload Length	24 bytes				

Table C.3: Switch To NMEA Protocol

[a] A value of 0x00 implies NOT to send message, otherwise data is sent at 1 message every X seconds requested (i.e., to request a message to be sent every 5 seconds, request the message using a value of 0x05.) Maximum rate is 1/255s.

[b] A value of 0x00 implies the checksum is NOT transmitted with the message (not recommended). A value of 0x01 will have a checksum calculated and transmitted as part of the message (recommended).

Note – *In Trickle Power mode, update rate is specified by the user. When you switch to NMEA protocol, message update rate is also required. The resulting update rate is the product of the Trickle Power Update rate AND the NMEA update rate (i.e. Trickle Power update rate = 2 seconds, NMEA update rate = 5 seconds, resulting update rate is every 10 seconds, (2 X 5 = 10)).*

C.2.3 Set Almanac - Message I.D. 130

This command enables the user to upload an almanac to the GPS receiver.

Note – *This feature is not documented in this manual.*

C.2.4 Software Version - Message I.D. 132

Table C.4 contains the input values for the following example:
Poll the software version
Example:

`A0A20002` -- Start Sequence and Payload Length
`8400` -- Payload
`0084B0B3` -- Message Checksum and End Sequence

Name	Bytes	Scale	Binary (Hex) Example	Units	Description
Message ID	1		84		ASCII 132
TBD	1		00		Reserved
Payload Length	2 bytes				

Table C.4: Software Version

C.2.5 Set Main Serial Port - Message I.D. 134

Table C.5 contains the input values for the following example:
Set Main Serial port to 9600,n,8,1.
Example:

A0A20009 -- Start Sequence and Payload Length
860000258008010000 -- Payload
0134B0B3 -- Message Checksum and End Sequence

Name	Bytes	Scale	Binary (Hex) Example	Units	Description
Message ID	1		86		decimal 134
Baud	4		00002580		38400,19200,9600,4800,2400,1200
Data Bits	1		08		8,7
Stop Bit	1		01		0,1
Parity	1		00		None=0, Odd=1, Even=2
Pad	1		00		Reserved
Payload Length	9 bytes				

Table C.5: Set Main Serial Port

C.2.6 Mode Control - Message I.D. 136

Table C.6 contains the input values for the following example:

3D Mode	= Always	Alt Constraining	= Yes
Degraded Mode	= clock then direction	TBD	=1
DR Mode	= Yes	Altitude	= 0
Alt Hold Mode	= Auto	Alt Source	=Last Computed
Coast Time Out	= 20	Degraded Time Out	=5
DR Time Out	= 2	Track Smoothing	= Yes

The meaning of these parameters and their effect on the navigation calculation process is documented in the Evaluation Kit Manual, Section “Navigation”.

Example:

A0A2000E -- Start Sequence and Payload Length
8801010101010000000002140501 -- Payload
00A9B0B3 -- Message Checksum and End Sequence

Name	Bytes	Binary (Hex) Example	Units	Description
Message ID	1	88		ASCII 136
3D Mode	1	01		Always 1 (unused)
Alt Constraint	1	01		YES=1, NO=0
Degraded Mode	1	01		See Table C.7
TBD	1	01		Reserved
DR Mode	1	01		YES=1, NO=0
Altitude	2	0000	meters	range -1,000 to 10,000
Alt Hold Mode	1	00		Auto=0, Always=1,Disable=2
Alt Source	1	02		Last Computed=0,Fixed to=1, Dynamic=2[a]
Coast Time Out	1	14	seconds	0 to 120
Degraded Time Out	1	05	seconds	0 to 120
DR Time Out	1	01	seconds	0 to 120
Track Smoothing	1	01		YES=1, NO=0
Payload Length	14 bytes			

Table C.6: Mode Control

[a] Currently not implemented

Byte Value	Description
0	Use Direction then Clock Hold
1	Use Clock then Direction Hold
2	Direction (Curb) Hold Only
3	Clock (Time) Hold Only
4	Disable Degraded Modes

Table C.7: Degraded Mode Byte Value

C.2.7 DOP Mask Control - Message I.D. 137

Table C.8 contains the input values for the following example:
Auto Pdop/Hdop, Gdop =8 (default), Pdop=8,Hdop=8
Example:

```
A0A20005   -- Start Sequence and Payload Length
8900080808   -- Payload
00A1B0B3   -- Message Checksum and End Sequence
```

Name	Bytes	Scale	Binary (Hex) Example	Units	Description
Message ID	1		89		ASCII 137
DOP Selection	1		00		See Table C.9
GDOP Value	1		08		Range 1 to 50
PDOP Value	1		08		Range 1 to 50
HDOP Value	1		08		Range 1 to 50
Payload Length	5 bytes				

Table C.8: DOP Mask Control

Byte Value	Description
0	Auto PDOP/HDOP
1	PDOP
2	HDOP
3	GDOP
4	Do Not Use

Table C.9: DOP Selection

C.2.8 DGPS Control - Message I.D. 138

Table C.10 contains the input values for the following example:
Set DGPS to exclusive with a time out of 30 seconds.
Example:

```
A0A20003 -- Start Sequence and Payload Length
8A011E -- Payload
00A9B0B3 -- Message Checksum and End Sequence
```

Name	Bytes	Scale	Binary (Hex) Example	Units	Description
Message ID	1		8A		ASCII 138
DGPS Selection	1		01		See Table C.11
DGPS Time Out:	1		1E	seconds	Range 1 to 120
Payload Length	3 bytes				

Table C.10: DGPS Control

Byte Value	Description
0	Auto
1	Exclusive
2	Never

Table C.11: DGPS Selection

C.2.9 Elevation Mask - Message I.D. 139

Table C.12 contains the input values for the following example:
Set Navigation Mask to 15.5 degrees (Tracking Mask is defaulted to 5 degrees).
Example:

`A0A20005` -- Start Sequence and Payload Length
`8B0032009B` -- Payload
`0158B0B3` -- Message Checksum and End Sequence

			Binary (Hex)		
Name	Bytes	Scale	Example	Units	Description
Message ID	1		8B		ASCII 139
Tracking Mask	2	*10	0032	degrees	Not currently used
Navigation Mask	2	*10	009B	degrees	Range -20.0 to 90.0
Payload Length	5 bytes				

Table C.12: Elevation Mask

C.2.10 Power Mask - Message I.D. 140

Table C.13 contains the input values for the following example:
Navigation mask to 33 dBHz (tracking default value of 28)
Example:

`A0A20003` -- Start Sequence and Payload Length
`8C1C21` -- Payload
`00C9B0B3` -- Message Checksum and End Sequence

			Binary (Hex)		
Name	Bytes	Scale	Example	Units	Description
Message ID	1		8C		ASCII 140
Tracking Mask	1		1C	dBHz	Not currently implemented
Navigation Mask	1		21	dBHz	Range 28 to 50
Payload Length	3 bytes				

Table C.13: Power Mask

C.2.11 Editing Residual- Message I.D. 141

***Note** – Not currently implemented.*

C.2.12 Steady State Detection - Message I.D. 142

Table C.14 contains the input values for the following example:
Set Steady State Threshold to 1.5 m/sec2
Example:

A0A20002 -- Start Sequence and Payload Length
8E0F -- Payload
009DB0B3 -- Message Checksum and End Sequence

		Binary (Hex)			
Name	Bytes	Scale	Example	Units	Description
Message ID	1		8E		ASCII 142
Threshold	1	*10	0F	m/sec2	Range 0 to 20
Payload Length	2 bytes				

Table C.14: Steady State Detection

C.2.13 Static Navigation- Message I.D. 143

Note – *Not currently implemented.*

C.2.14 Clock Status - Message I.D. 144

Table C.15 contains the input values for the following example:
Poll the clock status.
Example:

A0A20002 -- Start Sequence and Payload Length
9000 -- Payload
0090B0B3 -- Message Checksum and End Sequence

		Binary (Hex)			
Name	Bytes	Scale	Example	Units	Description
Message ID	1		90		ACSII 144
TBD	1		00		Reserved
Payload Length	2 bytes				

Table C.15: Clock Status

C.2.15 Set DGPS Serial Port - Message I.D. 145

Table C.16 contains the input values for the following example:
Set DGPS Serial port to 9600,n,8,1.
Example:

```
A0A20009 -- Start Sequence and Payload Length
910000258008010000 -- Payload
013FB0B3 -- Message Checksum and End Sequence
```

Name	Bytes	Scale	Binary (Hex) Example	Units	Description
Message ID	1		91		ASCII 145
Baud	4		00002580		38400,19200,9600,4800,2400,1200
Data Bits	1		08		8,7
Stop Bit	1		01		0,1
Parity	1		00		None=0, Odd=1, Even=2
Pad	1		00		Reserved
Payload Length	9 bytes				

Table C.16: Set DGPS Serial Port

C.2.16 Almanac - Message I.D. 146

Table C.17 contains the input values for the following example:
Poll for the Almanac.
Example:

```
A0A20002 -- Start Sequence and Payload Length
9200 -- Payload
0092B0B3 -- Message Checksum and End Sequence
```

Name	Bytes	Scale	Binary (Hex) Example	Units	Description
Message ID	1		92		ASCII 146
TBD	1		00		Reserved
Payload Length	2 bytes				

Table C.17: Almanac

To this request, the receiver replies with a MID 14.

C.2.17 Ephemeris Message I.D. 147

Table C.18 contains the input values for the following example:
Poll for Ephemeris Data for all satellites.
Example:

A0A20003 -- Start Sequence and Payload Length
930000 -- Payload
0092B0B3 -- Message Checksum and End Sequence

Name	Bytes	Scale	Binary (Hex) Example	Units	Description
Message ID	1		93		ASCII 147
Sv I.D.[a]	1		00		Range 0 to 32
TBD	1		00		Reserved
Payload Length	3 bytes				

Table C.18: Ephemeris Message I.D. 147

[a] A value of 0 requests all available ephemeris records, otherwise the ephemeris of the Sv I.D. is requested.

To this request, the receiver replies with a MID 15.

C.2.18 Switch To SiRF Protocol

Note – *To switch to SiRF protocol you must send a SiRF NMEA message to revert to SiRF binary mode. (See Section D NMEA Input Messages for more information.)*

C.2.19 Switch Operating Modes - Message I.D. 150

Table C.19 contains the input values for the following example:
Sets the receiver to track a single satellite on all channels.
Example:

A0A20007 -- Start Sequence and Payload Length
961E510006001E --Payload
0129B0B3 -- Message Checksum and End Sequence

Name	Bytes	Scale	Binary (Hex) Example	Units	Description
Message ID	1		96		ASCII 150
Mode	2		1E51		1E51=test, 0=normal
SvID	2		0006		Satellite to Track
Period	2		001E	seconds	Duration of Track
Payload Length	7 bytes				

Table C.19: Switch Operating Mode

C.2.20 Set Trickle Power Parameters - Message I.D. 151

Table C.20 contains the input values for the following example:
Sets the receiver into low power Modes.
Example:
Set receiver into Trickle Power at 1 hz update and 200 ms On Time.

`A0A20009` -- Start Sequence and Payload Length
`97000000C8000000C8` Payload
`0227B0B3` -- Message Checksum and End Sequence

			Binary (Hex)		
Name	Bytes	Scale	Example	Units	Description
Message ID	1		97		ASCII 151
Push To Fix Mode	2		0000		ON = 1, OFF = 0
Duty Cycle	2	*10	00C8	%	% Time ON
Milli Seconds On Time	4		000000C8	ms	range 200 - 500 ms
Payload Length	9 bytes				

Table C.20: Trickle Power Parameters

Computation of Duty Cycle and On Time

The Duty Cycle is the desired time to be spent tracking.The On Time is the duration of each tracking period (range is 200 - 900 ms). To calculate the TricklePower update rate as a function of Duty cycle and On Time, use the following formula:

$$OffTime = \frac{OnTime - (DutyCycle * OnTime)}{DutyCycle}$$

$$Updaterate = OffTime + OnTime$$

Note – *On Time inputs of > 900 ms will default to 1000 ms*

Table C.21 lists some examples of selections:

Mode	On Time (ms)	Duty Cycle (%)	Update Rate(1/Hz)
Continuous	1000	100	1
Trickle Power	300	30	1
Trickle Power	400	20	2
Trickle Power	400	10	4
Trickle Power	500	5	10

Table C.21: Example of Selections for Trickle Power Mode of Operation

---

Note – *To confirm the receiver is performing at the specified duty cycle and ms On Time, open the 12-Channel Signal Level View Screen in SiRFDemo. The C/No data bins will be fully populated at 100% duty and only a single C/No data bin populated at 20% duty cycle. Your position should be updated at the computed update rate.*

In Release 131 144 there are Trickle Power limitations. See Table C.22 for supported/unsupported settings.

	1 second	2 - 8 seconds
200	no	no
300	yes	no
400	yes	yes
>400	yes	yes

Table C.22: Trickle Power Mode Settings

Push-to-Fix

In this mode, the receiver will turn on periodically to check whether ephemeris collection is required (i.e., if a new satellite has become visible). If it is required, the receiver will collect ephemeris at that time. In general this takes on the order of 18 to 30 seconds. If it is not required, the receiver will turn itself off again.
The user specifies the DutyCycle parameter, ranging up to 10%. In either case, the amount of time the receiver remains off will be in proportion to how long it stayed on:

$$Offperiod = \frac{OnPeriod * (1 - DutyCycle)}{DutyCycle}$$

Off Period is limited to not more than 30 minutes, which means that in practice the duty cycle will not be less than approximately On Period/1800, or about 1%. Because

Push-to-Fix keeps the ephemeris for all visible satellites up to date, a position/velocity fix can generally be computed relatively quickly when requested by the user: on the order of 3 seconds versus 46 seconds if Push-to-Fix were not available and the receiver warm-started.

Note – *The 3 second TTFF figure increases to 6 seconds if the off period exceeds 30 minutes. Frame synchronization is commanded in this case.*
For more information on Trickle power mode, see the Trickle Power Mode application note.

C.2.21 Poll Navigation Parameters - Message I.D. 152

Table C.23 contains the input values for the following example:
Poll receiver for current navigation parameters. The receiver replie with a Message ID 19.
Example:

```
A0A20002 -- Start Sequence and Payload Length
9800 --Payload
0098B0B3 -- Message Checksum and End Sequence
```

			Binary (Hex)		
Name	Bytes	Scale	Example	Units	Description
Message ID	1		98		ASCII 152
Reserved	1		00		Reserved
Payload Length	2 bytes				

Table C.23: Poll Navigation Parameters

C.3 Output Messages for SiRF Binary Protocol

Note – *All output messages are received in BINARY format. SiRFdemo interprets the binary data and saves it to the log file in ASCII format.*

Table C.24 lists the message list for the SiRF output messages.

Hex	ASCII	Name	Description
0 x 02	2	Measured Navigation Data	Position, velocity, and time
0 x 04	4	Measured Tracking Data	Signal to noise information
0 x 05	5	Raw Track Data	Measurement information
0 x 06	6	SW Version	Receiver software
0 x 07	7	Clock Status	
0 x 08	8	50 BPS Subframe Data	Standard ICD format
0 x 09	9	Throughput	CPU load
0 x 0B	11	Command Acknowledgment	Successful request
0 x 0C	12	Command NAcknowledgment	Unsuccessful request
0 x 0D	13	Visible List	
0 x 0E	14	Almanac Data	
0 x 0F	15	Ephemeris Data	
0 x 12	18	OkToSend	CPU ON / OFF (Trickle Power)
0 x 13	19	Navigation Parameters	Response to Poll
0 x FF	255	Development Data	Various data messages

Table C.24: SiRF Messages - Output Message List

C.3.1 Measure Navigation Data Out - Message I.D. 2

Output Rate: 1 Hz
Table C.25 lists the binary and ASCII message data format for the measured navigation data
Example:

`A0A20029` -- Start Sequence and Payload Length
`02FFD6F78CFFBE536E003AC00400030104A00036B039780E3`
`0612190E160F04000000000000` -- Payload
`09BBB0B3` -- Message Checksum and End Sequence

		Binary (Hex)			ASCII (Decimal)	
Name	Bytes	Scale	Example	Units	Scale	Example
Message ID	1		02			2
X-position	4		FFD6F78C	m		-2689140
Y-position	4		FFBE536E	m		-4304018
Z-position	4		003AC004	m		3850244
X-velocity	2	*8	0000	m/s	Vx/8	0
Y-velocity	2	*8	0003	m/s	Vy/8	0.375
Z-velocity	2	*8	0001	m/s	Vz/8	0.125
Mode 1	1		04	Bitmap[a]		4
DOP[b]	1	*5	A		/5	2.0
Mode 2	1		00	Bitmap[c]		0
GPS Week	2		036B			875
GPS TOW	4	*100	039780E3	seconds	/100	602605.79
SVs in Fix	1		06			6
CH 1	1		12			18
CH 2	1		19			25
CH 3	1		0E			14
CH 4	1		16			22
CH 5	1		0F			15
CH 6	1		04			4
CH 7	1		00			0
CH 8	1		00			0
CH 9	1		00			0
CH 10	1		00			0
CH 11	1		00			0
CH 12	1		00			0
Payload Length	41 bytes					

Table C.25: Measured Navigation Data Out

[a] Table C.26 lists the meaning of this field.
[b] Dilution of precision (DOP) field contains value of PDOP when position is obtained using 3D solution and HDOP in all other cases.
[c] Table C.27 lists the meaning of the individual bits.

Note – *Binary units scaled to integer values need to be* divided *by the scale value to receive true decimal value (i.e., decimal Xvel = (binary Xvel)/8).*

Mode 1	Hex	ASCII	Description
Bit 0..2	0x00	0	No Navigation Solution
	0x01	1	1 Satellite Solution[a]
	0x02	2	2 Satellite Solution[b]
	0x03	3	3 Satellite Solution (2D) [c]
	0x04	4	$\geq$ 4 Satellite Solution (3D)
	0x05	5	2D Point Solution (Krause)
	0x06	6	3D Point Solution (Krause)
	0x07	7	Dead Reckoning
Bit 3	0x08	8	Reserved
Bit 4	0x10	16	Reserved
Bit 5	0x20	32	Reserved
Bit 6	0x40	64	DOP Mask Exceeded
Bit 7	0x80	128	DGPS Position

Table C.26: Mode 1

[a] Altitude hold, direction hold and time hold
[b] Altitude hold and direction or time hold
[c] Altitude hold

Example: A value of 0x84 (132) is a DGPS fix with $\geq$ 4 Satellites (3D)

Mode 2	Hex	Ascii	Description
Bit 0	0x01	1	DR Sensor Data
Bit 1	0x02	2	1=Validated Fix/0=Unvalidated
Bit 2	0x04	4	if set, Dead Reckoning (Time Out)
Bit 3	0x08	8	if set, Output Edited by UI (i.e., DOP Mask exceeded)
Bit 4	0x10	16	Reserved
Bit 5	0x20	32	Reserved
Bit 6	0x40	64	Reserved
Bit 7	0x80	128	Reserved

Table C.27: Mode 2

C.3.2 Measured Tracker Data Out - Message I.D. 4

Output Rate: 1 Hz

Table C.28 lists the binary and ASCII message data format for the measured tracker data.

Example:

```
A0A200BC -- Start Sequence and Payload Length
04036C0000937F0C0EAB46003F1A1E1D1D191D1A1A1D1F1D59423F1A1A... --
Payload
****B0B3 -- Message Checksum and End Sequence
```

		Binary (Hex)			ASCII (Decimal)	
Name	Bytes	Scale	Example	Units	Scale	Example
Message ID	1		04	None		4
GPS Week	2		036C			876
GPS TOW	4	s*100	0000937F	s	s/100	37759
Chans	1		0C			12
1st SVid	1		0E			14
Azimuth	1	Az*[2/3]	AB	deg	/[2/3]	256.5
Elev	1	El*2	46	deg	/2	35
State	2		003F	Bitmap (Table C.29)		63
C/No 1	1		1A			26
C/No 2	1		1E			30
C/No 3	1		1D			29
C/No 4	1		1D			29
C/No 5	1		19			25
C/No 6	1		1D			29
C/No 7	1		1A			26
C/No 8	1		1A			26
C/No 9	1		1D			29
C/No 10	1		1F			31
2nd SVid	1		1D			29
Azimuth	1	Az*[2/3]	59	deg	/[2/3]	89
Elev	1	El*2	42	deg	/2	66
State	2		3F	Bitmap (Table C.29)		63
C/No 1	1		1A			26
C/No 2	1		1A			63
....						
Payload Length	188 bytes					

Table C.28: Measured Tracker Data Out

Note – *Message length is fixed to 188 bytes with nontracking channels reporting zero values.*

Note – *When a channel is fully locked and all data is valid, the status shown is 0 x BF.*

Field Definition	Hex Value	Description
ACQ_SUCCESS	0x0001	Set if acq/reacq is done successfully
DELTA_CARPHASE_VALID	0x0002	Integrated carrier phase is valid
BIT_SYNC_DONE	0x0004	Bit sync completed flag
SUBFRAME_SYNC_DONE	0x0008	Subframe sync has been done
CARRIER_PULLIN_DONE	0x0010	Carrier pullin done
CODE_LOCKED	0x0020	Code locked
ACQ_FAILED	0x0040	Failed to acquire S/V
GOT_EPHEMERIS	0x0080	Ephemeris data available

Table C.29: TrktoNAVStruct.trk_status Field Definition

Note – *The status is reflected by the value of all bits as the receiver goes through each stage of satellite acquisition. The status will have a 0xBF value when a channel is fully locked and all data is valid.*

C.3.3 Raw Tracker Data Out - Message I.D. 5

GPS Pseudo-Range and Integrated Carrier Phase Computations Using SiRF Binary Protocol

This section describes the necessary steps to compute the GPS pseudo-range, pseudo-range rate, and integrated carrier phase data that can be used for post processing applications such as alternative navigation filters. This data enables the use of third party software to calculate and apply differential corrections based on the SiRF binary protocol. Additionally, description and example code is supplied to calculate the measurement data and decode the broadcast ephemeris required for post processing applications.

Output Rate: 1 Hz

Table C.30 lists the binary and ASCII message data format for the raw tracker data.

Example:

```
a0a20033 -- Start Sequence and Payload Length
05000000010007003f00e2facf000a00830000dbb0
0012bc0900004a40fa2d2a6a0000 -- Payload
2e2e2d2e2e2e2e2e2e2e000003e80005
0ae6b0b3 -- Message Checksum and End Sequence
```

		Binary (Hex)			ASCII (Decimal)	
Name	Bytes	Scale	Example	Units	Scale	Example
Message ID	1		05			5
Channel	4		00000001			1
SVID	2		0007			07
State	2		003F	Bitmap (Table C.29)		63
Bits	4		00e2facf	bit		14875343
ms	2		000a	ms		10
Chips	2		0083	chip		131
Code Phase	4	2^{16}	0000dbb0	chip	2^{-16}	0.858154296875
Carrier Doppler	4	2^{10}	0012bc09	rad/2ms	2^{-10}	1199.00878906
Time Tag	4		00004a40	ms		19008
Delta Carrier[a]	4	2^{10}	fa2d2a6a	cycles	2^{-10}	- 95413.3964844
Search Count	2		0000			0
C/No 1	1		2e	dBHz		46
C/No 2	1		2e	dBHz		46
C/No 3	1		2d	dBHz		45
C/No 4	1		2e	dBHz		46
C/No 5	1		2e	dBHz		46
C/No 6	1		2e	dBHz		46
C/No 7	1		2e	dBHz		46
C/No 8	1		2e	dBHz		46
C/No 9	1		2e	dBHz		46
C/No 10	1		2e	dBHz		46
Power Bad Cnt	1		00			0
Phase Bad Cnt	1		00			0
Delta Car Int	2		03e8	ms		1000
Correl Int	2		0005			5
Payload Length	51 bytes per satellite tracked (up to 12)					

Table C.30: Raw Tracker Data Out

[a] Multiply by $\frac{1000}{4\pi}2^{-16}$ to convert to Hz.

Note – *The status is reflected by the value of all bits as the receiver goes through each stage of satellite acquisition. The status will have a 0xBF value when a channel is fully locked and all data is valid.*

Message ID Each SiRF binary message is defined based on the ID. Channel: Receiver channel where data was measured (range 1-12).

SVID	PRN number of the satellite on current channel.
State	Current channel tracking state (see Table C.29).
Bit Number	Number of GPS bits transmitted since Sat-Sun midnight (in Greenwich) at a 50 bps rate.
Millisecond Number	Number of milliseconds of elapsed time since the last received bit (20 ms between bits).
Chip Number	Current C/A code symbol being transmitted (range 0 to 1023 chips; 1023 chips = 1 ms).
Code Phase	Fractional chip of the C/A code symbol at the time of sampling (scaled by 2 -16 , = 1/65536).
Carrier Doppler	The current value of the carrier frequency as maintained by the tracking loops.

Note – *The Bit Number, Millisecond Number, Chip Number, Code Phase, and Carrier Doppler are all sampled at the same receiver time.*

Receiver Time Tag	This is the count of the millisecond interrupts from the start of the receiver (power on) until the measurement sample is taken. The ms interrupts are generated by the receiver clock.
Delta Carrier Phase	The difference between the carrier phase (current) and the carrier phase (previous). Units are in carrier cycles with the LSB = 0.00185 carrier cycles. The delta time for the accumulation must be known.

Note – *Carrier phase measurements are not necessarily in sync with code phase measurement for each measurement epoch.*

Search Count	This is the number of times the tracking software has completed full satellite signal searches.
C/No	Ten measurements of carrier to noise ratio (C/No) values in dBHz at input to the receiver. Each value represents 100 ms of tracker data and its sampling time is not necessarily in sync with the code phase measurement.
Power Loss Count	The number of times the power detectors fell below the threshold between the present code phase sample and the previous code phase sample. This task is performed every 20 ms (max count is 50).

Phase Loss Count	The number of times the phase lock fell below the threshold between the present code phase sample and the previous code phase sample. This task is performed every 20 ms (max count is 50).
Integration Interval	The time in ms for carrier phase accumulation. This is the time difference (as calculated by the user clock) between the Carrier Phase (current) and the Carrier Phase (previous).
Track Loop Iteration	The tracking Loops are run at 2 ms and 10 ms intervals. Extrapolation values for each interval is 1 ms and 5 ms for range computations.

Calculation of Pseudo-Range Measurements

The pseudo-range measurement in meters can be determined from the raw track data by solving the following equation:

$$Pseudorange(PR) = [ReceivedTime(RT) - TransmitTime(TT)] * C$$

where C = speed of light.
The following variables from the raw track data are required for each satellite:

- Bit Number (BN) - 50 bits per second
- Millisecond Number (MSN)
- Chip Number (CN)
- Code Phase (CP)
- Receiver Time Tag (RTTag)
- Delta Carrier Phase (DCP)

The following steps are taken to get the psr data and carrier data for each measurement epoch.

Note – *See source code to* `calcpsr` *(part of the Toolkit).*

---

1. Computation of initial Receiver Time (RT) in seconds.

Note – *The initial arbitrary value is chosen at start up to make the PR reasonable (i.e., set equal to TT + 70 ms) and then incriminated by one second for each measurement epoch.*

2. Computation of Transmit Time (TT) in seconds.

3. Calculate Pseudo-range at a common receiver time of the first channel of the measurement data set.

Note – *All channel measurements are NOT taken at the same time. Therefore, all ranges must be extrapolated to a common measurement epoch. For simplicity, the first channel of each measurement set is used as the reference to which all other measurements are extrapolated.*

4. Extrapolate the pseudo-range based on the correlation interval to improve precision.

5. Compute the delta range.

If the accumulation time of the Delta Carrier Phase is 1000 ms then the measurement is valid and can be added to the previous Delta Carrier Phase to get Accumulated Carrier Phase data. If the accumulation time of the Delta Carrier Phase is not equal to 1000 ms then the measurement is not valid and the accumulation time must be restarted to get Accumulated Carrier Phase data.

C.3.4 Response: Software Version String - Message I.D. 6

Output Rate: Response to polling message
Example:

`A0A20015` -- Start Sequence and Payload Length
`0606312E322E30444B495431313920534D0000000000` -- Payload
`0382B0B3` -- Message Checksum and End Sequence

			Binary (Hex)			ASCII (Decimal)
Name	Bytes	Scale	Example	Units	Scale	Example
Message ID	1		06			6
Character	20		06312E32 2E30444B 49543131 3920534D 00000000			1.2.0DKit119 SM
Payload Length	21 bytes					

Table C.31: Software Version String

Note – *Convert to symbol to assemble message (i.e., 0x4E is 'N'). These are low priority task and are not necessarily output at constant intervals.*

C.3.5 Response: Clock Status Data - Message I.D. 7

Output Rate: 1 Hz or response to polling message
Example:

```
A0A20014 -- Start Sequence and Payload Length
0703BD021549240822317923DAEF -- Payload
0598B0B3 -- Message Checksum and End Sequence
```

			Binary (Hex)			ASCII (Decimal)
Name	Bytes	Scale	Example	Units	Scale	Example
Message ID	1		07			7
GPS Week	2		03BD			957
GPS TOW	4	s*100	02154924	s	s/100	349494.12
Svs	1		08			8
Clock Drift	4		2231	Hz		74289
Clock Bias	4		7923	nano s		128743715
Estimated GPS Time	4		DAEF	milli s		349493999
Payload Length	20 bytes					

Table C.32: Clock Status Data Message

C.3.6 50 BPS Data - Message I.D. 8

Output Rate: As available (12.5 minute download time)

Example:

`A0A2002B` -- Start Sequence and Payload Length
`08********` --Payload
`****B0B3` -- Message Checksum and End Sequence

	Binary (Hex)				ASCII (Decimal)	
Name	Bytes	Scale	Example	Units	Scale	Example
Message ID	1		08			8
Channel	1					
Sv I.D	1					
Word[10]	40					
Payload Length	43 bytes per subframe (6 subframes per page, 25 pages Almanac)					

Table C.33: 50 BPS Data

Note – *Data is logged in ICD format (available from* `www.navcen.uscg.mil`*).*

C.3.7 CPU Throughput - Message I.D. 9

Output Rate: 1 Hz
Example:

`A0A20009` -- Start Sequence and Payload Length
`09003B0011001601E5` -- Payload
`0151B0B3` -- Message Checksum and End Sequence

	Binary (Hex)				ASCII (Decimal)	
Name	Bytes	Scale	Example	Units	Scale	Example
Message ID	1		09			9
SegStatMax	2	*186	003B	milli s	/186	.3172
SegStatLat	2	*186	0011	milli s	/186	.0914
AveTrkTime	2	*186	0016	milli s	/186	.1183
Last MS	2		01E5	milli s		485
Payload Length	9 bytes					

Table C.34: CPU Throughput

C.3.8 Command Acknowledgment - Message I.D. 11

Output Rate: Response to successful input message

This is successful almanac (message ID 0x92) request example:

`A0A20002` -- Start Sequence and Payload Length
`0B92` -- Payload
`009DB0B3` -- Message Checksum and End Sequence

		Binary (Hex)			ASCII (Decimal)	
Name	Bytes	Scale	Example	Units	Scale	Example
Message ID	1		0B			11
Ack. I.D.	1		92			146
Payload Length	2 bytes					

Table C.35: Command Acknowledgment

C.3.9 Command NAcknowledgment - Message I.D. 12

Output Rate: Response to rejected input message
This is unsuccessful almanac (message ID 0x92) request example:

`A0A20002` -- Start Sequence and Payload Length
`0C92` -- Payload
`009EB0B3` -- Message Checksum and End Sequence

		Binary (Hex)			ASCII (Decimal)	
Name	Bytes	Scale	Example	Units	Scale	Example
Message ID	1		0C			12
NAck. I.D.	1		92			146
Payload Length	2 bytes					

Table C.36: Command NAcknowledgment

C.3.10 Visible List - Message I.D. 13

Output Rate: Updated approximately every 2 minutes

Note – *This is a variable length message. Only the number of visible satellites are reported (as defined by Visible Svs in Table C.37). Maximum is 12 satellites.*

Example:

A0A2002A -- Start Sequence and Payload Length
0D0807002900380901330002C****************** -- Payload
****B0B3 -- Message Checksum and End Sequence

	Binary (Hex)				ASCII (Decimal)	
Name	Bytes	Scale	Example	Units	Scale	Example
Message ID	1		0D			13
Visible Svs	1		08			8
CH 1 - Sv I.D.	1		07			7
CH 1 - Sv Azimuth	2		0029	degrees		41
CH 1 - Sv Elevation	2		0038	degrees		56
CH 2 - Sv I.D.	1		09			9
CH 2 - Sv Azimuth	2		0133	degrees		307
CH 2 - Sv Elevation	2		002C	degrees		44
.....						
Payload Length	62 bytes (maximum)					

Table C.37: Visible List

C.3.11 Almanac Data - Message I.D. 14

Output Rate: Response to poll
Example:

A0A203A1 -- Start Sequence and Payload Length
0E01************* -- Payload
****B0B3 -- Message Checksum and End Sequence

	Binary (Hex)				ASCII (Decimal)	
Name	Bytes	Scale	Example	Units	Scale	Example
Message I.D.	1		0E			14
Sv I.D. (1)	1		01			1
AlmanacData[14][2]	28					
....						
Sv I.D. (32)	1		20			32
AlmanacData[14][2]	28					
Payload Length	929 bytes					

Table C.38: Almanac Data

C.3.12 Ephemeris Data - Message I.D. 15

This message consists of the ephemeris data for a particular SVID. Data consisting of 45 16-bit unsigned integers which make up 3 subframes of data each consisting of 15 unsigned 16 bit integers. This data is the ephemeris subframe data collected

from the 50BPS data stream, and compressed by packing the each subframe from 10 subframe words (32 bits/word) into 15 words (16 bits/word) with the tlm and parity words stripped off. Successful reception will be indicated by ACK message output.
Output Rate: Response to poll

		Binary (Hex)			ASCII (Decimal)	
Name	Bytes	Scale	Example	Units	Scale	Example
Message I.D.	1		0F			15
Sv I.D. (1)	1		01			1
EphemerisData[45][2]	90					
Payload Length	92 bytes					

Table C.39: Ephemeris Data

C.3.13 OkToSend - Message I.D. 18

Output Rate: Trickle Power CPU on/off indicator
Example:

```
A0A20002 -- Start Sequence and Payload Length
1200     -- Payload
0012B0B3 -- Message Checksum and End Sequence
```

		Binary (Hex)			ASCII (Decimal)	
Name	Bytes	Scale	Example	Units	Scale	Example
Message I.D.	1		12			18
Send Indicator	1		00[a]			00
Payload Length	2 bytes					

Table C.40: OkToSend

[a] 0 implies that CPU is about to go OFF, OkToSend==NO, 1 implies CPU has just come ON, OkToSend==YES

C.3.14 Navigation Parameters (Response to Poll) - Message I.D. 19

Output Rate: Response to Poll
Example:

```
A0A20018 -- Start Sequence and Payload Length
130100000000011E3C0104001E004B1E00000500016400C8    Payload
022DB0B3 -- Message Checksum and End Sequence
```

		Binary (Hex)			ASCII (Decimal)	
Name	Bytes	Scale	Example	Units	Scale	Example
Message I.D.	1		13			19
Altitude Constraint	1		01			1
Altitude Hold Mode	1		00			0
Altitude Hold Source	1		00			0
Altitude Source Input	2		0000	meters		0
Degraded Mode(see table C.6)	1		01			1
Degraded Timeout	1		1E	seconds		30
DR Timeout	1		3C	seconds		60
Track Smooth Mode	1		01			1
DOP Mask Mode (see table C.8)	1		04			4
DGPS Mode (see table C.10)	1		00			0
DGPS Timeout	1		1E	seconds		30
Elevation Mask	2	*10	004B	degrees	/10	7.5
Power Mask	1		1E	dBHz		30
Editing Residual	2		0000			0
Steady-State Detection	1	*10	05	m/s^2	/10	0.5
Static Navigation	1	*10	00		/10	0
Low Power Mode (see C.20)	1		01			1
Low Power Duty Cycle	1		64	percent		100
Low Power On-Time	2		00C8	ms		200
Payload Length	24 bytes					

Table C.41: Navigation Parameters

C.3.15 Development Data - Message I.D. 255

Output Rate: Receiver generated

Example:

```
A0A2****  --Start Sequence and Payload Length
FF**************  --Payload
****B0B3  -- Message Checksum and End Sequence
```

		Binary (Hex)			ASCII (Decimal)	
Name	Bytes	Scale	Example	Units	Scale	Example
Message ID	1		FF			255
Payload Length	variable					

Table C.42: Development Data

Note – *Messages are output to give the user information of receiver activity. Convert to symbol to assemble message (i.e.,0 x 4E is 'N'). These are low priority task and are not necessarily output at constant intervals.*

Appendix D

NMEA Input/Output Messages

The GPS receiver provided by µ-blox AG may also output data in NMEA-0183 format as defined by the National Marine Electronics Association (NMEA), Standard For Interfacing Marine Electronic Devices, Version 2.20, January 1, 1997.

Contents

D.1 NMEA Checksum

All NMEA sentences have an optional checksum. The Checksum can be enabled/disabled when setting up the NMEA Protocol. The optional checksum field consists of a "*" and two hex digits representing the exclusive OR of all characters between, but not including, the “$” and “*”. The following pseudo code calculates a checksum over an array of characters “line”. The first character in the array is “line[0]”:

```
line = getline()
index = 1
checksum = 0
while line[index] <> '*' do
    checksum = checksum EXOR line[index]
    index = index+1
end while
```

D.2 NMEA Output Messages

The GPS receiver outputs the following messages as shown in table D.1:

NMEA Record	Description
GGA	Global positioning system fixed data
GLL	Geographic position - latitude/longitude
GSA	GNSS DOP and active satellites
GSV	GNSS satellites in view
RMC	Recommended minimum specific GNSS data
VTG	Course over ground and ground speed

Table D.1: NMEA-0183 Output Messages

D.2.1 GGA – Global Positioning System Fixed Data

Table D.2 contains the values for the following example:

```
$GPGGA,161229.487,3723.2475,N,12158.3416,W,1,07,1.0,9.0,M, , , ,0000*18
```

Name	Example	Units	Description
Message ID	$GPGGA		GGA protocol header
UTC Time	161229.487		hhmmss.sss
Latitude	3723.2475		ddmm.mmmm
N/S Indicator	N		N=north or S=south
Longitude	12158.3416		dddmm.mmmm
E/W Indicator	W		E=east or W=west
Position Fix Indicator[a]	1		
Satellites Used	07		Range 0 to 12
HDOP	1.0		Horizontal Dilution of Precision
MSL Altitude[b]	9.0	meters	
Units	M	meters	
Geoid Separation[b]		meters	
Units	M	meters	
Age of Diff. Corr.		second	Null fields when DGPS is not used
Diff. Ref. Station ID	0000		
Checksum	*18		
CR LF			End of message termination

Table D.2: GGA Data Format

[a] See Table D.3
[b] This implementation does not support geoid corrections. Values are WGS84 ellipsoid heights

Value	Description
0	Fix not available or invalid
1	GPS SPS Mode, fix valid
2	Differential GPS, SPS Mode, fix valid
3	GPS PPS Mode, fix valid

Table D.3: Position Fix Indicator

D.2.2 GLL – Geographic Position - Latitude/Longitude

Table D.4 contains the values for the following example:

```
$GPGLL,3723.2475,N,12158.3416,W,161229.487,A*2C
```

Name	Example	Units	Description
Message ID	$GPGLL		GLL protocol header
Latitude	3723.2475		ddmm.mmmm
N/S Indicator	N		N=north or S=south
Longitude	12158.3416		dddmm.mmmm
E/W Indicator	W		E=east or W=west
UTC Time	161229.487		hhmmss.sss
Status	A		A=data valid or V=data not valid
Checksum	*2C		
CR LF			End of message termination

Table D.4: GLL Data Format

D.2.3 GSA – GNSS DOP and Active Satellites

Table D.5 contains the values for the following example:

```
$GPGSA,A,3,07,02,26,27,09,04,15, , , , , ,1.8,1.0,1.5*33
```

Name	Example	Units	Description
Message ID	$GPGSA		GSA protocol header
Mode 1	A		See Table D.7
Mode 2	3		See Table D.6
Satellite Used[a]	07		Sv on Channel 1
Satellite Used[a]	02		Sv on Channel 2
....			....
Satellite Used[a]			Sv on Channel 12
PDOP	1.8		Position Dilution of Precision
HDOP	1.0		Horizontal Dilution of Precision
VDOP	1.5		Vertical Dilution of Precision
Checksum	*33		
CR LF			End of message termination

Table D.5: GSA Data Format

[a] Used in solution

Value	Description
1	Fix not available
2	2D
3	3D

Table D.6: Mode 1

Value	Description
M	Manual–forced to operate in 2D or 3D mode
A	Automatic–allowed to automatically switch 2D/3D

Table D.7: Mode 2

D.2.4 GSV – GNSS Satellites in View

Table D.8 contains the values for the following example:

```
$GPGSV,2,1,07,07,79,048,42,02,51,062,43,26,36,256,42,27,27,138,42*71
$GPGSV,2,2,07,09,23,313,42,04,19,159,41,15,12,041,42*41
```

Name	Example	Units	Description
Message ID	$GPGSV		GSV protocol header
Number of Messages[a]	2		Range 1 to 3
Message Number[a]	1		Range 1 to 3
Satellites in View	07		
Satellite ID	07		Channel 1 (Range 1 to 32)
Elevation	79	degrees	Channel 1 (Maximum 90)
Azimuth	048	degrees	Channel 1 (True, Range 0 to 359)
SNR (C/No)	42	dBHz	Range 0 to 99, null when not tracking
....			....
Satellite ID	27		Channel 4 (Range 1 to 32)
Elevation	27	degrees	Channel 4 (Maximum 90)
Azimuth	138	degrees	Channel 4 (True, Range 0 to 359)
SNR (C/No)	42	dBHz	Range 0 to 99, null when not tracking
Checksum	*71		
CR LF			End of message termination

Table D.8: GSV Data Format

[a] Depending on the number of satellites tracked multiple messages if GSV data may be required. This is reported in the "Number of Messages" and "Message Number" fields.

D.2.5 RMC – Recommended Minimum Specific GNSS Data

Table D.9 contains the values for the following example:

```
$GPRMC,161229.487,A,3723.2475,N,12158.3416,W,0.13,309.62,120598, ,*10
```

Name	Example	Units	Description
Message ID	$GPRMC		RMC protocol header
UTC Time	161229.487		hhmmss.sss
Status	A		A=data valid or V=data not valid
Latitude	3723.2475		ddmm.mmmm
N/S Indicator	N		N=north or S=south
Longitude	12158.3416		dddmm.mmmm
E/W Indicator	W		E=east or W=west
Speed Over Ground	0.13	knots	
Course Over Ground	309.62	degrees	True
Date	120598		ddmmyy
Magnetic Variation[a]		degrees	E=east or W=west
Checksum	*10		
CR LF			End of message termination

Table D.9: RMC Data Format

[a]Magnetic Declination is not supported. All "course over ground" data are geodetic WGS84 directions.

D.2.6 VTG – Course Over Ground and Ground Speed

Table D.10 contains the values for the following example:

```
$GPVTG,309.62,T, ,M,0.13,N,0.2,K*6E
```

Name	Example	Units	Description
Message ID	$GPVTG		VTG protocol header
Course	309.62	degrees	Measured heading
Reference	T		True
Course		degrees	Measured heading
Reference[a]	M		Magnetic
Speed	0.13	knots	Measured horizontal speed
Units	N		Knots
Speed	0.2	km/hr	Measured horizontal speed
Units	K		Kilometer per hour
Checksum	*6E		
CR LF			End of message termination

Table D.10: VTG Data Format

[a]Magnetic Declination is not supported. All "course over ground" data are geodetic WGS84 directions.

D.3 SiRF Proprietary NMEA Input Messages

NMEA input messages are provided to allow you to control the GPS receiver while in NMEA protocol mode. The receiver may be put into NMEA mode by sending the SiRF Binary protocol message (Section C.2.2) using a user program or using `Sirfdemo.exe` and selecting Switch to NMEA Protocol from the Action menu. If the receiver is in SiRF Binary mode, all NMEA input messages are ignored. Once the receiver is put into NMEA mode, the following messages may be used to command the module.

D.3.1 Transport Message

Start Sequence	Payload	Checksum	End Sequence
$PSRF<MID>[a]	Data[b]	*CKSUM[c]	<CR> <LF>[d]

[a] Message Identifier consisting of three numeric characters. Input messages begin at MID 100.

[b] Message specific data. Refer to a specific message section for <data>...<data> definition.

[c] CKSUM is a two-hex character checksum as defined in the NMEA specification. Use of checksums is required on all input messages.

[d] Each message is terminated using Carriage Return (CR) Line Feed (LF) which is \r \n which is hex 0D 0A. Because \r \n are not printable ASCII characters, they are omitted from the example strings, but must be sent to terminate the message and cause the receiver to process that input message.

Note – *All fields in all proprietary NMEA messages are required, none are optional. All NMEA messages are comma delimited.*

D.3.2 SiRF NMEA Input Messages

Message	Message Identifier (MID)	Description
SetSerialPort	100	Set PORT A parameters and protocol
Navigation Initialization	101	Parameters required for start using X/Y/Z
SetDGPSPort	102	Set PORT B parameters for DGPS input
Query/Rate Control	103	Query standard NMEA message and/or set output rate
LLANavigationInitialization	104	Parameters required for start using Lat/Lon/Alt (WGS84)
Development Data On/Off	105	Development Data messages On/Off

D.3.3 SetSerialPort

This command message is used to set the protocol (SiRF Binary or NMEA) and/or the communication parameters (baud, data bits, stop bits, parity). Generally, this command is used to switch the module back to SiRF Binary protocol mode where a more extensive command message set is available. When a valid message is received, the parameters are stored in battery-backed SRAM and then the receiver restarts using the saved parameters.
Table D.11 contains the input values for the following example:
Switch to SiRF Binary protocol at 9600,8,N,1

```
$PSRF100,0,9600,8,1,0*0C
```

Name	Example	Units	Description
Message ID	$PSRF100		PSRF100 protocol header
Protocol	0		0=SiRF Binary, 1=NMEA
Baud	9600		4800, 9600, 19200, 38400
DataBits	8		8,7[a]
StopBits	1		0,1
Parity	0		0=None, 1=Odd, 2=Even
Checksum	*0C		
CR LF			End of message termination

Table D.11: Set Serial Port Data Format

[a]SiRF protocol is only valid for 8 data bits, 1 stop bit and no parity.

D.3.4 NaviagtionInitialization

This command is used to initialize the module for a warm start, by providing current position (in X, Y, Z coordinates), clock offset, and time. This enables the GPS receiver to search for the correct satellite signals at the correct signal parameters. Correct initialization parameters enable the receiver to acquire signals quickly.
Table D.12 contains the input values for the following example:
Start using known position and time.

```
$PSRF101,-2686700,-4304200,3851624,95000,497260,921,12,3*22
```

Name	Example	Units	Description
Message ID	$PSRF101		PSRF101 protocol header
ECEF X	-2686700	meters	X coordinate position
ECEF Y	-4304200	meters	Y coordinate position
ECEF Z	3851624	meters	Z coordinate position
ClkOffset	95000	Hz	Clock Offset of the Unit[a]
TimeOfWeek	497260	seconds	GPS Time Of Week
WeekNo	921		GPS Week Number
ChannelCount	12		Range 1 to 12
ResetCfg	3		See D.13
Checksum	*22		
CR LF			End of message termination

Table D.12: Navigation Initialization Data Format

[a] Use 0 for last stored value. If this is not available, a factory programmed default will be used.

Hex	Description
0x01	Data Valid–Warm/Hot Starts=1
0x02	Clear Ephemeris–Warm Start=1
0x04	Clear Memory–Cold Start=1

Table D.13: Reset Configuration

D.3.5 SetDGPSPort

This command is used to control Serial Port B which is an input-only serial port used to receive RTCM differential corrections. Differential receivers may output corrections using different communication parameters. The default communication parameters for PORT B are 9600 baud, 8 data bits, stop bit, and no parity. If a DGPS receiver is used which has different communication parameters, use this command to allow the receiver to correctly decode the data. When a valid message is received, the parameters are stored in battery-backed SRAM and then the receiver restarts using the saved parameters.
Table D.14 contains the input values for the following example:
Set DGPS Port to be 9600,8,N,1.

```
$PSRF102,9600,8,1,0*3C
```

Name	Example	Units	Description
Message ID	$PSRF102		PSRF102 protocol header
Baud	9600		4800, 9600, 19200, 38400
DataBits	8		8,7
StopBits	1		0,1
Parity	0		0=None, 1=Odd, 2=Even
Checksum	*3C		
CR LF			End of message termination

Table D.14: Set DGPS Port Data Format

D.3.6 Query/Rate Control

This command is used to control the output of standard NMEA messages GGA, GLL, GSA, GSV, RMC, and VTG. Using this command message, standard NMEA messages may be polled once, or setup for periodic output. Checksums may also be enabled or disabled depending on the needs of the receiving program. NMEA message settings are saved in battery-backed memory for each entry when the message is accepted. Table D.15 contains the input values for the following examples:
Query the GGA message with checksum enabled

```
$PSRF103,00,01,00,01*25
```

Enable VTG message for a 1 Hz constant output with checksum enabled

```
$PSRF103,05,00,01,01*20
```

Disable VTG message

```
$PSRF103,05,00,00,01*21
```

Name	Example	Units	Description
Message ID	$PSRF103		PSRF103 protocol header
Msg	00		See D.16
Mode	01		0=SetRate, 1=Query
Rate	00	seconds	Output–off=0, max=255
CksumEnable	01		0=Disable Checksum, 1=Enable Checksum
Checksum	*25		
CR LF			End of message termination

Table D.15: Query/Rate Control Data Format (See example 1.)

Value	Description
0	GGA
1	GLL
2	GSA
3	GSV
4	RMC
5	VTG

Table D.16: Messages Query/Rate

Note – *In Trickle Power mode, update rate is specified by the user. When you switch to NMEA protocol, message update rate is also required. The resulting update rate is the product of the Trickle Power Update rate AND the NMEA update rate (i.e. Trickle Power update rate = 2 seconds, NMEA update rate = 5 seconds, resulting update rate is every 10 seconds, (2 X 5 = 10)).*

D.3.7 LLANavigationInitialization

This command is used to initialize the module for a warm start, by providing current position (in latitude, longitude, and altitude coordinates), clock offset, and time. This enables the receiver to search for the correct satellite signals at the correct signal parameters. Correct initialization parameters enable the receiver to acquire signals quickly.

Table D.17 contains the input values for the following example:

Start using known position and time.

```
$PSRF104,37.3875111,-121.97232,0,95000,237759,922,12,3*3A
```

Name	Example	Units	Description
Message ID	$PSRF104		PSRF104 protocol header
Lat	37.3875111	degrees	Latitude position (Range 90 to -90)
Lon	-121.97232	degrees	Longitude position (Range 180 to -180)
Alt	0	meters	Altitude position
ClkOffset	95000	Hz	Clock Offset of the GPS receiver[a]
TimeOfWeek	237759	seconds	GPS Time Of Week
WeekNo	922		GPS Week Number
ChannelCount	12		Range 1 to 12
ResetCfg	3		See D.18
Checksum	*3A		
CR LF			End of message termination

Table D.17: LLA Navigation Initialization Data Format

[a]Use 0 for last stored value. If this is not available, a factory programmed default will be used.

Hex	Description
0x01	Data Valid–Warm/Hot Starts=1
0x02	Clear Ephemeris–Warm Start=1
0x04	Clear Memory–Cold Start=1

Table D.18: Reset Configuration

D.3.8 Development Data On/Off

Use this command to enable development data information if you are having trouble getting commands accepted. Invalid commands generate debug information that enables the user to determine the source of the command rejection. Common reasons for input command rejection are invalid checksum or parameter out of specified range.
Table D.19 contains the input values for the following examples:
Debug On

```
$PSRF105,1*3E
```

Debug Off

```
$PSRF105,0*3F
```

Name	Example	Units	Description
Message ID	$PSRF105		PSRF105 protocol header
Debug	1		0=Off, 1=On
Checksum	*3E		
CR LF			End of message termination

Table D.19: Development Data On/Off Data Format

Appendix E

Datum Transformations of GPS Positions

Contents

E.1 ECEF Coordinate System

The Cartesian coordinate frame of reference used in GPS is called Earth-Centered, Earth-Fixed (ECEF). ECEF uses three-dimensional XYZ coordinates (in meters) to describe the location of a GPS user or satellite. The term "Earth-Centered" comes from the fact that the origin of the axis (0,0,0) is located at the mass center of gravity (determined through years of tracking satellite trajectories). The term "Earth-Fixed" implies that the axes are fixed with respect to the earth (that is, they rotate with the earth). The Z-axis pierces the North Pole, and the XY-axis defines the equatorial plane. (Figure E.1)

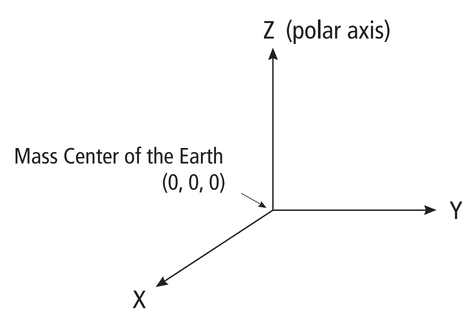
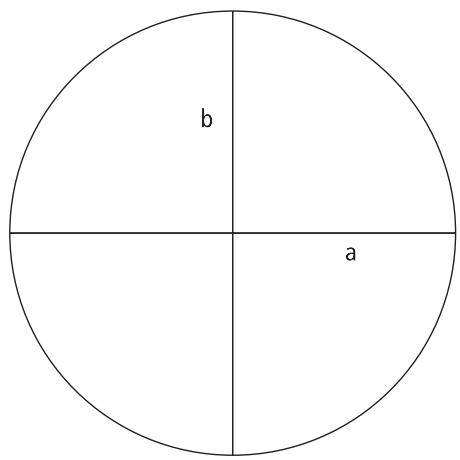


Figure E.1: ECEF Coordinate Reference Frame

ECEF coordinates are expressed in a reference system that is related to mapping representations. Because the earth has a complex shape, a simple, yet accurate, method to approximate the earth's shape is required. The use of a reference ellipsoid allows for the conversion of the ECEF coordinates to the more commonly used geodetic-mapping coordinates of Latitude, Longitude, and Altitude (LLA). Geodetic coordinates can then be converted to a second map reference known as Mercator Projections, where smaller regions are projected onto a flat mapping surface (that is, Universal Transverse Mercator – UTM or the USGS Grid system).

A reference ellipsoid can be described by a series of parameters that define its shape and which include a semi-major axis (a), a semi-minor axis (b) and its first eccentricity (e) and its second eccentricity (e') as shown in Figure E.2. Depending on the formulation used, ellipsoid flattening (f) may be required.



WGS84 Parameters

$$
\begin{aligned}
a &= 6378137 \\
b &= a\,(1-f) \\
  &= 6356752.31424518 \\
f &= \frac{1}{298.257223563} \\
e &= \sqrt{\frac{a^2-b^2}{a^2}} \\
e' &= \sqrt{\frac{a^2-b^2}{b^2}}
\end{aligned}
$$

Figure E.2: Ellipsoid Parameters

For global applications, the geodetic reference (datum) used for GPS is the World Geodetic System 1984 (WGS84). This ellipsoid has its origin coincident with the ECEF origin. The X-axis pierces the Greenwich meridian (where longitude = 0 degrees) and the XY plane make up the equatorial plane (latitude = 0 degrees). Altitude is described as the perpendicular distance above the ellipsoid surface (which not to be confused with the mean sea level datum).

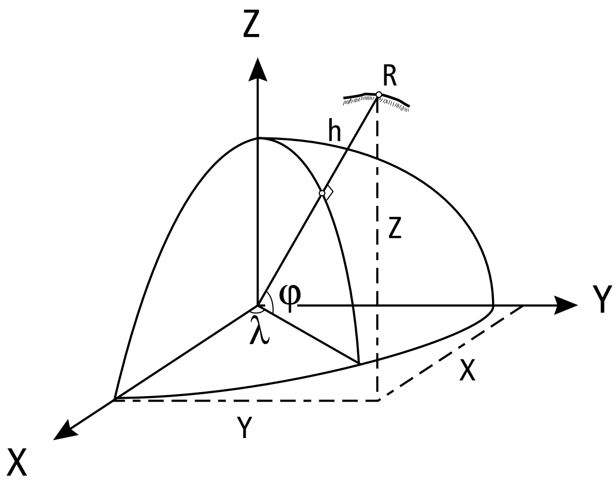


Figure E.3: ECEF and Reference Ellipsoid

E.2 Conversion between ECEF and Local Tangential Plane

E.2.1 LLA to ECEF

The conversion between the two reference coordinate systems can be performed using closed formulas (although iteration methods also exist). The conversion from LLA to ECEF (in meters) is shown below.

$$
\begin{aligned}
X &= (N+h)\cos\varphi\cos\lambda \\
Y &= (N+h)\cos\varphi\sin\lambda \\
Z &= (\frac{b^2}{a^2}N+h)\sin\varphi
\end{aligned}
$$

where

φ = latitude

λ = longitude

h = height above ellipsoid (meters)

N = Radius of Curvature (meters), defined as:

$$= \frac{a}{\sqrt{1-e^2\sin^2\varphi}}$$

E.2.2 ECEF to LLA

The conversion between XYZ and LLA is slightly more involved but can be achieved using one of the following methods:

By iteration for φ and h. There is quick convergence for $h \ll N$ starting at $h_0 = 0$.

$$\lambda = \arctan\frac{Y}{X}$$

$$
\begin{aligned}
&\text{Start with } h_0 = 0 \\
\varphi_0 &= \arctan \frac{Z}{p\,(1-e^2)} \\
&\text{Iterate } \varphi \text{ and } h \\
N_i &= \frac{a}{\sqrt{1-e^2 \sin^2 \varphi_i}} \\
h_{i+1} &= \frac{p}{\cos \varphi_i} - N_i \\
\varphi_{i+1} &= \arctan \frac{Z}{p\left(1 - e^2 \frac{N_i}{N_i + h_{i+1}}\right)}
\end{aligned}
$$

Or by closed formula set.

$$
\begin{aligned}
\lambda &= \arctan \frac{Y}{X} \\
\varphi &= \arctan \frac{Z + e'^2 b \sin^3 \theta}{p - e^2 a \cos^3 \theta} \\
h &= \frac{p}{\cos \varphi} - N
\end{aligned}
$$

Where auxiliary values are:

$$
\begin{aligned}
p &= \sqrt{X^2 + Y^2} \\
\theta &= \arctan \frac{Za}{pb}
\end{aligned}
$$

E.2.3 GPS Heights

The height determined by GPS measurements relates to the perpendicular distance above the reference ellipsoid and should not be confused with the more well-known height datum Mean Sea Level (MSL). The datum that defines the MSL (also called the geoid) is a complex surface that requires dense and accurate gravity data to define its shape. The WGS84 ellipsoid approximates the geoid on a worldwide basis with deviations between the two datums never exceeding 100 meters. The transformation between the two surfaces is illustrated in Figure E.4.
The conversion between the two reference datums is shown by:

$$
h = H + N
$$

where h = ellipsoidal height (Geodetic), H = orthometric height (MSL), N = geoid separation (undulation) and ε = deflection of the vertical.

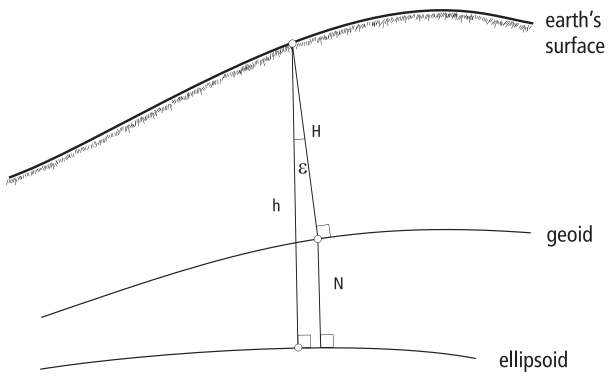


Figure E.4: Ellipsoid and MSL Reference Datums

Note – *The ellipsoid/geoid separation ranges from a value of +100 meters to -100 meters.*

Although the conversion between the different height datums is straightforward, the accuracy at which the undulation is known (N) varies greatly with gravity measurement data density. It is even more difficult to determine in mountainous regions where mass distribution can vary rapidly.

E.2.4 Converting ECEF Velocities to Local Tangent Plane Velocities

GPS also resolves the speed and direction of travel in the ECEF XYZ reference frame. To convert these values to a local tangent plane (LTP), the velocity vector must be rotated to reflect directions in terms more usable to the user. The LTP uses the orientation of North, East, and Down, which is consistent with the geodetic coordinates LLA. To transform the velocity vector, you use the following direction cosine matrix (North, East, Down) and solving for each component results in the following equations:

$$\begin{aligned}
V_{north} &= -V_x \sin\varphi\cos\lambda - V_y \sin\varphi\sin\lambda + V_z cos\varphi \\
V_{east} &= -V_x \sin\lambda + V_y \cos\lambda \\
V_{down} &= -V_x \cos\varphi\cos\lambda - V_y \cos\varphi\sin\lambda - V_z \sin\varphi
\end{aligned}$$

E.2.5 Speed and Heading Computations

The speed and heading data can be derived from the velocity information. Because we have already transformed the velocity vector into the local frame of east, north, and down, out speed and velocity are also in the local frame.

$$
\begin{aligned}
Speed &= \sqrt{V_{north}^2 + V_{east}^2} \\
Heading &= \arctan \frac{V_{east}}{V_{north}}
\end{aligned}
$$

Note – *The C programming function* `atan2` *returns a value between* π *and* $-\pi$ *(+180 and -180 degrees). If the value is negative then* 2π *(360 degrees) must be added to the results to get a positive full circle value. The heading is generally denoted in degrees as a full-circle azimuth ranging from 0 – 360 degrees (i.e., north = 0 degrees, south = 180 degrees).*

E.3 Transformation to Other Reference Datums

Many reference ellipsoids are used throughout the world. The main reason for choosing a reference datum other than WGS84 is to minimize the local differences between the geoid and the ellipsoid separation or other mapping distortions. Table E.1 lists several of the reference ellipsoids in use worldwide and their associated parameters.

Name	a	b	1/f
Airy	6377563.396	6356256.909	299.324965
Airy (Modified)	6377340.189	6356034.448	299.324965
Australian National	6378160.000	6356774.719	298.250000
Bessel 1841	6377397.155	6356078.963	299.152813
Bessel 1841 (Namibia)	6377483.865	6356165.383	299.152813
Clarke 1866	6378206.400	6356583.800	294.978698
Clarke 1880	6378249.145	6356514.870	293.465000
Everest (Sabah & Sarawak)	6377298.556	6356097.550	300.801700
Everest 1830	6377276.345	6356075.413	300.801700
Everest 1948	6377304.063	6356103.039	300.801700
Everest 1956	6377301.243	6356100.228	300.801700
Everest 1969	6377295.664	6356094.668	300.801700
Fischer 1960	6378166.000	6356784.284	298.300000
Fischer 1960 (Modified)	6378155.000	6356773.320	298.300000
Fischer 1968	6378150.000	6356768.337	298.300000
GRS 1980	6378137.000	6356752.314	298.257222
Helmert 1906	6378200.000	6356818.170	298.300000
Hough	6378270.000	6356794.343	297.000000
International	6378388.000	6356911.946	297.000000
Krassovsky	6378245.000	6356863.019	298.300000
SGS 85	6378136.000	6356751.302	298.257000
South American 1969	6378160.000	6356774.719	298.250000
WGS 60	6378165.000	6356783.287	298.300000
WGS 66	6378145.000	6356759.769	298.250000
WGS 72	6378135.000	6356750.520	298.260000
WGS 84	6378137.000	6356752.314	298.257224

Reference: DoD, WGS84, DMA TR 8350.2-B,1 Sept. 1991

Table E.1: Commonly Used Ellipsoids

E.3.1 Datum Translations

Many other datums worldwide use the ellipsoid parameters shown in Table E-1 but do not have the same origin (that is, the centre of the ellipsoid does not coincide with the defined ECEF XYZ origin at the mass center of the earth). This creates a translation of the XYZ which must be performed prior to computing the geodetic positions and velocities. Table E-2 contains a list of datums, their associated ellipsoid, and the XYZ translation between the ECEF origin and the center of the ellipsoid.
To convert the ECEF coordinates to a geodetic datum, the translation vector must be applied prior to converting the LLA of the selected datum. The formulation for this conversion is shown in the following formulas.
To translate between two datums A $\Rightarrow$ B in ECEF :

$$X_{datum_B} = X_{datum_A} - D_{X,AB}$$

$$
\begin{aligned}
Y_{datum_B} &= Y_{datum_A} - D_{Y,AB} \\
Z_{datum_B} &= Z_{datum_A} - D_{Z,AB}
\end{aligned}
$$

Note – *The Dx, Dy, and Dz values shown in Table E.2 are defined as* from *any datum* to *ECEF.*

Example: Translate from WGS84 (datum A) to Tokyo-Korea (datum B)

1. Identify the Tokyo-Korea datum in Table E.2
   Reference ellipsoid is Bessel 1841 (a = 6377397.155, b = 6356078.963)
   XYZ Translation (Dx = 146, Dy = 507, Dz = 685)
2. Give an ECEF coordinate X = 2686727, Y = -4304285, Z = 3851643

$$
\begin{aligned}
X_{Tokyo-Korea} &= -2686727 - (-146) = -2686581 \\
Y_{Tokyo-Korea} &= -4304285 - (507) = -4304792 \\
Z_{Tokyo-Korea} &= 3851643 - (685) = 3850958
\end{aligned}
$$

3. Convert to LLA using Bessel 1841 ellipsoid parameters.

E.3.2 Common Datum Shift Parameters

Datum	Reference Ellipsoid	D_x	D_y	D_z
Adindan - Burkina Faso	Clarke 1880	-118	-14	218
Adindan - Ethiopia	Clarke 1880	-165	-11	206
Adindan - Ethiopia, Sudan	Clarke 1880	-166	-15	204
Adindan - Mali	Clarke 1880	-123	-20	220
Adindan - Regional Mean	Clarke 1880	-166	-15	204
Adindan - Senegal	Clarke 1880	-128	-18	224
Adindan - Sudan	Clarke 1880	-161	-14	205
Adindan - Cameroon	Clarke 1880	-134	-2	210
Afgooye - Somalia	Krassovsky	-43	-163	45
Ain el Abd 1970 - Bahrain	International	-150	-251	-2
Ain el Abd 1970 - Saudi Arabia	International	-143	-236	7
American Samoa 1962 - Samoa Islands	Clarke 1866	-115	118	426
Anna 1 Astro 1965 - Cocos Islands	Australian National	-491	-22	435
Antigua Island Astro 1965 - Leward Islands	Clarke 1880	-270	13	62
Arc 1950 - Botswana	Clarke 1880	-138	-105	-289
Arc 1950 - Burundi	Clarke 1880	-153	-5	-292

continued on next page

Datum	Reference Ellipsoid	D_x	D_y	D_z
Arc 1950 - Lesotho	Clarke 1880	-125	-108	-295
Arc 1950 - Malawi	Clarke 1880	-161	-73	-317
Arc 1950 - Regional Mean	Clarke 1880	-143	-90	-294
Arc 1950 - Swaziland	Clarke 1880	-134	-105	-295
Arc 1950 - Zaire	Clarke 1880	-169	-19	-278
Arc 1950 - Zambia	Clarke 1880	-147	-74	-283
Arc 1950 - Zimbabwe	Clarke 1880	-142	-96	-293
Arc 1960 - Kenya	Clarke 1880	-157	-2	-299
Arc 1960 - Kenya, Tanzania	Clarke 1880	-160	-6	-302
Arc 1960 - Tanzania	Clarke 1880	-175	-23	-303
Ascension Island 1958	International	-191	103	51
Astro Beacon E 1945 - Iwo Jima	International	145	75	-272
Astro DOS 71/4 St Helena Island	International	-320	550	-494
Astro Tern Island (FRIG) 1961	International	114	-116	-333
Astronomical Station 1952 - Marcus Island	International	124	-234	-25
Australian Geodetic 1966	Australian National	-133	-48	148
Australian Geodetic 1984	Australian National	-134	-48	149
Ayabelle Lighthouse - Djibouti	Clarke 1880	-79	-129	145
Bellevue (IGN)	International	-127	-769	472
Bermuda 1957 Bermuda	Clarke 1866	-73	213	296
Bissau - Guinea-Bissu	International	-173	253	27
Bogota Observatory - Colombia	International	307	304	-318
Bukit Rimpah Indonesia	Bessel 1841	-384	664	-48
Camp Area Astro - Antarctica	International	-104	-129	239
Campo Inchauspe - Argentina	International	-148	136	90
Canton Astro 1966 - Phoenix Islands	International	298	304	-375
Cap - South Africa	Clarke 1880	-136	108	-292
Cape Canaveral - Bahamas, Florida	Clarke 1866	-2	151	181
Carthage Tunisia	Clarke 1880	-263	6	431
Chatham Island Astro 1971 - New Zealand	International	175	-38	113
Chua Astro Paraguay	International	-134	229	-29
Corrego Alegre Brazil	International	-206	172	-6
Dabola Guinea	Clarke 1880	-83	37	124
Deception Island - Deception Island	Clarke 1880	260	12	-147
Djakarta (Batavia)	Bessel 1841	-377	681	-50
DOS 1968 - New Georgia Islands	International	230	-199	-752
Easter Island 1967 - Easter Island	International	211	147	111
Estonia Coordinate System 1937	Bessel 1841	374	150	588
European 1950 - Cyprus	International	-104	-101	-140
European 1950 - Eastern Regional Mean	International	-87	-96	-120
European 1950 - Egypt	International	-130	-117	-151
European 1950 - Finland, Norway	International	-87	-95	-120
European 1950 - Greece	International	-84	-95	-130
European 1950 - Iran	International	-117	-132	-164
European 1950 - Italy (Sardinia)	International	-97	-103	-120
European 1950 - Italy (Sicily)	International	-97	-88	-135

continued on next page

Datum	Reference Ellipsoid	D_x	D_y	D_z
European 1950 - Malta	International	-107	-88	-149
European 1950 - Northern Regional Mean	International	-86	-96	-120
European 1950 - Portugal, Spain	International	-84	-107	-120
European 1950 - Southern Regional Mean	International	-103	-106	-141
European 1950 - Tunisia	International	-112	-77	-145
European 1950 - Western Regional Mean	International	-87	-98	-121
European 1979 - Central Regional Mean	International	-86	-98	-119
Fort Thomas 1955 - Nevis, St Kitts	Clarke 1880	-7	215	225
Gan 1970 - Republic of Maldives	International	-133	-321	50
Geodetic Datum 1949 - New Zealand	International	84	-22	209
Graciosa Base SW 1948 - Azores	International	-104	167	-38
Guam 1963 - Guam	Clarke 1866	-100	-248	259
Gunung Segara - Indonesia	Bessel 1841	-403	684	41
GUX 1 Astro - Guadalcanal Island	International	252	-209	-751
Herat North - Afganistan	International	-333	-222	114
Hermannskogel Datum - Croatia, Serbia	Bessel 1841	653	-212	449
Hjorsey 1955 - Iceland	International	-73	46	-86
Hong Kong 1963 - Hong Kong	International	-156	-271	-189
Hu-Tsu-Shan - Taiwan	International	-637	-549	-203
Indian - Bangladesh	Everest 1830	282	726	254
Indian - India, Nepal	Everest 1956	295	736	257
Indian - Pakistan	Everest (Pakistan)	283	682	231
Indian 1954 - Thailand, Vietnam	Everest 1830	218	816	297
Indian 1960 -	Everest 1830	198	881	317
Indian 1960 - Vietnam (Con Son Islands)	Everest 1830	182	915	344
Indian 1975 - Thailand	Everest 1830	209	818	290
Indonesian 1974 - Indonesia	Indonesian 1974	-24	-15	5
Ireland 1965 - Ireland	Modified Airy	506	-122	611
ISTS 061 Astro 1968 - South Georgia Islands	International	-794	119	-298
ISTS 073 Astro 1969 - Diego Garcia	International	208	-435	-229
Johnston Island 1961 -Johnston Island	International	189	-79	-202
Kandawala - Sri Lanka	Everest 1830	-97	787	86
Kerguelen Island 1949	International	145	-187	103
Kertau 1948 - West Malaysia & Singapore	Everest 1948	-11	851	5
Korean Geodetic System - South Korea	GRS 1980	0	0	0
Kusaie Astro 1951 - Caroline Islands	International	647	1777	-1124
L. C. 5 Astro 1961 - Cayman Brac Islands	Clarke 1866	42	124	147
Legion - Ghana	Clarke 1880	-130	29	364
Liberia 1964 - Liberia	Clarke 1880	-90	40	88
Luzon - Philippines	Clarke 1866	-133	-77	-51
Luzon - Philippines (Mindanao)	Clarke 1866	-133	-79	-72
Mahe 1971 - Mahe Island	Clarke 1880	41	-220	-134
Massawa - Ethiopia (Eritrea)	Bessel 1841	639	405	60
Merchich - Morocco	Clarke 1880	31	146	47
Midway Astro 1961 - Midway Islands	International	912	-58	122
7 Minna - Cameroon	Clarke 1880	-81	-84	115

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Datum	Reference Ellipsoid	D_x	D_y	D_z
Minna - Nigeria	Clarke 1880	-92	-93	122
Montserrat Island Astro 1958	Clarke 1880	174	359	365
M'Poraloko - Gabon	Clarke 1880	-74	-130	42
Nahrwan - Oman (Masirah Island)	Clarke 1880	-247	-148	369
Nahrwan - Saudi Arabia	Clarke 1880	-243	-192	477
Nahrwan - United Arab Emirates	Clarke 1880	-249	-156	381
Naparima BWI - Trinidad & Tobago	International	-10	375	165
North American 1927 - Alaska	Clarke 1866	-5	135	172
North American 1927 - Alaska (Aleutian Islands E)	Clarke 1866	-2	152	149
North American 1927 - Alaska (Aleutian Islands W)	Clarke 1866	2	204	105
North American 1927 - Bahamas	Clarke 1866	-4	154	178
North American 1927 - Bahamas (San Salvador)	Clarke 1866	1	140	165
North American 1927 - Canada (Yukon)	Clarke 1866	-7	139	181
North American 1927 - Canal Zone	Clarke 1866	0	125	201
North American 1927 - Central America	Clarke 1866	0	125	194
North American 1927 - Central Canada	Clarke 1866	-9	157	184
North American 1927 - Cuba	Clarke 1866	-9	152	178
North American 1927 - East Canada	Clarke 1866	-22	160	190
North American 1927 - East of Mississippi	Clarke 1866	-9	161	179
North American 1927 - Greenland	Clarke 1866	11	114	195
North American 1927 - Gulf of Mexico	Clarke 1866	-3	142	183
North American 1927 - Mean for Canada	Clarke 1866	-10	158	187
North American 1927 - Mean for Conus	Clarke 1866	-8	160	176
North American 1927 - Mexico	Clarke 1866	-12	130	190
North American 1927 - Northwest Canada	Clarke 1866	4	159	188
North American 1927 - West Canada	Clarke 1866	-7	162	188
North American 1927 - West of Mississippi	Clarke 1866	-8	159	175
North American 1983 - Alaska, Canada, Conus	GRS 1980	0	0	0
North American 1983 - Aleutian Islands	GRS 1980	-2	0	4
North American 1983 - Central America, Mexico	GRS 1980	0	0	0
North American 1983 - Hawaii	GRS 1980	1	1	-1
North Sahara - Algeria	Clarke 1880	-186	-93	310
Observatorio Metereo 1939 - Azores	International	-425	-169	81
Old Egyptian 1907 - Egypt	Helmert 1906	-130	110	-13
Old Hawaiian - Hawaii	Clarke 1866	89	-279	-183
Old Hawaiian - Kauai	Clarke 1866	45	-290	-172
Old Hawaiian - Maui	Clarke 1866	65	-290	-190
Old Hawaiian - Oahu	Clarke 1866	58	-283	-182
Old Hawaiian - Regional Mean	Clarke 1866	61	-285	-181
Oman - Oman	Clarke 1880	-346	-1	224
Ord. Survey G. Britain 1936 - England	Airy	371	-112	434
Ord. Survey G. Britain 1936 - Isle of Man	Airy	371	-111	434
Ord. Survey G. Britain 1936 - Regional Mean	Airy	375	-111	431
Ord. Survey G. Britain 1936 - Scotland, Shetland	Airy	384	-111	425
Ord. Survey G. Britain 1936 - Wales	Airy	370	-108	434
Pico de las Nieves - Canary Islands	International	-307	-92	127

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Datum	Reference Ellipsoid	D_x	D_y	D_z
Pitcairn Astro 1967 - Pitcairn Island	International	185	165	42
Point 58 - Mean for Burkina Faso & Niger	Clarke 1880	-106	-129	165
Pointe Noire 1948 - Congo	Clarke 1880	-148	51	-291
Porto Santo 1936 - Maderia Islands	International	-499	-249	314
Provisional S. American 1956 - Bolivia	International	-270	188	-388
Provisional S. American 1956 - Chile (Northern)	International	-270	183	-390
Provisional S. American 1956 - Chile (Southern)	International	-305	243	-442
Provisional S. American 1956 - Colombia	International	-282	169	-371
Provisional S. American 1956 - Ecuador	International	-278	171	-367
Provisional S. American 1956 - Guyana	International	-298	159	-369
Provisional S. American 1956 - Peru	International	-279	175	-379
Provisional S. American 1956 - Regional Mean	International	-288	175	-376
Provisional S. American 1956 - Venezuela	International	-295	173	-371
Provisional S. Chilean 1963 - Chile	International	16	196	93
Puerto Rico - Virgin Islands	Clarke 1866	11	72	-101
Pulkovo 1942 - Russia	Krassovsky 1940	28	-130	-95
Qatar National - Qatar	International	-128	-283	22
Qornoq - Greenland (South)	International	164	138	-189
Reunion - Mascarene Islands	International	94	-948	-1262
Rome 1940 - Italy (Sardinia)	International	-225	-65	9
S-42 (Pulkovo 1942) - Albania	Krassovsky 1940	24	-130	-92
S-42 (Pulkovo 1942) - Czechoslovakia	Krassovsky 1940	26	-121	-78
S-42 (Pulkovo 1942) - Hungary	Krassovsky 1940	28	-121	-77
S-42 (Pulkovo 1942) - Kazakhstan	Krassovsky 1940	15	-130	-84
S-42 (Pulkovo 1942) - Latvia	Krassovsky 1940	24	-124	-82
S-42 (Pulkovo 1942) - Poland	Krassovsky 1940	23	-124	-82
S-42 (Pulkovo 1942) - Romania	Krassovsky 1940	28	-121	-77
Santo (DOS) 1965 - Espirito Santo Island	International	170	42	84
Sao Braz - Azores	International	-203	141	53
Sapper Hill 1943 - East Falkland Island	International	-355	21	72
Schwarzeck - Namibia	Bessel 1841 (Namibia)	616	97	-251
Selvagem Grande - Salvage Islands	International	-289	-124	60
SGS 85 - Soviet Geodetic system 1985	S85	3	9	-9
Sierra Leone 1960 - Sierra Leone	Clarke 1880	-88	4	101
S-JTSK - Czechoslovakia (prior to Jan 1993)	Bessel 1841	589	76	480
South American 1969 - Argentina	South American 1969	-62	-1	-37
South American 1969 - Bolivia	South American 1969	-61	2	-48
South American 1969 - Brazil	South American 1969	-60	-2	-41
South American 1969 - Chile	South American 1969	-75	-1	-44
South American 1969 - Colombia	South American 1969	-44	6	-36
South American 1969 - Ecuador	South American 1969	-48	3	-44
South American 1969 - Ecuador (Baltra, Galapagos)	South American 1969	-47	27	-42
South American 1969 - Guyana	South American 1969	-53	3	-47
South American 1969 - Paraguay	South American 1969	-61	2	-33
South American 1969 - Peru	South American 1969	-58	0	-44
South American 1969 - Regional Mean	South American 1969	-57	1	-41

continued on next page

Datum	Reference Ellipsoid	D_x	D_y	D_z
South American 1969 - Trinidad & Tobago	South American 1969	-45	12	-33
South American 1969 - Venezuela	South American 1969	-45	8	-33
South Asia - Singapore	Modified Fischer 1960	7	-10	-26
Tananarive Observatory 1925 - Madagascar	International	-189	-242	-91
Timbalai 1948 - Brunei, East Malaysia	Everest (Sabah, Sarawak)	-679	669	-48
Tokyo - Japan	Bessel 1841	-148	507	685
Tokyo - Korea	Bessel 1841	-146	507	687
Tokyo Okinawa	Bessel 1841	-158	507	676
Tokyo - Regional Mean	Bessel 1841	-148	507	685
Tokyo - South Korea	Bessel 1841	-147	506	687
Tristan Astro 1968 - Tristan da Cunha	International	-632	438	-609
Viti Levu Fiji	Clarke 1880	51	391	-36
Voirol 1960 Algeria	Clarke 1880	-123	-206	219
Wake Island Astro 1952 - Wake Atoll	International	276	-57	149
Wake-Eniwetok 1960 - Marshall Islands	Hough	102	52	-38
WGS 1972 Global Definition	WGS 72	0	0	0
WGS 1984 Global Definition	WGS 84	0	0	0
Yacare Uruguay	International	-155	171	37
Zanderij Suriname	International	-265	120	-358

Table E.2: Translation Components for Selected Reference Datums

Appendix F

Acronyms, Abbreviations, and Glossary

This appendix describes acronyms, abbreviations, and selected terms used in this document.

2-D	Two dimensional.
3-D	Three dimensional.
50BPS	50 Bit per second. The usable data stream coming from an SV
A/D	Analog to Digital.
Almanac	A set of orbital parameters that allows calculation of the approximate GPS satellite positions and velocities. A GPS receiver uses the almanac as an aid to determine satellite visibility during acquisition of GPS satellite signals. The almanac is a subset of satellite ephemeris data and is updated weekly by GPS Control.
Altitude	The distance between the current position and the nearest point on WGS84 reference ellipsoid. Altitude is usually expressed in meters and is positive outside the ellipsoid. In terms of the GPS-E1 Evaluation Unit, this has no bearing on the height above mean sea level (which depends on the time and place, due to gravity of Sun, Moon, etc.). Determining height with respect to mean sea level requires making appropriate corrections to the altitude computed by the GPS-E1 Evaluation Unit.

Altitude Hold	A technique that allows navigation using measurements from three GPS satellites plus an independently obtained value of altitude.
Altitude Hold Mode	A Navigation Mode during which a value of altitude is processed by the Kalman Filter as if it were a range measurement from a satellite at the Earth's center (WGS-84 reference ellipsoid center).
Baud	(See Bps.)
Bps	Bits per second (also referred to as a baud rate).
C/A Code	Coarse/Acquisition Code. A spread spectrum direct sequence code that is used primarily by commercial GPS receivers to determine the range to the transmitting GPS satellite.
CEP	Circular Error Probable. The radius of a circle, centered at the user's true location, that contains 50 percent of the individual position measurement made using a particular navigation system.
Clock Error	The uncompensated difference between synchronous GPS system time and time best known within the GPS receiver.
C/No	Carrier-to-Noise density ratio.
Cold Start	A condition in which the GPS receiver can arrive at a navigation solution without initial position, time, current Ephemeris, and almanac data.
Control Segment	The Master Control Station and the globally dispersed Monitor Stations used to manage the GPS satellites, determine their precise orbital parameters, and synchronize their clocks.
dB	Decibel.
dBiC	Decibel-Isometric-Circular (measure of power relative to an isometric antenna with circular polarization).
dBm	Decibels per milliwatt.
dBW	Decibel-Watt (measure of power relative to one watt).
DC	Direct Current.

DGPS	Differential GPS. A technique to improve GPS accuracy that uses pseudorange errors recorded at known locations to improve the measurements made by other GPS receivers within the same general geographic area.
Doppler Aiding	A signal processing strategy that uses a measured doppler shift to help a receiver smoothly track a GPS signal to allow a more precise velocity and position measurement.
DoD	Department of Defense.
DOP	Dilution of Precision (see GDOP, HDOP, PDOP, TDOP, and VDOP).
DSP	Digital Signal Processor.
DTR	Data Terminal Ready.
ECEF	Earth-Centered Earth-Fixed. A Cartesian coordinate system with its origin located at the center of the Earth. The coordinate system used by GPS to describe 3-D location. For the WGS-84 reference ellipsoid, ECEF coordinates have the Z-axis aligned with the Earth's spin axis, the X-axis through the intersection of the Prime Meridian and the Equator and the Y-axis is rotated 90 degrees East of the X-axis about the Z-axis.
EEPROM	Electrically Erasable Programmable Read Only Memory.
EHPE	Expected Horizontal Position Error.
EMC	Electromagnetic Compatibility.
EMI	Electromagnetic Interference.
Ephemeris	A set of satellite orbital parameters that is used by a GPS receiver to calculate precise GPS satellite positions and velocities. The ephemeris is used to determine the navigation solution and is updated frequently to maintain the accuracy of GPS receivers.
EPROM	Erasable Programmable Read Only Memory.
EVPE	Expected Vertical Position Error.
FP	Floating-Point mathematics, as opposed to fixed point.

FRP	Federal Radionavigation Plan. The U.S. Government document that contains the official policy on the commercial use of GPS.
GaAs	Gallium Arsenide, a semiconductor material.
GDOP	Geometric Dilution of Precision. A factor used to describe the effect of the satellite geometry on the position and time accuracy of the GPS receiver solution. The lower the value of the GDOP parameter, the less the errors in the position solution. Related indicators include PDOP, HDOP, TDOP, and VDOP.
GMT	Greenwich Mean Time.
GPS	Global Positioning System. A space-based radio positioning system that provides suitably equipped users with accurate position, velocity, and time data. GPS provides this data free of direct user charge worldwide, continuously, and under all weather conditions. The GPS constellation consists of 24 orbiting satellites, four equally spaced around each of six different orbital planes. The system is developed by the DoD under Air Force management, primarily for military purposes, but current policy calls for civil availability with degradation in system accuracy to protect U.S. national security interests.
GPS Time	The number of seconds since Saturday/Sunday Midnight UTC, with time zero being this midnight. Used with GPS Week Number to determine a specific point in GPS time.
HDOP	Horizontal Dilution of Precision. A measure of how much the geometry of the satellites affects the position estimate (computed from the satellite range measurements) in the horizontal (East, North) plane.
Held Altitude	The altitude value that will be sent to the Kalman filter as a measurement when in Altitude Hold Mode. It is an Auto Hold Altitude unless an Amended Altitude is supplied by the application processor.
Hot Start	Start mode of the GPS receiver when current position, clock offset, approximate GPS time and current ephemeris data are all available.
Hz	Hertz, a unit of frequency.
I/O	Input/ Output.

IF	Intermediate Frequency.
IGRF	International Geomagnetic Reference Field.
IODE	Issue of Data Ephemeris.
JPO	Joint Program Office. An office within the U.S. Air Force Systems Command, Space Systems Division. The JPO is responsible of managing the development and production aspect of the GPS system and is staffed by representatives from each branch of the U.S. military, the U.S. Department of transportation, Defense Mapping Agency, NATO member nations, and Australia.
Kalman Filter	Sequential estimation filter which combines measurements of satellite range and range rate to determine the position, velocity, and time at the GPS receiver antenna.
L1 Band	The 1575.42 MHz GPS carrier frequency which contains the C/A code, P-code, and navigation messages used by commercial GPS receivers.
L2 Band	A secondary GPS carrier, containing only P-code, used primarily to calculate signal delays caused by the atmosphere. The L2 frequency is 1227.60 MHz.
Latitude	Halfway between the poles lies the equator. Latitude is the angular measurement of a place expressed in degrees north or south of the equator. Latitude runs from 0°at the equator to 90°N or 90°S at the poles. When not prefixed with letters N or S, it is assumed positive north of Equator and negative south of Equator. Lines of latitude run in an east-west direction. They are called parallels.
LLA	Latitude, Longitude, Altitude geographical coordinate system used for locating places on the surface of the Earth. Latitude and longitude are angular measurements, expressed as degrees of a circle measured from the center of the Earth. The Earth spins on its axis, which intersects the surface at the north and south poles. The poles are the natural starting place for the graticule, a spherical grid of latitude and longitude lines. See also Altitude.
Longitude	Lines of longitude, called meridians, run in a north-south direction from pole to pole. Longitude is the angular measurement of a place east or west of the prime meridian. This meridian is also known as the Greenwich Meridian, because it runs through the original site of the Royal Observatory, which was located at Greenwich, just outside London, England. Longitude runs from 0°at the prime meridian to 180°east or west, halfway around the globe. When not prefixed with letters E or W, it is assumed positive east of Greenwich and negative west of Greenwich. The International Date Line follows the 180°meridian, making a few jogs to avoid cutting through land areas.

LPTS	Low Power Time Source.
LSB	Least Significant Bit of a binary word.
LTP	Local Tangent Plane coordinate system. The coordinates are supplied in a North, East, Down sense. The North will be in degrees or radians, East in same units and Down will be height below WGS84 ellipsoid in meters.
m/sec	Meters per second (unit of velocity).
m/sec/sec	Meters per second per second (unit of acceleration).
m/sec/sec/sec	Meters per second per second per second (unit of impulse or jerk).
Mask Angle	The minimum GPS satellite elevation angle permitted by a particular GPS receiver design.
Measurement	The square of the standard deviation of a measurement quality. The standard deviation Error Variance is representative of the error typically expected in a measured value of the quantity.
MID	Message Identifier. In case of SiRF protocol, it is a number between 1 and 256.
MHz	Megahertz, a unit of frequency.
MSB	Most Significant Bit within a binary word or a byte.
MSL	Mean Sea Level.
MTBF	Mean Time Between Failure.
Multipath Error	GPS positioning errors caused by the interaction of the GPS satellite signal and its reflections.
mV	Millivolt.
mW	Milliwatt.
NED	North, East, Down coordinate system. See LTP.
NF	Noise Factor.

NMEA	National Marine Electronic Association. Also commonly used to refer to Standard For Interfacing Marine Electronic Devices. μ-blox receivers support version 2.01 of standard NMEA 0183.
NVRAM	Non-volatile RAM, portion of the SRAM that is powered by a backup battery power supply when prime power is removed. It is used to preserve important data and allow faster entry into the Navigation Mode when prime power is restored. All of the SRAM in the μ-blox receiver is powered by the backup battery power supply (sometimes also referred to as keep-alive SRAM).
Obscuration	Term used to describe periods of time when a GPS receiver's line-of-sight to GPS satellites is blocked by natural or man-made objects.
OEM	Original Equipment Manufacturer.
Overdetermined Solution	The solution of a system of equations containing more equations than unknowns. The GPS receiver computers, when possible, an overdetermined solution using the measurements from five GPS satellites, instead of the four necessary for a three-dimensional position solution.
P-Code	Precision Code. A spread spectrum direct sequence code that is used primarily by military GPS receivers to determine the range to the transmitting GPS satellite.
Parallel Receiver	A receiver that monitors four or more satellites simultaneously. The μ-blox GPS-MS1 and GPS-PS1 can monitor up to 12 satellites simultaneously, thanks to the capabilities of the SiRF chipset it uses.
PDOP	Position Dilution of Precision. A measure of how much the error in the position estimate produced form satellite range measurements is amplified by a poor arrangement of the satellites with respect to the receiver antenna.
Pi	The mathematical constant having a value of approximately 3.14159.
P-P	Peak to Peak.
PPS	Precise Positioning Service. The GPS positioning, velocity, and time service which will be available on a continuous, worldwide basis to users authorized by the DoD.

PRN	Pseudorandom Noise Number. The identity of the GPS satellites as determined by a GPS receiver. Since all GPS satellites must transmit on the same frequency, they are distinguished by their pseudorandom noise codes.
Pseudorange	The calculated range form the GPS receiver to the satellite determined by measuring the phase shift of the PRN code received from the satellite with the internally generated PRN code from the receiver. Because of atmospheric and timing effects, this time is not exact. Therefore, it is called a pseudorange instead of a true range.
PVT	Position, Velocity, and Time.
RAM	Random Access Memory.
Receiver Channels	A GPS receiver specification which indicates the number of independent hardware signal processing channels included in the receiver design.
RF	Radio Frequency.
RFI	Radio Frequency Interference.
ROM	Read Only Memory.
RTCA	Radio Technical Commission of Aeronautics.
RTCM	Radio Technical Commission of Maritime Services. Also commonly used as a reference to the standard format that DGPS corrections data is distributed in (RTCM Recommended Standard for Differential Navstar GPS Service). SiRFstar receiver supports the latest Version 2.1 of this standard.
SA	Selective Availability. The method used by the DoD to control access to the full accuracy achievable with the C/A code.
Satellite Elevation	The angle of the satellite above the horizon.
SEP	Spherical Error Probable. The radius of a sphere, centered at the user's true location, that contain 50 percent of the individual 3-D position measurements made using a particular navigation system.
Sequential Receiver	A GPS receiver in which the number of satellite signals to be tracked exceeds the number of available hardware channels. Sequential receivers periodically reassign hardware channels to particular satellite signals in a predetermined sequence.

SNR — Signal-to-Noise Ratio, often expressed in decibels.

SPS — Standard Positioning Service. A position service available to all GPS users on a continuous, worldwide basis with no direct charge. SPS uses the C/A code to provide a minimum dynamic and static positioning capability.

SRAM — Static Random Access Memory. In context of this document, see also NVRAM.

SV — Satellite Vehicle.

TDOP — Time Dilution of Precision. A measure of how much the geometry of the satellites affects the time estimate computed from the satellite range measurements.

3-D Coverage — The number of hours-per-day with four or more satellites visible. Four visible satellites are required to determine location and altitude.

3-D Navigation — Navigation Mode in which altitude and horizontal position are determined from satellite range measurements.

TTFF — Time-To-First-Fix. The actual time required by a GPS receiver to achieve a position solution. This specification will vary with the operating state of the receiver, the length of time since the last position fix, the location of the last fix, and the specific receiver design. See also Hot Start, Warm Start and Cold Start mode descriptions.

2-D Coverage — The number of hours-per-day with three or more satellites visible. Three visible (hours) satellites can be used to determine location if the GPS receiver is designed to accept an external altitude input (Altitude Hold).

2-D Navigation — Navigation Mode in which a fixed value of altitude is used for one or more position calculations while horizontal (2-D) position can vary freely based on satellite range measurements.

UART — Universal Asynchronous Receiver/Transmitter that produces an electrical signal and timing for transmission of data over a communications path, and circuitry for detection and capture of such data transmitted from another UART.

UDRE — User Differential Range Error. A measure of error in range measurement to each satellite as seen by the receiver.

UERE	User Equivalent Range Error.
Update Rate	The GPS receiver specification which indicates the solution rate provided by the receiver when operating normally. It is typically once per second.
UTC	Universal Time Coordinated. This time system uses the second defined true angular rotation of the Earth measured as if the Earth rotated about its Conventional Terrestrial Pole. However, UTC is adjusted only in increments of one second. The time zone of UTC is that of Greenwich Mean Time (GMT).
VCO	Voltage Controlled Oscillator.
VDOP	Vertical Dilution of Precision. A measure of how much the geometry of the satellites affects the position estimate (computed from the satellite range measurements) in the vertical (perpendicular to the plane of the user) direction.
VSWR	Voltage Standing Wave Ratio.
Warm Start	Start mode of the GPS receiver when current position, clock offset and approximate GPS time are input by the user. Almanac is retained, but ephemeris data is cleared.
WGS-84	World Geodetic System (1984). A mathematical ellipsoid designed to fit the shape of the entire Earth. It is often used as a reference on a worldwide basis, while other ellipsoids are used locally to provide a better fit to Earth in a local region. GPS uses the center of the WGS-84 ellipsoid as the center of the GPS ECEF reference frame.

Table F.0:

List of Tables

List of Figures

This document contains information on a product under development at µ-blox AG. This information is intended to help you evaluate this product. µ-blox reserves the right to change or discontinue work on this product without notice.

Part Numer: GPSE-MN-06/99
Revision: 1.3.1

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