RFMD GPS Receiver Evaluation Kit

DK8000 User Manual

July 17, 2002

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1. General Information

1.1 Description

The RFMD Global Positioning System (GPS) Receiver evaluation kit is a tool set for testing the performance of the RFMD GPS receiver in customer applications. The kit can be used in both static and mobile test environments.

Note: This version (V3.3.7.0) of the RFMDgps evaluation tool is designed to operate with the RFMD GPS receivers (RF800x) running software versions V4.4.0 or later. DGPS capability is enabled in software versions V4.5.0 or later.

The GPS Receiver Evaluation Kit contains the following items:

- GPS evaluation unit
- GPS active antenna (see Appendix A)
- Automotive power adapter
- AC power converter
- RS-232 serial interface cable
- Software CD

The CD contained in the GPS evaluation kit, includes the RFMD GPS Receiver User Manual, and the RFMDgps evaluation program.

The RFMD GPS receiver is the primary component of the GPS Receiver Evaluation Unit. It combines advanced technologies, such as silicon germanium (SiGe) and a highly integrated CMOS ASIC architecuter. This 12-parallel channel GPS receiver works in a wide variety of end products including; marine navigation, telematics, automotive navigation, and asset tracking.

The GPS receiver processes signals from all the visible GPS satellites broadcasting radio frequency (RF) navigation information. “All-in-view” satellite tracking produces highly accurate, smoothed navigation data. The data is relatively immune to position jumps that occur when fewer satellites are monitored. Therefore, the receiver performs robustly in situations where extreme vehicle movement or high signal blockage are concerns, such as dense urban areas.

When fewer than four satellites are available or when operating conditions require, the receiver supports two-dimensional (2D) navigation. To calculate a fix while in 2D navigation mode, the receiver uses either the last altitude determined while in 3D navigation mode or data supplied by the user.

Rapid time to first fix (TTFF) is a feature of the rapid acquisition engine and multi-correlator architecture of the GPS receiver. The flexible satellite acquisition system takes advantage of all available information to provide a rapid TTFF, even without user initiation. To minimize TTFF when primary power is removed from the receiver, a DC supply voltage maintains the real time clock (RTC). This allows the receiver to use the prior position data and satellite information stored in the GPS receiver’s flash memory.

The GPS receiver has two independent, asynchronous serial ports. The primary port outputs navigation data and accepts user commands, in NMEA-0183 or Binary message formats. The auxiliary port accepts RTCM SC-104 DGPS corrections.

1.2 Ordering Information

Part Number	Description
DK8000	RFMD Global Positioning System Receiver Evaluation Kit

1.3 Conventions and Notation

Throughout this document, commands the user types are represented in a font that stands out from the surrounding text. For example: type CD RFMDgps at the C:\ prompt.

Numeric notation is as follows:

- Hexadecimal values are preceded by x and enclosed in single quotation marks. For example: x‘0B00’.
- Binary values in text are either spelled out (zero and one) or appear in single quotation marks. For example: ‘1010’.

For a list of commonly used abbreviations, see section *5. Glossary* on page 151.

2. Setup and Operation

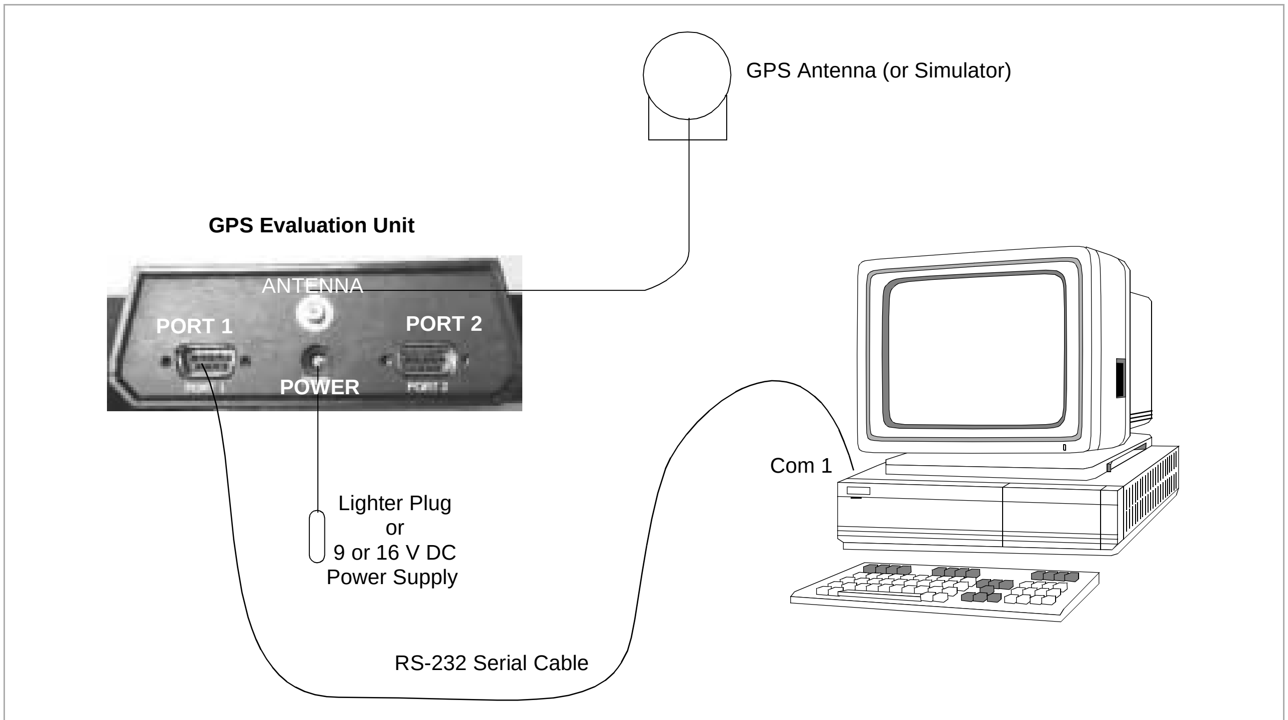
The connection of the GPS evaluation unit to a PC is shown in Figure 2-1 below.

The RFMD GPS receiver evaluation kit contains both an automotive cigarette lighter adapter cable and an AC power converter, which provide the appropriate power levels to the evaluation unit. An active GPS antenna, required for operation, is included in the evaluation kit as well. The female-to-female RS-232 serial cable provided in the evaluation kit is used to connect Port 1 of the GPS evaluation unit to one of the communication ports (Com1 - Com2) of the PC.

A GPS simulator can be used in place of the active antenna connection. If a GPS simulator is used, the following operational considerations apply:

- An external LNA (with constant noise figure) must be used to provide the “real-world” noise required of a direct sampling receiver.
- The RF signal level at the receiver antenna connector must be between -70 dBm and -103 dBm.
- The antenna power enable jumper, J1, located inside the evaluation unit (see Figure 2.1: *GPS Evaluation Unit Circuit Board Diagram* on page 16) must be removed.

Figure 2-1. Connecting the GPS Evaluation Unit



The block diagram of the RFMD GPS receiver module, located inside the GPS evaluation unit, is shown in Figure 2-2 below.

Figure 2-2. RFMD GPS Receiver Module Block Diagram

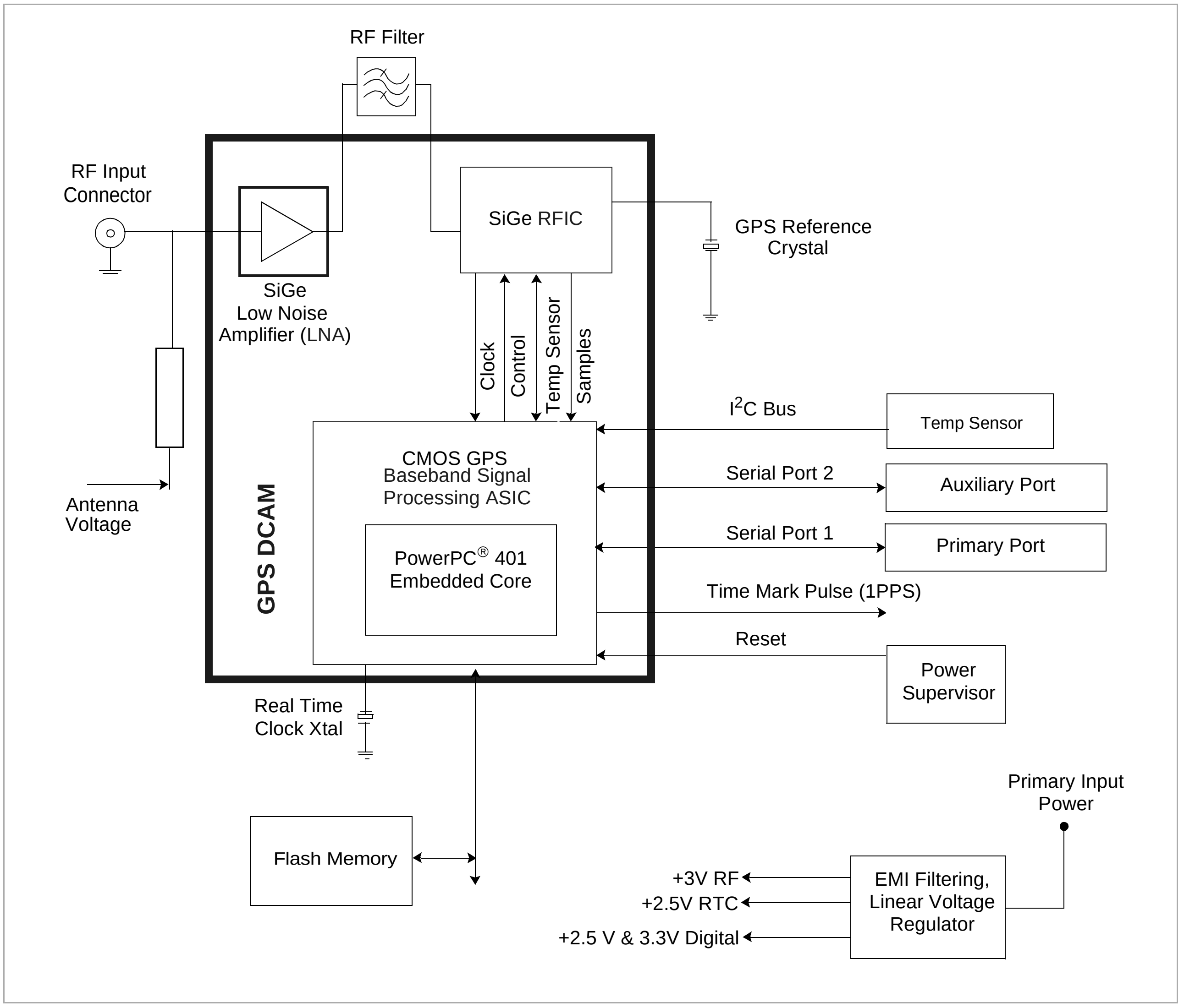


Figure 2-3. GPS Evaluation Unit Rear Panel

Power from the AC adapter is provided to the PWR connector on the rear panel. The GPS evaluation unit accepts unregulated DC voltage from 9 V to 14 V DC. The power connector is designed to mate with a standard ground on the sleeve.

The antenna is attached to the rear panel ANT connector. Antenna power is supplied via the center conductor and is user selectable from 3.3 V or 5.0 V via the antenna power jumper (labeled J1 in Figure 2.1: *GPS Evaluation Unit Circuit Board Diagram* on page 16). Communication between the GPS evaluation unit and a personal computer is established from port 1 using the supplied serial cable. Port 2 is used to input DGPS correction data.

Figure 2-4. GPS Evaluation Unit Front Panel

The front panel contains the following switches, status indicator LEDs, and connector:

Power Switch Provides power to the evaluation kit when on. On when up, off when down.

DGPS LED Pulses when data is being received on Port 2.

Note: Not an indication of a valid DGPS navigation mode.

NAV LED Navigation LED. Illuminates green when the receiver is in a valid navigation state (DGPS, 3D or 2D).

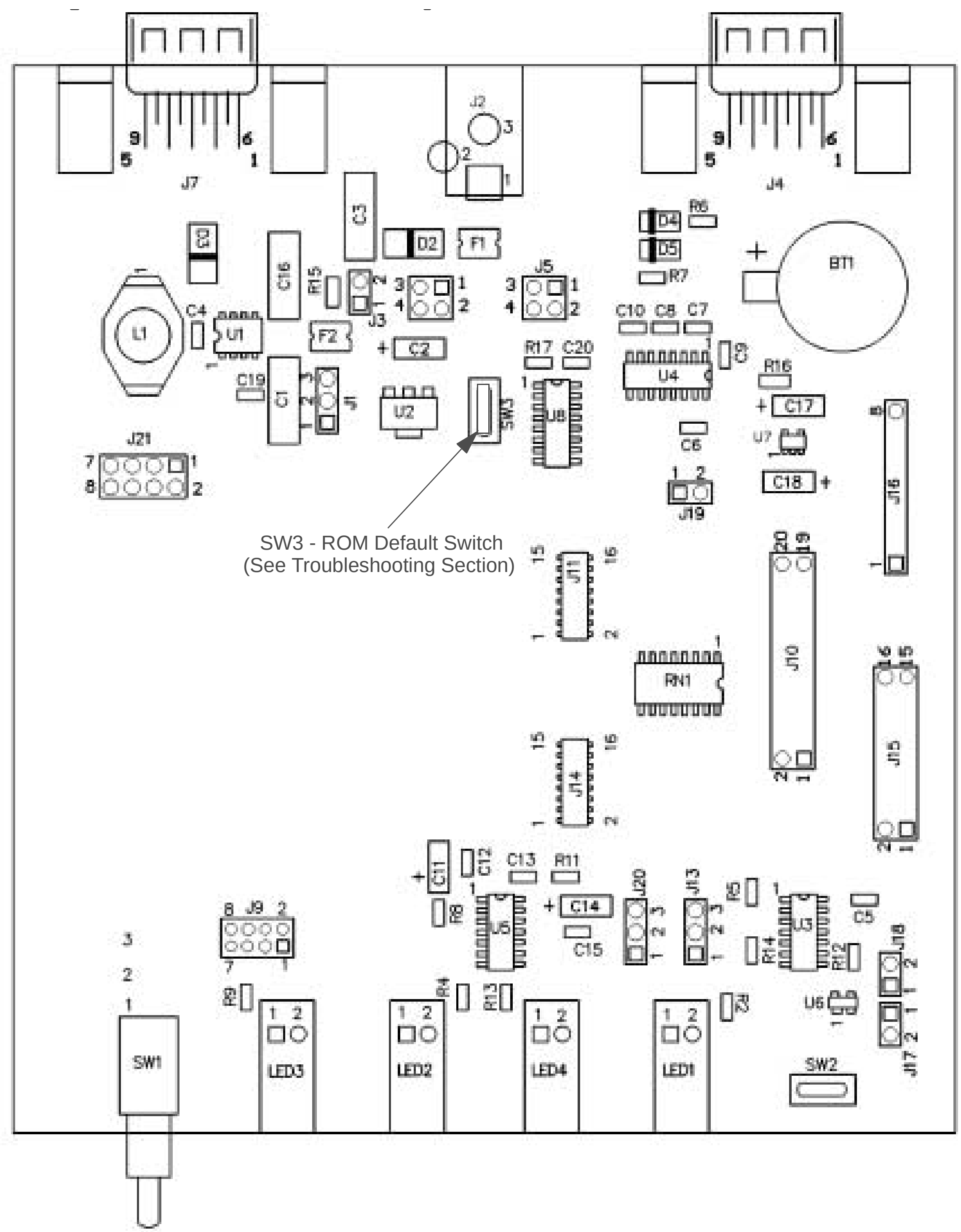
Note: Currently not implemented.

TM LED Time Mark. Pulses at a one pulse per second rate when the receiver is on.

PWR LED Power LED. Illuminates red when power is on.

2.1 GPS Evaluation Unit Circuit Board Diagram

Figure 2-1. GPS Evaluation Unit Circuit Board Diagram



Mnemonic	Block	Description
BACK PANEL		
J2	Power In	Connects a 9 to 14 V DC power source. The kit includes an automotive cigarette lighter adapter cable or an AC power converter to provide the necessary supply voltage.
J4	Port 1	Primary port. Sends and receives NMEA or Binary messages. The kit provides an RS-232 cable for interface to a PC.
J7	Port 2	Used to receive RTCM SC-104 Differential GPS (DGPS) corrections from the receiver. No data is output from this port.
RF	Antenna Input Connector	Connects the active magnetic mount antenna, included in the kit, or a GPS simulator to the RF input of the GPS receiver. (Located above J3, the power input connector.)
INTERNAL		
J1	Antenna Power Jumper	Used to select between 3.3 V and 5 V power, which is provided to the antenna coaxial center conductor for an active GPS antenna. Install the jumper across pins 1 and 2 to provide 3.3 volts to the antenna preamp. Install the jumper across pins 2 and 3 to provide 5 volts to the antenna preamp. When removed, this jumper removes DC voltage from the antenna coaxial cable. Note: This interface can also be used to measure the antenna power current.
J5	Port 1 Jumpers	Used to switch between a straight-through or null modem RS-232 port interface. Jumper pin 1 to pin 2 and pin 3 to pin 4 for straight through serial connection. Jumper pin 1 to pin 3 and pin 2 to pin 4 for a null modem serial connection. Note: The default interface is a straight-through serial connection.
J8	Port 2 Jumpers	Used to switch between a straight-through or null modem RS-232 port interface. Jumper pin 1 to pin 2 and pin 3 to pin 4 for straight through serial connection. Jumper pin 1 to pin 3 and pin 2 to pin 4 for a null modem serial connection. Note: The default interface is a straight-through connection.
J9	GPS Receiver Module Connector	Interface connector for the GPS Receiver module. Provides power, ground, and serial port interfaces to the RFMD GPS receiver board.
J13	DGPS Connection	Jumper pin 2 to pin 3 to connect serial port 2 to the DGPS LED.
J19	3.3 V Supply Jumper	Used to measure the GPS receiver power current. This jumper must be in place to provide power to the GPS receiver.
J20	T-Mark Connection	Jumper pin 1 to pin 2 to connect the T-Mark pulse to the T-Mark LED.
J3, J10, J11, J14, J15, J17, J18	N/C	These connector interfaces are currently not used.
BT1	2.5 V Lithium Battery Cell	Battery slot, for real time clock (RTC) backup power.
FRONT PANEL		
SW1	Power Switch	Provides power to the evaluation kit when on. On when up, off when down.
LED1	Power LED	Illuminates red when power is on.
LED2	Navigation LED	Illuminates green when the receiver is in a valid navigation state (3D or 2D). **Note:** Currently not implemented.
LED3	DGPS LED	Pulses when data is being received on Port 2. **Note:** Not an indication of a valid DGPS navigation mode.
LED4	Time Mark LED	Pulses at a one pulse per second rate when the receiver is on.

3. The RFMDgps Evaluation Tool

RFMDgps is a Microsoft Windows™ based software program that allows the user to communicate with the GPS evaluation unit using Binary or NMEA message formats. To install the RFMDgps Evaluation program, Microsoft Windows95™, Microsoft Windows NT™ V4.0 or later must be running. On most Windows systems, installation starts automatically when the RFMDgps CD is inserted into the CD_ROM drive. If installation does not start automatically, follow the steps below to install the RFMDgps program:

1. On a IBM PC, or compatible, insert the RFMDgps CD into the CD-ROM drive.
2. Choose Run from the Start menu.
3. In the Open box, type d:\setup, where "d" is the letter assigned to the CD-ROM drive.
4. Click OK and follow the instructions on the screen.

3.1 Starting your First RFMDgps Session

If installed properly, the RFMDgps evaluation program will now be available on your desktop and in the Programs list under the Start Menu. To start the program double-click on the RFMD GPS icon located on your desktop or press the Start button, then Programs, and then select the RFMD GPS program from the list.

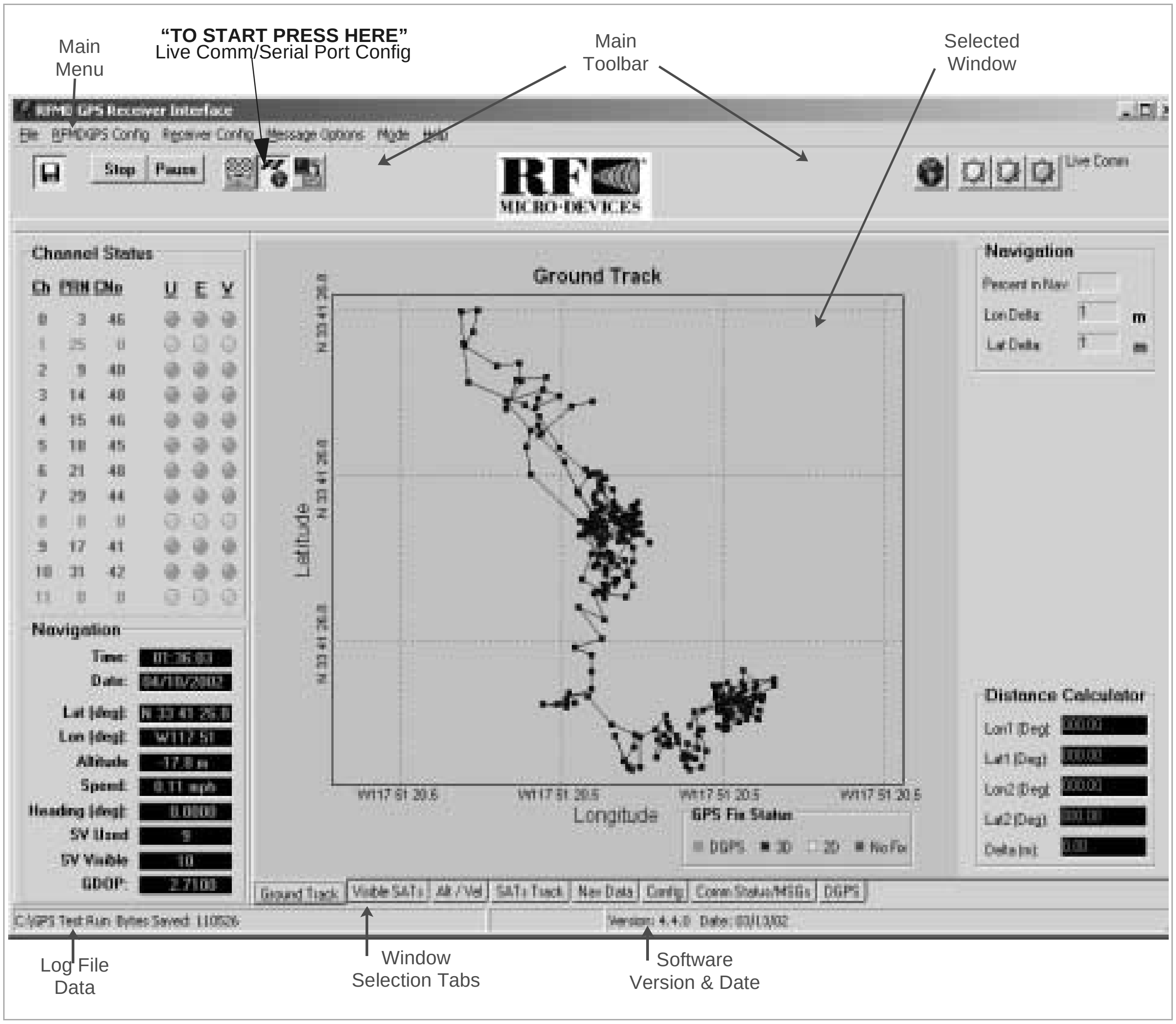
The RFMDgps Setup window, shown below, will appear the very first time the RFMDgps program is initiated. For further details on how to change the Data Logging and Setup selections, see Section *3.3.2.5 Configure RFMDgps* on page 41. Subsequent sessions will bring up the Main window as defined in Section *3.2.1 Main Window* on page 20. Press the Save button to bring up the Main window.

3.2 Window Descriptions

The Window selection tabs at the bottom of the Main window, shown below, allow the user to select between specific data views. The user can select from the following six tabs; Ground Track, Satellite Visibility (Visible SATs), Altitude and Velocity (Alt / Vel), Satellites in Track (SATs Track), Communication Status and Messages (Comm Status/MSGs) and Differential GPS (DGPS). Two additional tabs; Navigation Data (Nav Data), and User Configuration (Config), are only visible when Binary messages are enabled. These windows are described in the remainder of this section.

3.2.1 Main Window

The RFMDgps Main window screen, shown below, appears upon startup of the RFMDgps program. There are several ways to start communication to the Evaluation Unit. Auto Run on start up can be enabled in the Configure RFMDgps *Startup* window. See "Configure RFMDgps" on page 41. The user can use the *Main Menu - Mode* selection or the *Main Toolbar - Live Comm* tab (highlighted below).



3.2.2 Channel Status / Navigation Window

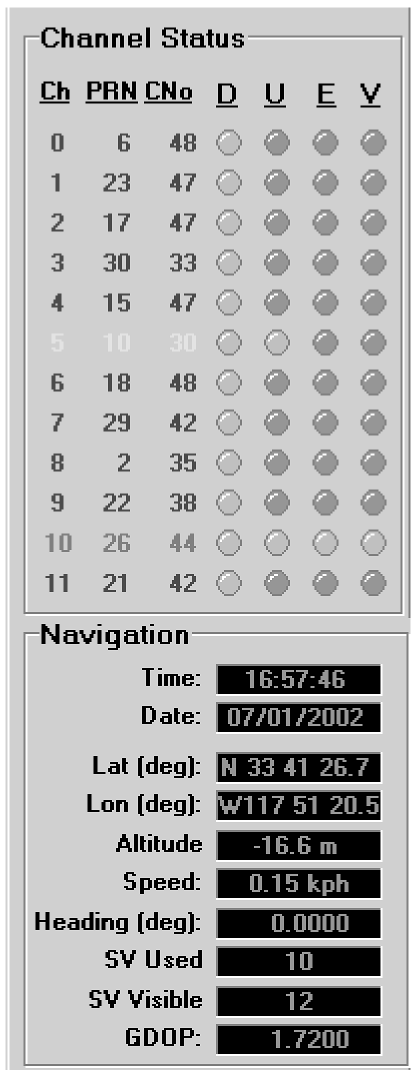
The Channel Status / Navigation window remains fixed on the left hand side of the display and contains the satellite tracking information for each of the receiver's twelve parallel processing channels. Navigation values are displayed for time, date, position, speed, heading, number of satellites being tracked, number of satellites visible, and geometric dilution of precision (GDOP).

The Channel Status / Navigation window descriptions for Binary, NMEA and Differential GPS (DGPS) are defined below.

3.2.2.1 Binary Mode

In Binary mode, the following screen is displayed.

The Binary output message (OCHS) must be turned on to view channel status information.
See section *4.1.1 Binary Output Messages* on page 63, for default Binary output message settings.



Channel Status Parameters	Description
Ch	Receiver channel number. A number between 0 and 11 assigned to each of the receiver's parallel processing channels.
PRN	Satellite identification number. A number between 1 and 32 assigned to the pseudo random noisepring (PRN) of each GPS satellite.
CNo	Carrier to Noise. Satellite carrier to noise level (dB HZ).
D	DGPS data is being used.
U	GPS data is being used.
E	Ephemeris data collected.
V	Measurement data is valid.

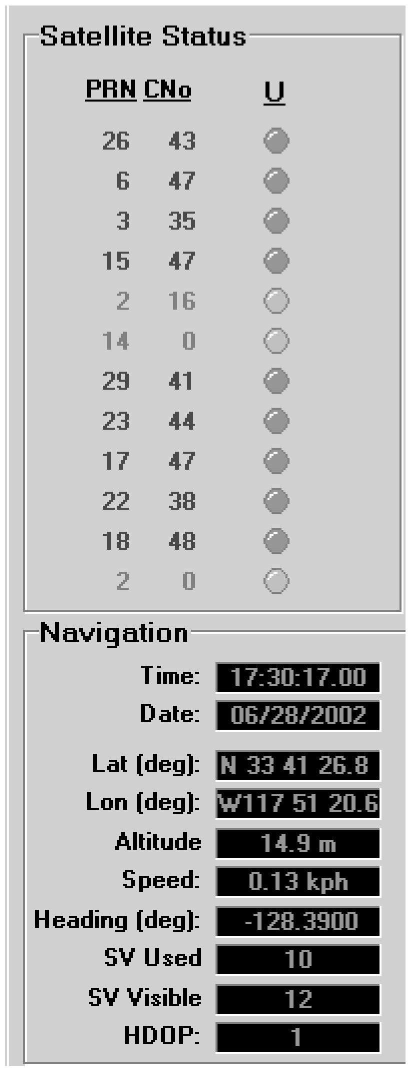
Navigation Parameters	Description
Time	Coordinated universal time (UTC).
Date	UTC date.
Lat (units)	Latitude of the receiver's antenna position. The units are specified in the RFMDgps Configuration, under format units.
Lon (units)	Longitude of the receiver's antenna position. The units are specified in the RFMDgps Configuration, under format units.
Altitude	Altitude of the receiver's antenna position.
Speed	Velocity, or speed over ground of the receiver.
Heading (units)	Heading of the receiver. The units are specified in the RFMDgps Configuration, under format units.
SV Used	Number of satellites used in the position solution.
SV Visible	Number of satellites visible, given a clear view of the sky.
GDOP	Geometric dilution of precision based on the satellites used in the position solution.

3.2.2.2 NMEA Mode

In NMEA mode, the following screen is displayed.

The NMEA status information is limited due to the availability of information in the standard NMEA output message set, so we have implemented a NMEA proprietary channel status message (CHS).

See section *4.2.1 NMEA Output Messages* on page 127, for default NMEA output message settings.



Channel Status Parameters	Description
PRN	Satellite identification number. A number between 1 and 32 assigned to the pseudo random noiseprint (PRN) of each GPS satellite.
CNo	Carrier to Noise. Satellite carrier to noise level (dB HZ).
U	GPS data is being used.

Navigation Parameters	Description
Time	Coordinated universal time (UTC).
Date	UTC date.
Lat (units)	Latitude of the receiver’s antenna position. The units are specified in the RFMDgps Configuration, under format units.
Lon (units)	Longitude of the receiver’s antenna position. The units are specified in the RFMDgps Configuration, under format units.
Altitude	Altitude (mean sea level) of the receiver’s antenna position.
Speed	Velocity, or speed over ground of the receiver.
Heading (units)	Heading of the receiver. The units are specified in the RFMDgps Configuration, under format units.
SV Used	Number of satellites used in the position solution.
SV Visible	Number of satellites visible, given a clear view of the sky.
HDOP	Horizontal dilution of precision based on the satellites used in the position solution.

3.2.2.3 DGPS Mode

In DGPS mode, the following screen is displayed.

The DGPS mode, the Binary output message (OCHS) must be turned on to view channel status information. See section *4.1.1 Binary Output Messages* on page 63, for default Binary output message settings.

Channel Status Parameters	Description
Ch	Receiver channel number. A number between 0 and 11 assigned to each of the receiver's parallel processing channels.
PRN	Satellite identification number. A number between 1 and 32 assigned to the pseudo random noiseprint (PRN) of each GPS satellite.
CNo	Carrier to Noise. Satellite carrier to noise level (dB HZ).
D	DGPS data is being used.
U	GPS data is being used.
E	Ephemeris data collected.

Channel Status Parameters	Description
V	Measurement data is valid.
Time	Coordinated universal time (UTC).
Date	UTC date.

Navigation Parameters	Description
Lat (units)	Latitude of the receiver's antenna position. The units are specified in the RFM Configuration, under format units.
Lon (units)	Longitude of the receiver's antenna position. The units are specified in the RFMDgps Configuration, under format units.
Altitude	Altitude of the receiver's antenna position.
Speed	Velocity, or speed over ground of the receiver.
Heading (units)	Heading of the receiver. The units are specified in the RFMDgps Configuration, under format units.
SV Used	Number of satellites used in the position solution.
SV Visible	Number of satellites visible, given a clear view of the sky.
GDOP	Geometric dilution of precision based on the satellites used in the position solution.

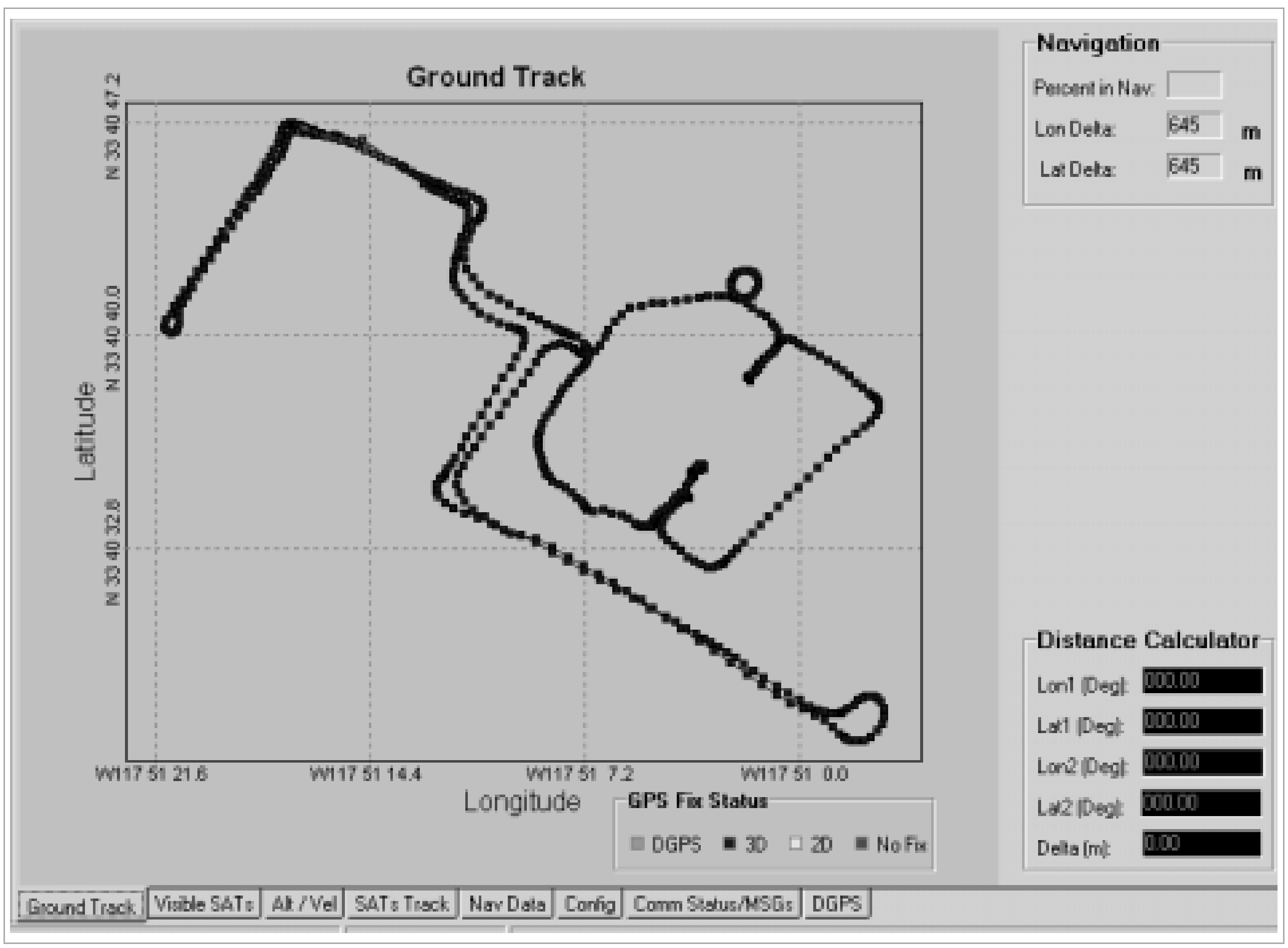
3.2.3 Ground Track Window

The Ground Track window, shown below, contains the following sections:

- Ground track. Represents the receiver's travelled route by displaying position updates on the latitude/longitude grid.
- Navigation. Percentage time in navigation. Includes both 2D and 3D fixes. The latitude and longitude deltas define the ground track plot area.
- Distance Calculator. The user selects two points in the ground track plot area, by clicking on the bread crumbs with the left mouse button. The calculator determines the distance between the two selected points.
- GPS Fix Status. Defines the navigational status of the receiver. The color key, in order of decreasing accuracy, is as follows:

Green	Differential GPS solution
Blue	3-dimensional solution
Yellow	2-dimensional solution
Red	No valid solution.

To zoom in on a section of the ground track, click and drag the mouse arrow across the desired section. Start from the upper left corner and move down and across to the right. To un-zoom or return to a full view, click and drag the mouse in reverse. Start from the lower right corner and move up and across to the left.

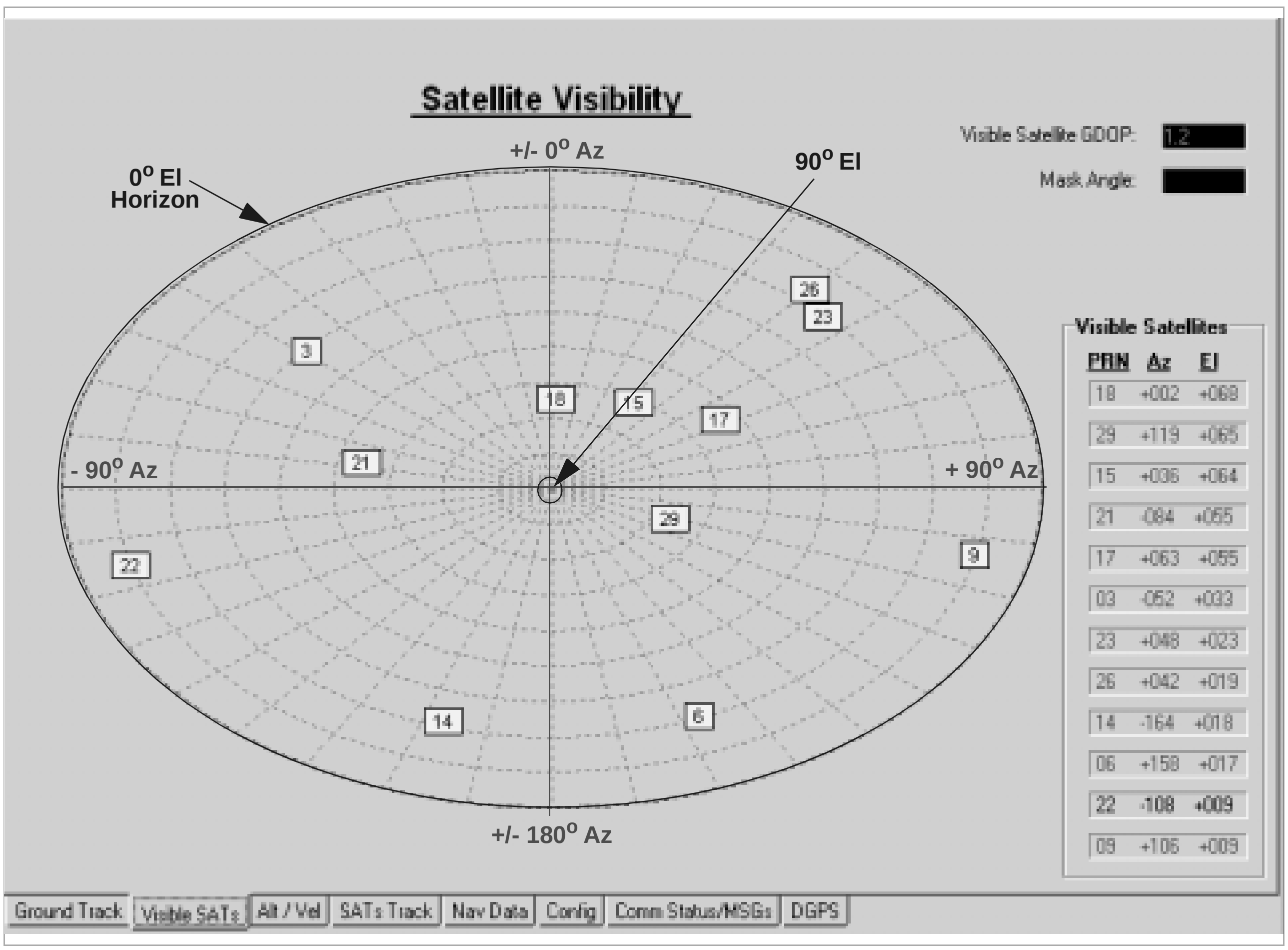


3.2.4 Satellite Visibility Window

The Satellite Visibility window, shown below, is a graphical representation of the satellite visibility list. These are the satellites that are overhead given an unobstructed view of the sky. The graph shows each satellite ID and its position relative to the other satellites in view. The upper right hand section of the window gives the receiver setting for mask angle (viewable after the Config window has been selected, which polls the user settings) and the value of geometric dilution of precision (GDOP). The GDOP value in this window is based on all the satellites in view. The table below lists each satellite ID and its associated azimuth and elevation.

The center of all the rings is at a 90 degree elevation and each ring moving outward represents -10 degrees in elevation, the outer most ring representing the horizon. Straight up from the center is True North. Moving to the right, each section represents an increase in azimuth of 10 degrees (0 to +180 degrees). Moving to the left, each section represents a decrease in azimuth of 10 degrees (0 to -180 degrees).

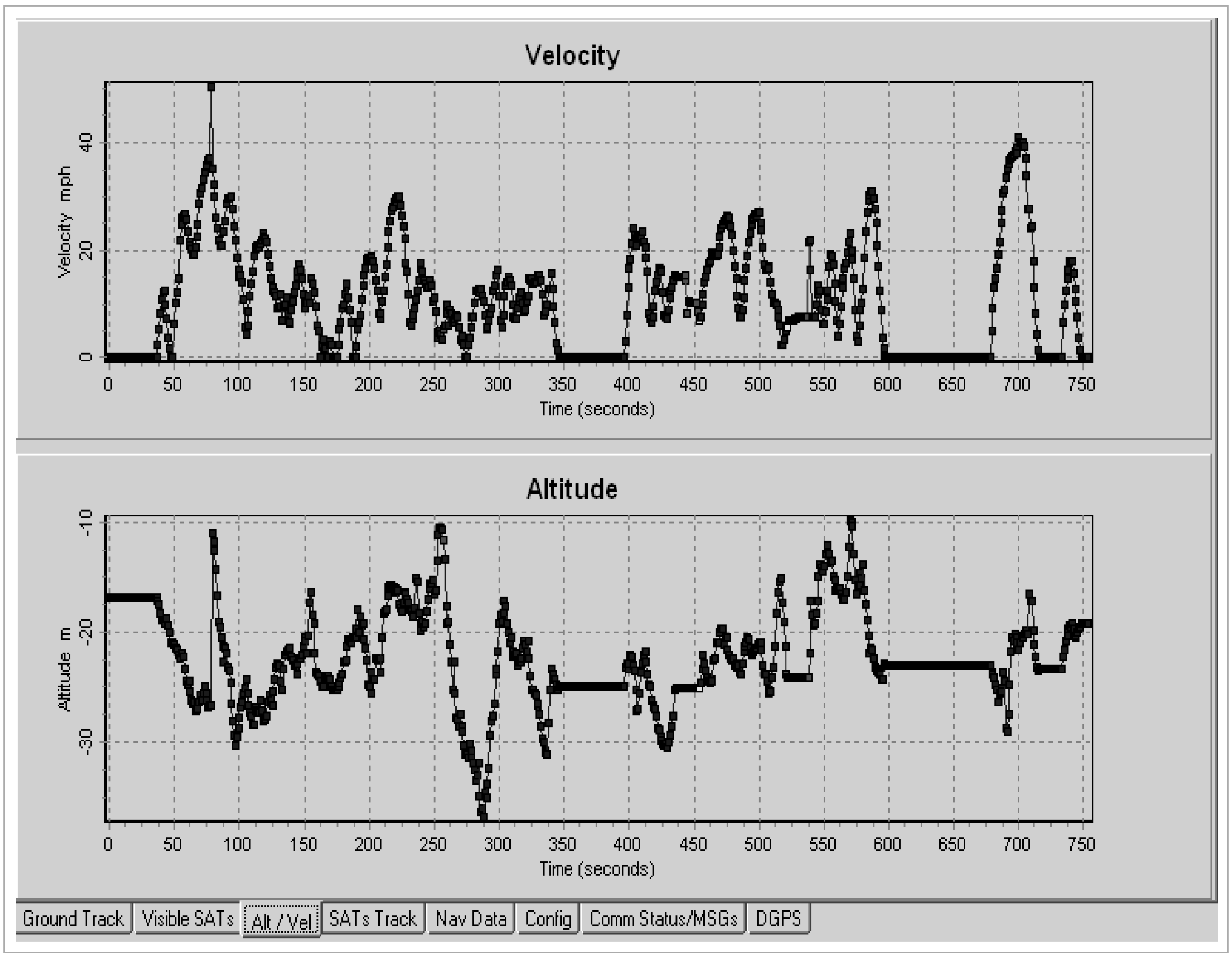
Note: There are several reasons why this display of satellites may not match the list in the Channel Status window (see “Channel Status / Navigation Window” on page 21). The receiver may use only a subset of the visible satellites, depending on the environment. The receiver antenna may be blocked from viewing certain satellites, or may experience multipath and have to reject satellites. The user mask settings are another factor in determining which satellites are used. The satellite visibility view shows all the satellites that are overhead, given a clear view of the sky down to the horizon level.



3.2.5 Altitude and Velocity Window

The Altitude/Velocity window, shown below, contains two plots. The velocity plot shows the speed over time (seconds). The unit of speed is either meters per second, miles per hour, or kilometer per hour depending on format options selected by the user (see Section *3.3.2.1 Clear Display* on page 38 for additional information). The altitude plot represents the height over time (seconds). The unit of altitude is either meters or feet, depending on the format options selected by the user (see Section *3.3.2.1 Clear Display* on page 38 for additional information).The colors represent the navigational status of the receiver at the time of the update. The color key, in order of decreasing accuracy, is as follows:

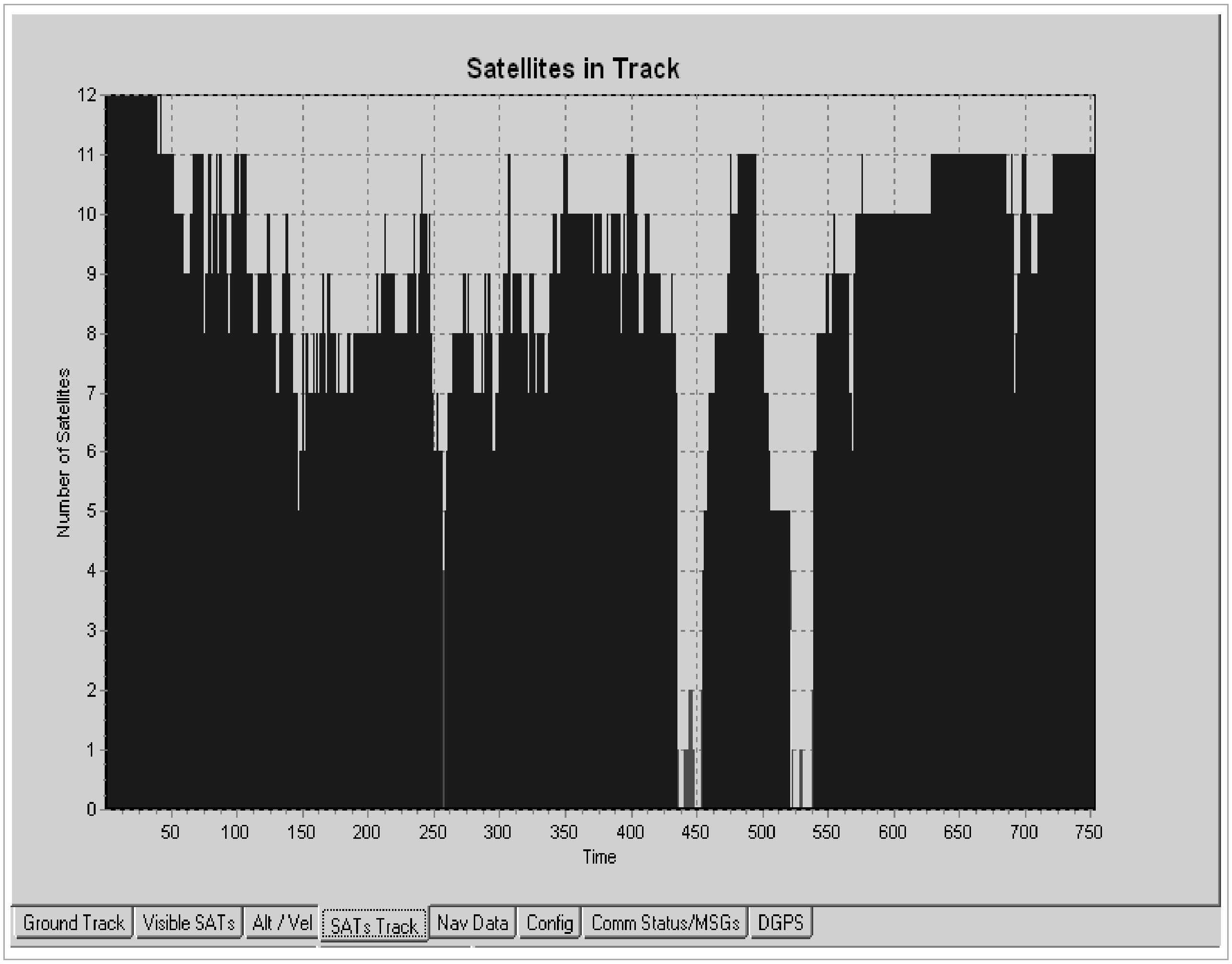
Green	Differential GPS solution
Blue	3-dimensional solution
Yellow	2-dimensional solution
Red	No valid solution



3.2.6 Satellites In Track Window

The Satellites In Track window, shown below, displays the number of satellites used by the receiver over time (seconds). The different colors represent the navigational status of the receiver at the time of the update. The color key, in order of decreasing accuracy, is as follows:

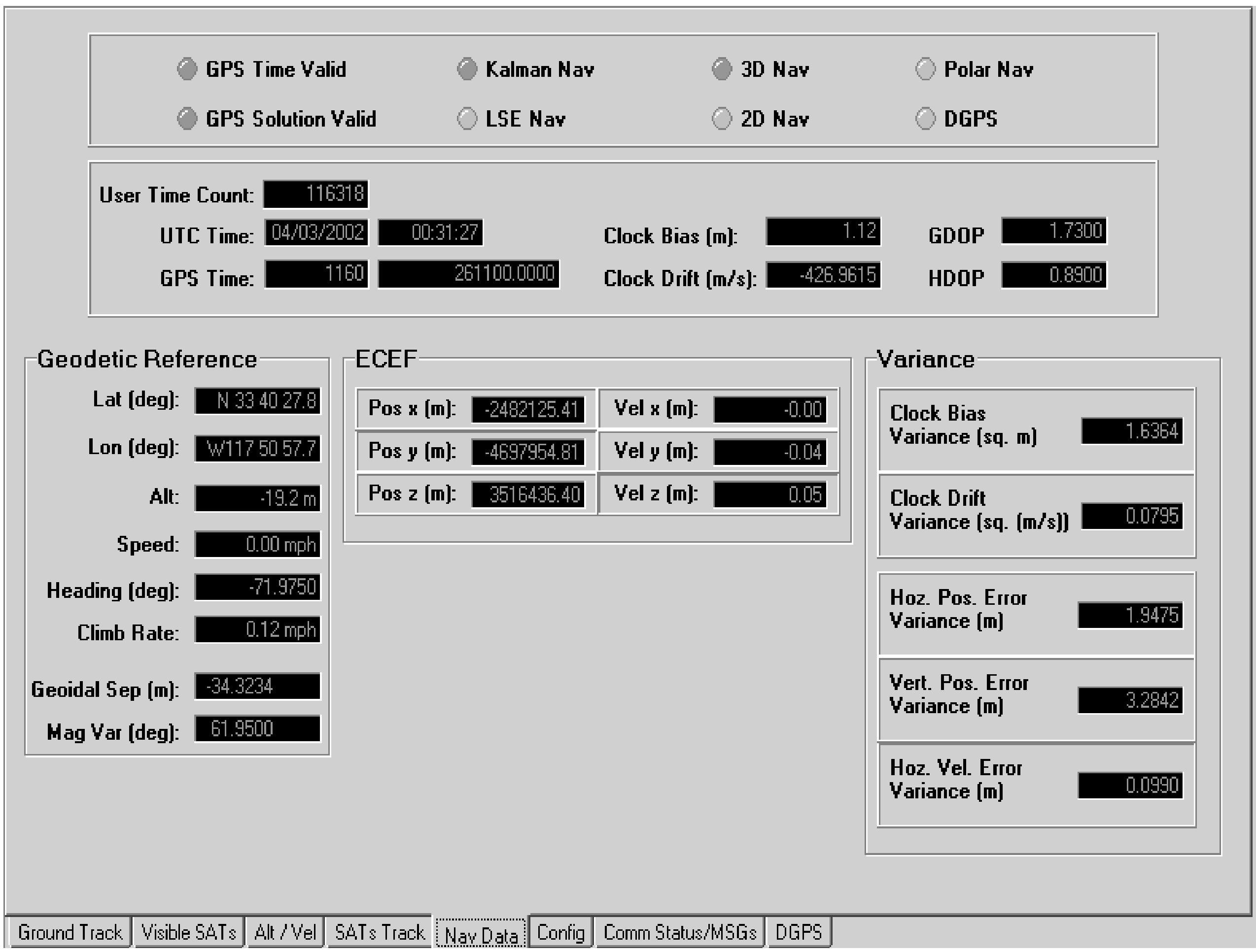
Green	Differential GPS solution
Blue	3-dimensional solution
Yellow	2-dimensional solution
Red	No valid solution



3.2.7 Navigation Data Window (Binary Mode Only)

The Navigation Data window, shown below, displays the receiver's navigational data at the current point in time. The boxes checked in the upper section of the window define the receiver's current navigational state.

Note: This window is only available when Binary messages are enabled.



Parameter	Description
GPS Time Valid	GPS time is valid.
GPS Solution Valid	Navigation solution is valid and within the set error limits. Defined in Section *3.2.8 User Configuration Window (Binary Mode Only)* on page 33.
Kalman Nav	The receiver is in kalman navigation.
LSE Nav	The receiver is in least squares estimator (LSE) navigation.
3D Nav	The receiver is in 3D navigation mode. Latitude, longitude, altitude and time are computed from four or more satellites.
2D Nav	The receiver is in 2D navigation mode. Latitude, longitude and time are computed from three or fewer satellites using a fixed value for altitude. The receiver uses the last valid 3D altitude.

Parameter	Description
Polar Nav	The receiver is in polar navigation mode. Earth centered/earth fixed position data should be used when operating near the poles. **Note:** Polar Nav mode is currently not implemented.
DGPS	The receiver is in DGPS mode. Latitude, longitude and time are computed from data collected from four or more differentially corrected satellites.
User Time Count	Internal receiver reference timer. Number of 10 ms counts since power-on.
UTC Time	Coordinated Universal Time (UTC) data. UTC is computed from GPS Time using the UTC correction parameters sent as part of the navigation data bits. At the transition between 23:59:59 UTC on Dec. 31, 1998 and 00:00:00 UTC on January 1, 1999, UTC was retarded by one-second. GPS Time is now ahead of UTC Time by 13 seconds.
GPS Time	GPS Time data. GPS Time is measured in weeks and seconds from 24:00:00, January 5, 1980 and is steered to within one microsecond of UTC. GPS Time has no leap seconds and is ahead of UTC Time by several seconds
Clock Bias	Clock bias data in meters. This is the clock offset error.
Clock Drift	Clock drift data in meters per second.
GDOP	Geometric dilution of precision.
HDOP	Horizontal dilution of precision.
Geodetic Reference	Geodetic position, speed, heading, climb rate, geoidal separation, and magnetic variation.
ECEF	Earth center/earth fixed position and velocity data.
Variance	Clock, position and velocity variance data.

3.2.8 User Configuration Window (Binary Mode Only)

The Configuration window, shown below, displays the current settings for Navigation (Nav) Configuration, Cold Start Configuration, Miscellaneous (Misc), Navigation (Nav) Solution Validity Criteria and DGPS Configuration. Selecting the Config window during a live session, polls the receiver for it's latest configuration.

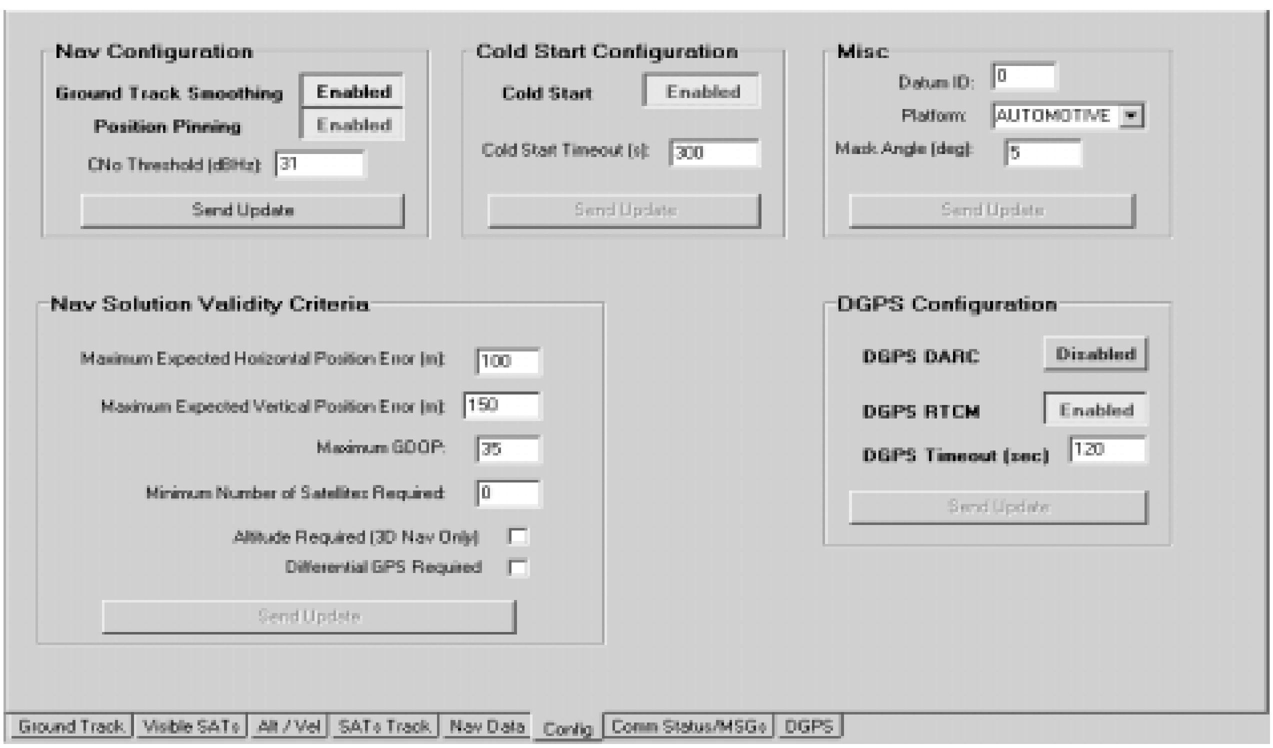
3.2.8.1 User Entered Configuration Data

This window is used to change/update the user configuration data to the receiver.

Each time this window is selected, the receiver will be polled for its latest configuration settings. Confirmation of the receiver's enable/disable settings will show up in color, green for enabled and red for disabled.

User-entered changes to the enable/disable selections will show up in black text. Pressing the Send Update tab confirms the selections and sends the update to the receiver. The selection text will then turn green for Enable and red for Disable.

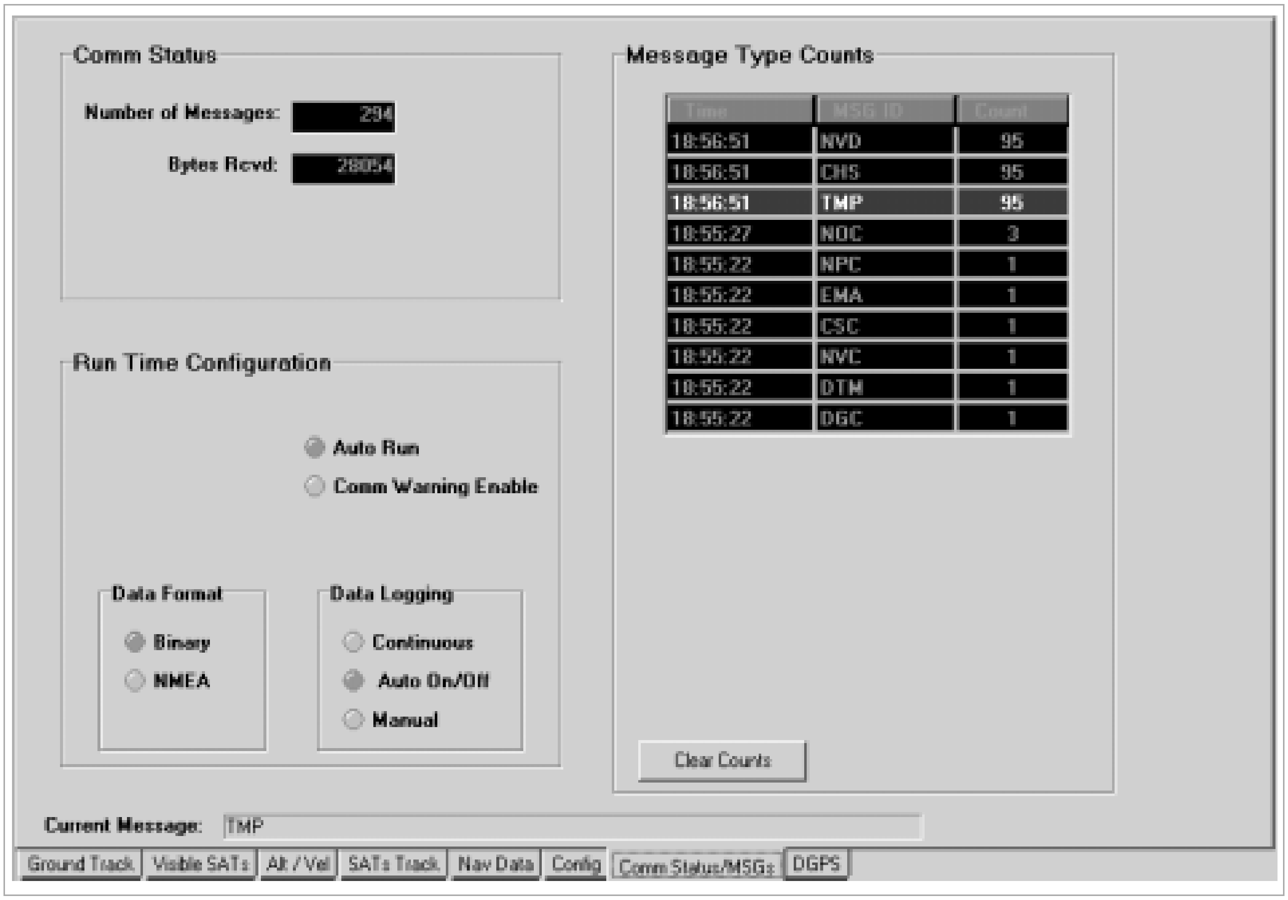
Note: User configuration setting are stored in Flash memory.



Parameter	Description
Ground Track Smoothing	Used for car navigation for smooth ground track aesthetics. The default is off. **Note:** Currently not implemented.
Position Pinning	Used for car navigation to pin a position when the vehicle velocity is below a set threshold. The default is on.
CNo Threshold (dbHz)	Carrier to noise threshold. Allows the user to set the minimum threshold for signal strength in dB Hz. The default is 31 dB Hz. A minimum value of 31 dB Hz is needed for tracking. Average values range from 35 to 41 for low-elevation satellites and from 42 to 50 for mid-to-high-elevation satellites.
Cold Start Enabled	Allows the user to set a cold start timer. The default is enabled.
Cold Start Timeout (s)	Sets the cold start timer duration, in seconds. The timer starts counting when no satellites are being tracked by the receiver. When the timeout period is reached, the receiver clears its position and time information and conducts a search-the-sky algorithm. The default is 300 seconds.
Enter Datum ID	Sets the receiver's Datum ID. The default is zero, WGS-84. Map Datum IDs are from 0:188. User Datum IDs are from 200:204. See *Appendix B: Map Datum Definitions* on page 159 for additional information.
Platform	This message allows the user to set the receiver's platform class: stationary, pedestrian, lake, sea, automotive, or airborne. This allows the system to adjust dynamic limits to achieve optimum navigation performance. **Note:** Currently not implemented.
Mask Angle	Allows the user to set the receiver's elevation mask angle. The default is 5 degrees.
Maximum Expected Horizontal Position Errors (m)	Sets the maximum receiver threshold for horizontal position errors, in meters. The default is 100m.
Maximum Expected Vertical Position Errors (m)	Sets the maximum receiver threshold for vertical position errors, in meters. The default is 150m.
Maximum GDOP	Sets the receiver's maximum level for geometric dilution of precision. The default is 35.
Minimum Number of Satellites Required	Sets the minimum number of satellites required for navigation. The default is zero and indicates that the receiver decides how many satellites to use.
Altitude Required (3D Nav only)	When selected, the receiver must determine its altitude position. This setting only allows a valid navigation solution when the receiver is in 3D navigation mode. When not selected, the receiver can force the altitude when necessary to obtain a less accurate, 2D navigation solution. The default is not selected.
Differential GPS Required	When selected, the receiver must use DGPS correction data,
DGPS DARC	Receiver setting that forces a DGPS Navigation solution. When DGPS DARC is enabled the receiver will use differential GPS correction data, only allowing a valid navigation solution when the receiver is in DGPS navigation mode. The default is disabled. Valid DGPS mode requires 4 or more satellites tracked with differential GPS corrections. **Note:** This setting forces a UDRE value of 2 (binary 10).
DGPS RTCM	Receiver setting that forces a DGPS Navigation solution. When DGPS RTCM is enabled the receiver will use differential GPS correction data, only allowing a valid navigation solution when the receiver is in DGPS navigation mode. The default is disabled. Valid DGPS mode requires 4 or more satellites tracked with differential GPS corrections.
DGPS Timeout (sec.)	This sets the maximum time period (correction age) during which the receiver will use the DGPS correction data to determine its DGPS Navigation solution.

3.2.9 Communication Status and Messages Window

The Communication Status and Messages window, shown below, displays the current status for Communication (Comm) Status, Message Type Counts, and the current settings for the RFMDgps Run Time Configuration.



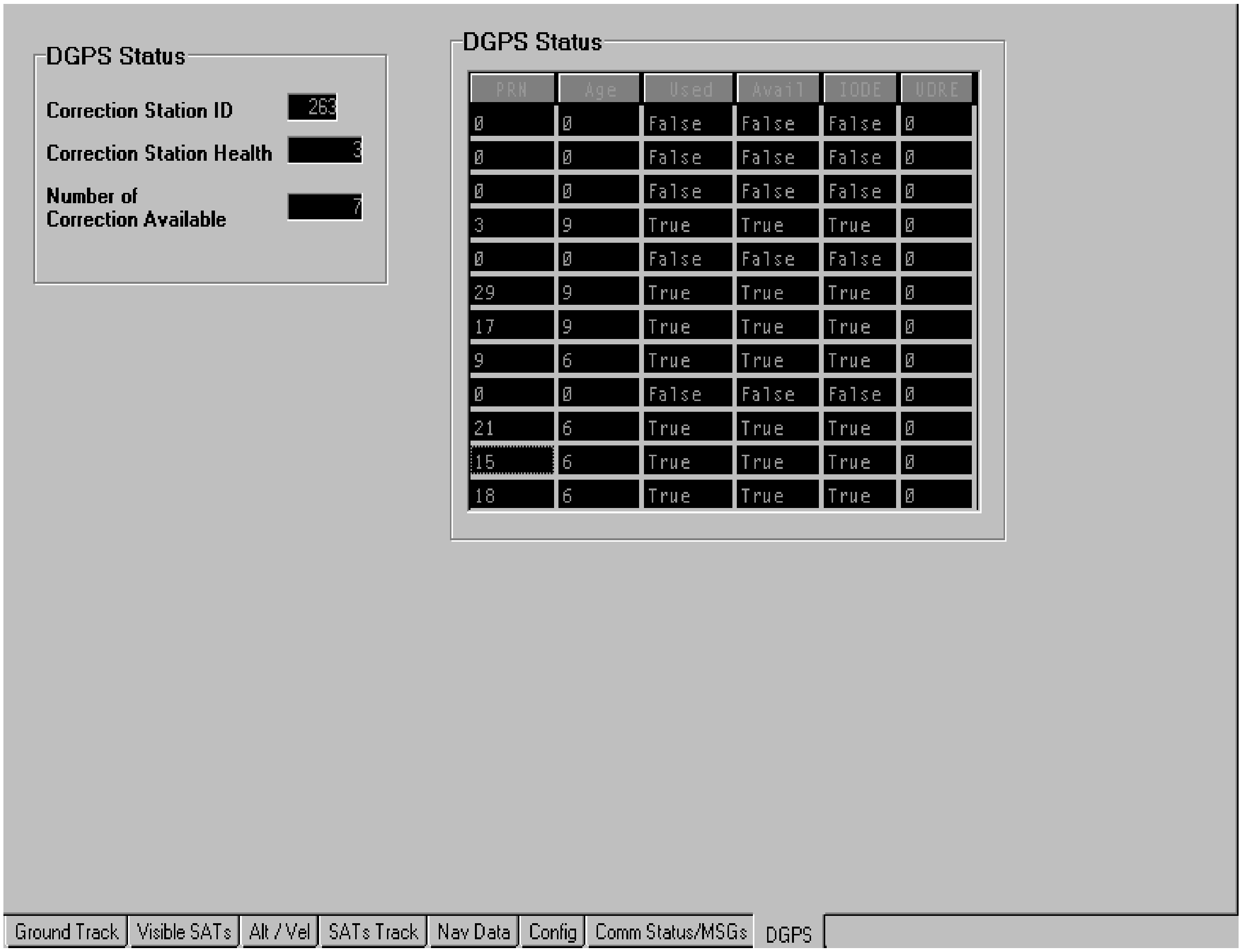
Parameter	Description
Number of Messages	Displays the number of messages received.
Bytes Received	Displays the number of bytes received.
Message Type Counts	Displays the time, message ID and count for the messages received. The Clear Counts button, clears the message type counts table.
Run Time Configuration	Auto Run. RFMDgps startup setting. When enabled, automatically starts a RFMDgps session. Comm Warning Enable. RFMDgps startup setting. When enabled send out a warning message when no data is present on the communication port. See “Configure RFMDgps” on page 41.
Data Format	Binary or NMEA. Displays the current message format setting for RFMDgps.
Data Logging	Continuous, Auto On/Off or Manual. Displays the current setting for the RFMDgps background data logging function. See “Configure RFMDgps” on page 41.
Current Message	Displays the current message (NMEA or Binary) being output by the Receiver.

3.2.10 Differential GPS Window

The DGPS window, shown below, displays the current status of the DGPS station and lists the differential correction data for each satellite being tracked.

Note: The Binary output message, DGS must be turned on to view DGPS Status updates in this window.

Note: The receiver must be in valid DGPS mode to display DGPS Status information..



Parameter	Description
DGPS Status	Displays the Station ID, Station Health and the Number of Corrections Available.
PRN	Displays the satellite ID numbers.
Age	Displays the age of the correction data in seconds.
Used	Displays True if the corrections are used in the solution.
Avail	Displays True if the corrections are available.
IODC	Displays True if the Issue of Data matches.
UDRE	Displays the User Data Range Error. See “Message ODGS: Differential GPS (DGPS) Status” on page 69.

3.3 Main Menu Selections

The Main Menu appears on the second line of every RFMDgps window. The Main Menu selections are File, RFMDgps Config, Receiver Config, Message Options, Mode and Help.

These selections are described in the remainder of this section.

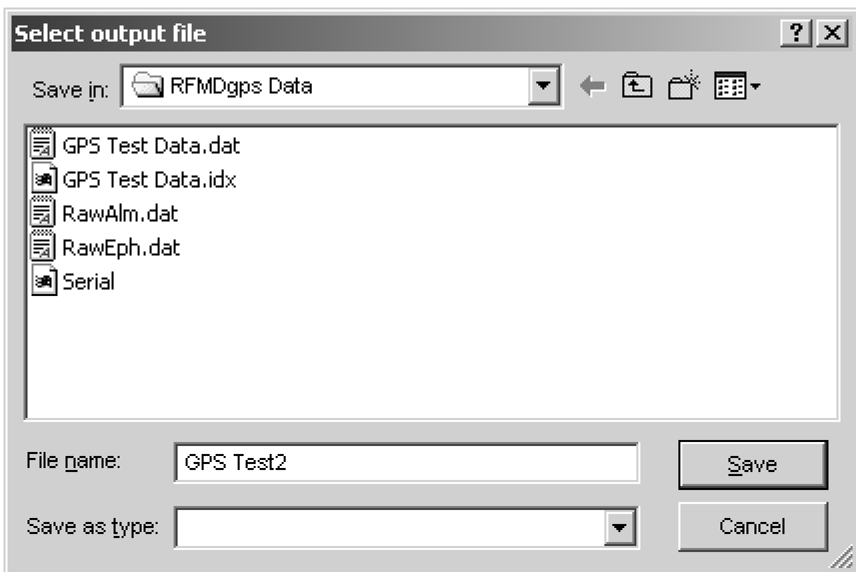
3.3.1 File Options

The following selections; Log to File and Exit are available from the Main Menu, under *File*.

3.3.1.1 Log to File

Log to File will allow the user to store the current sessions output messages to a file.

When selected the Select Output File window, shown below, opens.



Select the directory in which to store the file, then type in the file name and press the Save button.

The log file directory and file name will appear in the lower left hand corner of the Main window, followed by a bytes saved counter. Observe that the counter starts incrementing to verify that the new session is being recorded.

To stop collecting data, press the Stop tab on the Main toolbar or Exit the RFMDgps session. This will stop the current logging session.

Note: The log file will only become accessible after a RFMDgps program exit or after another log file has been opened.

3.3.1.2 Exit

When selected the RFMDgps program will close and end the current session.

3.3.2 RFMDgps Configuration Options

The following selections; Clear Display, Format Units, GT Options, Data Logging and Configure RFMDgps are available from the Main Menu, under *RFMDgps Config*.

These selections are useful in modifying the RFMDgps evaluation program's users interface, they do not effect the GPS receiver settings.

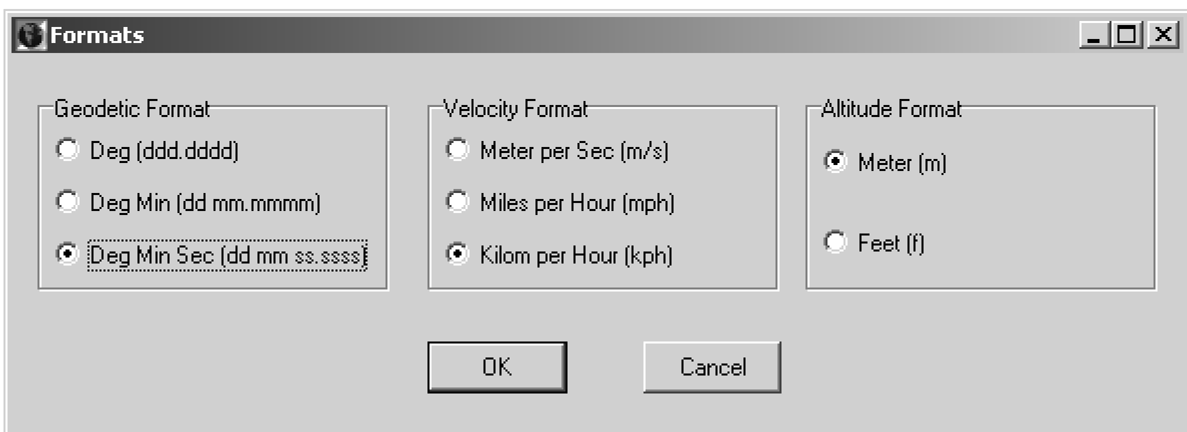
3.3.2.1 Clear Display

This selection will clear all the receiver data from the display screens.

Note: Background data logging is not affected.

3.3.2.2 Format Units

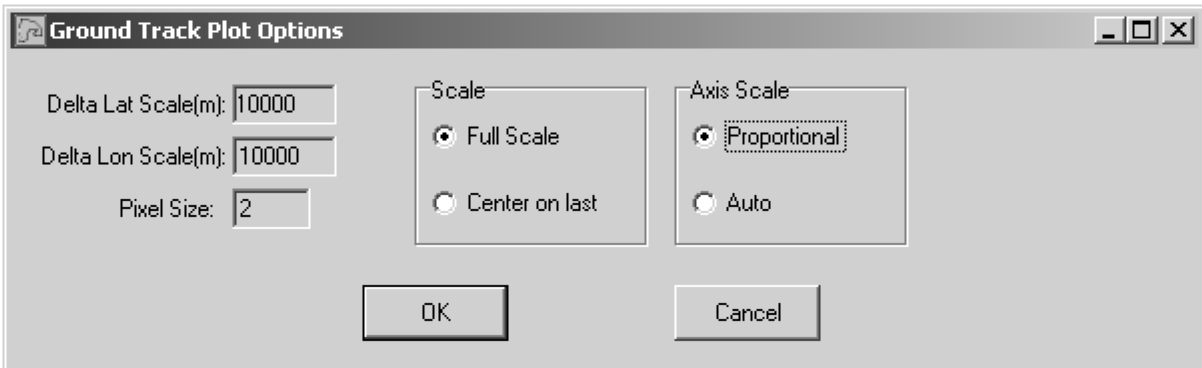
This selection will open the Formats window, shown below. This enables the user to select the Geodetic, Velocity and Altitude formatting options to be used throughout the RFMDgps menus.



Press the OK button to confirm the selections.

3.3.2.3 GT Plot Options

This selection opens the Ground Track Plot Options window, shown below. This enables the user to select the Ground Track plot screen scaling selections and pixel size definition. Press the OK button to confirm the selections.



Parameter	Description
Delta Lat Scale (m)	The ground track plot latitude size in meters. **Note:** Currently not implemented.
Delta Lon Scale (m)	The ground track plot longitude size in meters. **Note:** Currently not implemented.
Pixel Size	The pixel size.
Scale	The scale of the ground track plot, either full or center on last update.
Axis Scale	The axis scale of the ground track plot, either proportional or automatic.

3.3.2.4 Data Logging

This selections allows the user to enable the Continuous, Auto On/Off or Manual background data logging functions as defined below.

Continuous

Enables the serial port autolog function. When a RFMDgps session is started, data from a current live session is automatically logged (in the background) to the Serial.dat file.

A user log file started in parallel, will not effect the automatic data logging function. Subsequent starts over-write this log file.

Auto On/Off

Enables the serial port autolog function. When a RFMDgps session is started, data from a current live session is automatically logged (in the background) to the Serial.dat file.

A user log file started in parallel, will stop the automatic data logging function. The background logging will commence (over-writing the Serial.dat file) when the user data logging is stopped.

Manual

The automatic background data logging function is disabled. User data logging is the only logging function available.

3.3.2.5 Configure RFMDgps

This selection allows the user to configure the RFMDgps initial settings for Data Logging and Startup conditions.

Data Logging

Selecting the Data Logging tab open the RFMDgps Setup window, shown below. This function allows the user to enable/disable the background data logging function. Press the Save button to update.

Parameter	Description
Data Logging Directory	This area allows the user to select the default data logging directory. This directory will store the file defined in the *Default: Log file name* section of this screen. **Note:** The directory selection will be listed to the right of the text, *Data Save Directory*.
Prompt for Log File Save	Always on Exit. A save to file prompt will be displayed upon every session exit.
	On Start. A save to file prompt will be displayed on every session start-up.
	None. No prompts will be displayed.
Default Log File Name	Allows the user to define the log file name.
Logging Mode	Continuous. Enables the serial port autolog function. When a RFMDgps session is started, data from a current live session is automatically logged (in the background) to the Serial.dat file. A user log file started in parallel, will not effect the automatic data logging function. Subsequent starts will overwrite this log file.
	Auto On/Off. Enables the serial port autolog function. When a RFMDgps session is started, data from a current live session is automatically logged (in the background) to the Serial.dat file. A user log file started in parallel, will stop the automatic data logging function. The background logging will commence (over-writing the Serial.dat file) when the user data logging is stopped.
	Manual. The automatic background data logging function is disabled. User data logging is the only logging function available.

Startup

Selecting the Startup tab will bring up the RFMDgps Setup window, shown below. Press the Save button to confirm the updates.

This function allows the user to define the RFMDgps evaluation program’s start-up configuration for subsequent sessions.

Parameter	Description
Start Up	Auto Run on start up. Automatically starts the communication interface on subsequent sessions.
	Lost Comm Warning. A warning message is automatically displayed whenever communication port data is not present.
Message Format	Binary. Enables the message interface for Binary messages on subsequent sessions.
	NMEA. Enables the message interface for Binary messages on subsequent sessions.

3.3.3 Receiver Configuration Selections

The following selections; Reset Receiver, Initialize Receiver, Clear Ephemeris and DGPS Com Port are available from the Main Menu, under *Receiver Config*.

3.3.3.1 Reset Receiver

This selection allows the user to reset the receiver and command the following start-up modes; Hot Start, Warm Start and Cold Start are defined below.

Hot Start

This selection commands a software reset. If the receiver was previously in a valid navigation mode, the following data will remain valid: position, time, ephemeris, almanac and frequency standard parameters.

Warm Start

This selection commands a warm start reset. If the receiver was previously in a valid navigation mode, the following data will remain valid: position, time, almanac and frequency standard parameters.

Cold Start

This selection commands a cold start reset. Almanac and frequency standard parameters will be maintained.

3.3.3.2 Initialize Receiver

This selection allows the user to initialize the receiver with position (latitude, longitude and altitude) and time information. The Binary and NMEA initialization modes are defined below.

Binary Mode

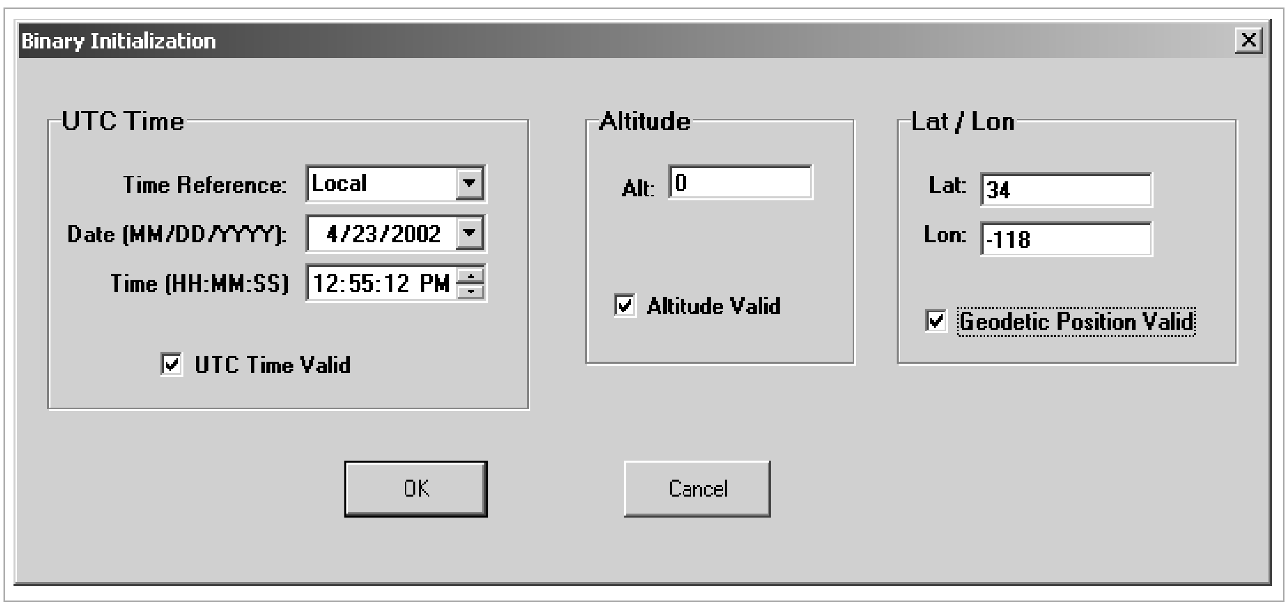
Initializing the receiver in Binary mode will bring up the Binary Initialization window, shown below. This window allows the user to input UTC Time, Altitude and/or Latitude/Longitude data. The user can choose to update any or all of the data entered by selecting the validity boxes located below each section.

Only the sections selected will get updated to the receiver. Press OK to confirm the selections.

Note:

1. The receiver will not accept UTC time information if it is already tracking a satellite and has already collected time information. The receiver will not accept position (Altitude and Lat/Lon) information if it is already in a valid navigation state.
2. The user entered position should be accurate to within 100 km. The time should be accurate to within five minutes.
3. It is not necessary to enter initialization data to begin a session. The receiver is able to completely initialize itself by tracking satellites. Initializing the receiver simply accelerates the process.

Once a satellite navigational solution is obtained, the receiver stores the new position to memory, provided the position change is greater than 50 km. Almanac data is updated in memory when the almanac is greater than one week old. Ephemeris data is stored in memory (> V4.3.0), so the receiver will go into a hot start when the receiver power is cycled (off for < 2 hours) and battery backup power to the real time clock (RTC) is maintained.



NMEA Mode

Initializing the receiver in NMEA mode will bring up the Receiver Initialization window, shown below. This window allows the user to input UTC Time, Altitude and/or Latitude/Longitude data.

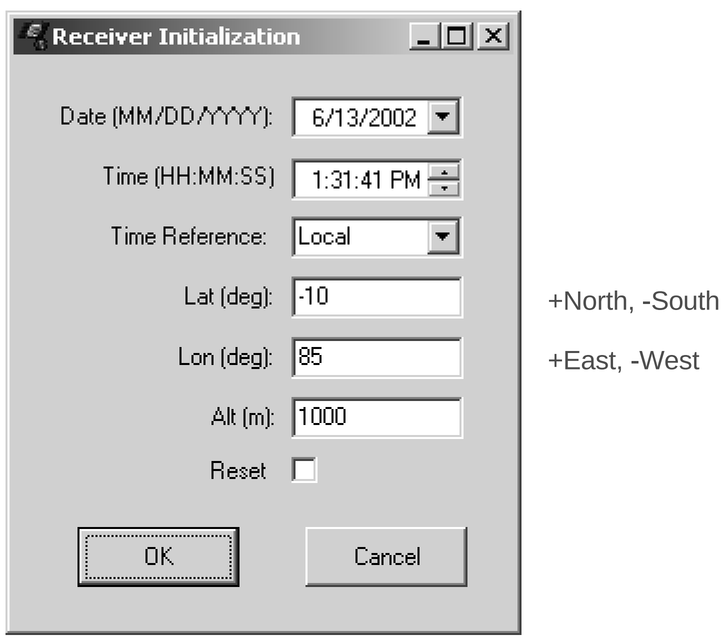
The Reset box located at the very end of the list, will force a software reset after the initialization data has been updated to the receiver. This function does not clear any of the data but it will clear and restart the satellite search process.

Press OK to confirm the selections.

Note:

1. The receiver will not accept UTC time information if it is already tracking a satellite and has already collected time information. The receiver will not accept position (Altitude and Lat/Lon) information if it is already in a valid navigational state.
2. The user entered position should be accurate to within 100 km. The time should be accurate to within five minutes.
3. It is not necessary to enter initialization data to begin a session. The receiver is able to completely initialize itself by tracking satellites. Initializing the receiver simply accelerates the process.

Once a satellite navigational solution is obtained, the receiver stores the new position to memory, provided the position change is greater than 50 km. Almanac data is updated in memory when the almanac is greater than one week old. Ephemeris data is stored in memory (> V4.3.0), so the receiver will go into a hot start when the receiver power is cycled (off for < 2 hours) and battery backup power to the real time clock (RTC) is maintained.



3.3.3.3 Clear Ephemeris (Binary Mode Only)

This selection allows the user to clear all stored ephemeris data.

The receiver stores Ephemeris data to non-volatile memory. When the receiver is powered off and battery power is maintain, the receiver will use the stored Ephemeris data to reduce the time to first fix (TTFF).

Note: The Ephemeris data is only useful for up to 2 hours.

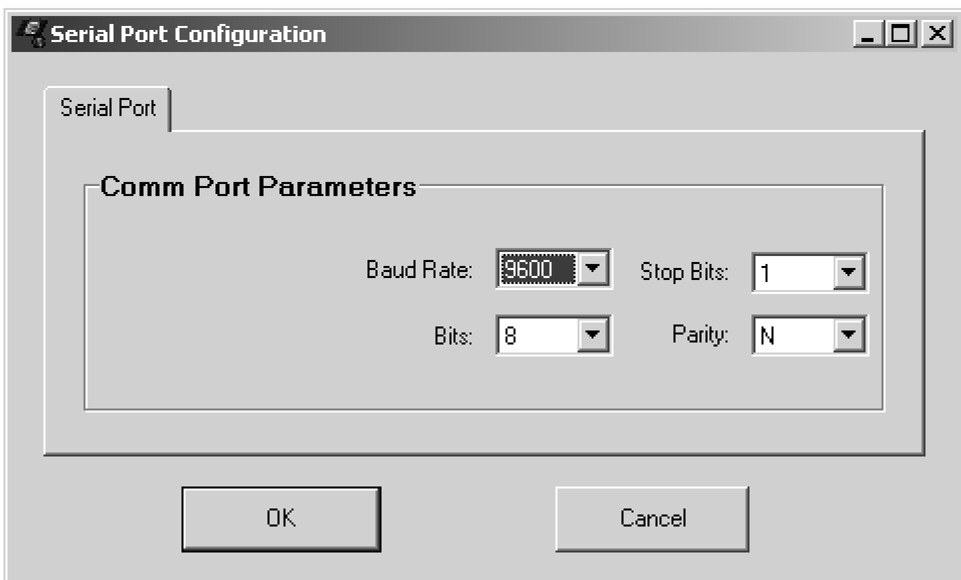
Note: NMEA Ephemeris clear can be accomplished by commanding a Warm or Cold Start reset.

3.3.3.4 Differential GPS (DGPS) Communication Port

This selection allows the user to configure the receivers port 2 settings. When selected the Serial Port Configuration window, shown below, opens. Select the serial port settings necessary to communicate to the DGPS transceiver. Press the OK button to confirm the selection.

The receiver's default settings for port 2 are as follows:

Baud	9600 bps
Parity	None
Data Bits	8
Stop Bits	1



3.3.4 Receiver Message Options

The following selections; Message Type, Output Msg Config, ALM/EPH/UTC and Built-in-Test (BIT) are available from the Main Menu, under *Message Options*.

3.3.4.1 Message Type

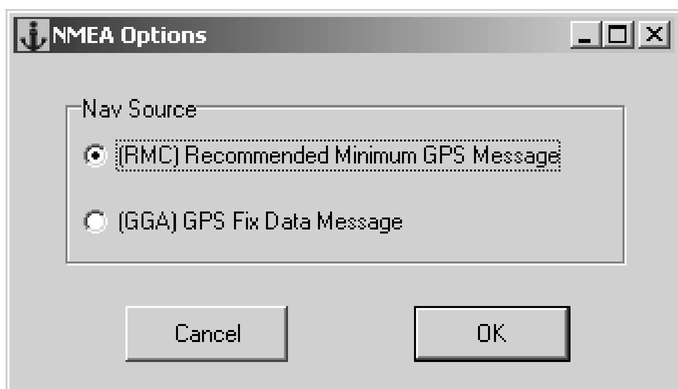
This selection allows the user to change the receivers message protocol type between Binary and NMEA mode. The message protocol selections for Binary and NMEA are defined below.

Binary Mode

Selecting Binary will automatically configure the receiver to output Binary messages as defined in Section *3.3.4.2 Output Message Configuration* on page 48.

NMEA Mode

Selecting NMEA opens the NMEA Options window, shown below. This allows the user to select the message source for navigation data information, Recommended minimum GPS message (RMC) or GPS fix data message (GGA). Press the OK button to confirm the selection. The receiver will automatically configure the receiver to output NMEA message as defined in Section *3.3.4.2 Output Message Configuration* on page 48.



3.3.4.2 Output Message Configuration

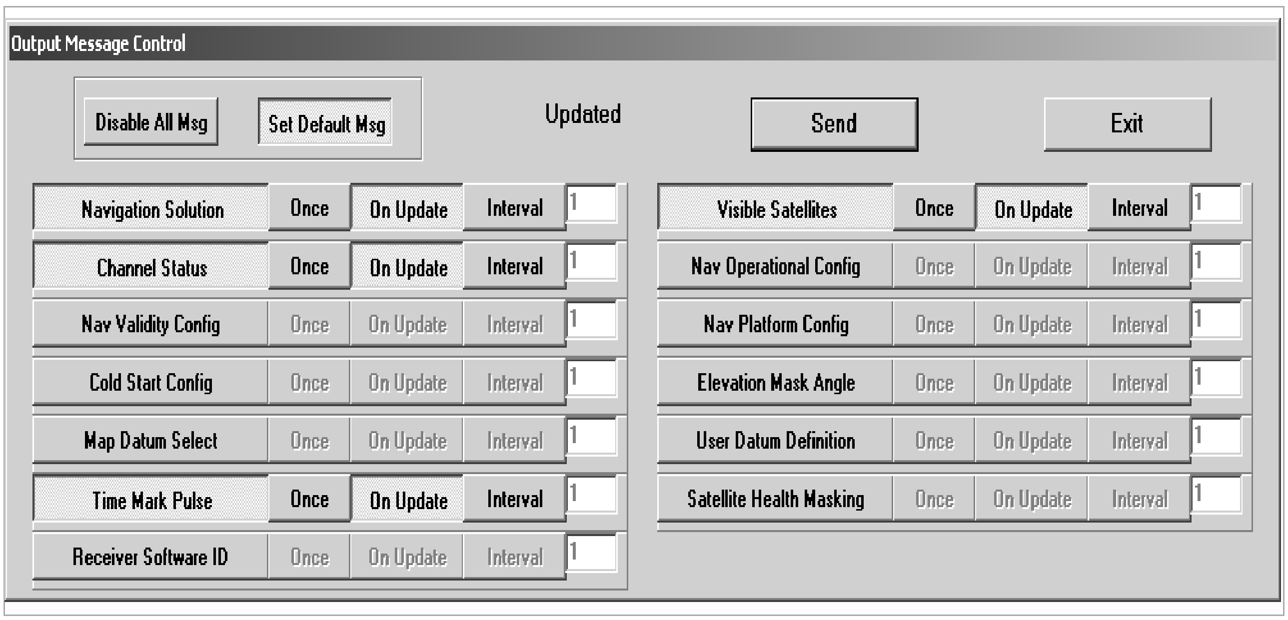
This selection allows the user to enable/disable the receivers output messages and to select their periodicity. The receiver output message configuration for Binary and NMEA are defined below.

The Binary output message definitions are listed in *Section 4.1.1* on page 63. The NMEA-0183 output message definitions are listed in *Section 4.2.1* on page 127.

Binary Mode

Selecting Output Msg Config while in Binary mode, will open the Output Message Control window, shown below. The RFMDgps tool will poll the receiver and display the current log configuration. To turn off a message deselect the message button and press. To turn on a message select the message button and the update mode type. Pressing the Send button will confirm the selections and store the new settings into non-volatile memory of the receiver.

Note: The *Waiting for Update* text in the upper middle section of the window, is displayed when this window first opens. This text is replaced with *Updated*, when the user presses the Send button and the RFMDgps program verifies the receiver output message configuration.



Parameter	Description
Disable All Msg	Turns off all output messages. returns the output message.
Set Default Msg	Returns the output message setting to its factory default settings.
Send	Sends the output message control configuration to the receiver.
Exit	Disables any changes and closes the Output Message Control window.
Messages	Enable each message to be output by the receiver by selecting from the following update modes: Once Outputs the message once On Update Outputs the message only when data has changes Interval Outputs the message at the rate input in the space to the right of this selection (1 = every 1 second).

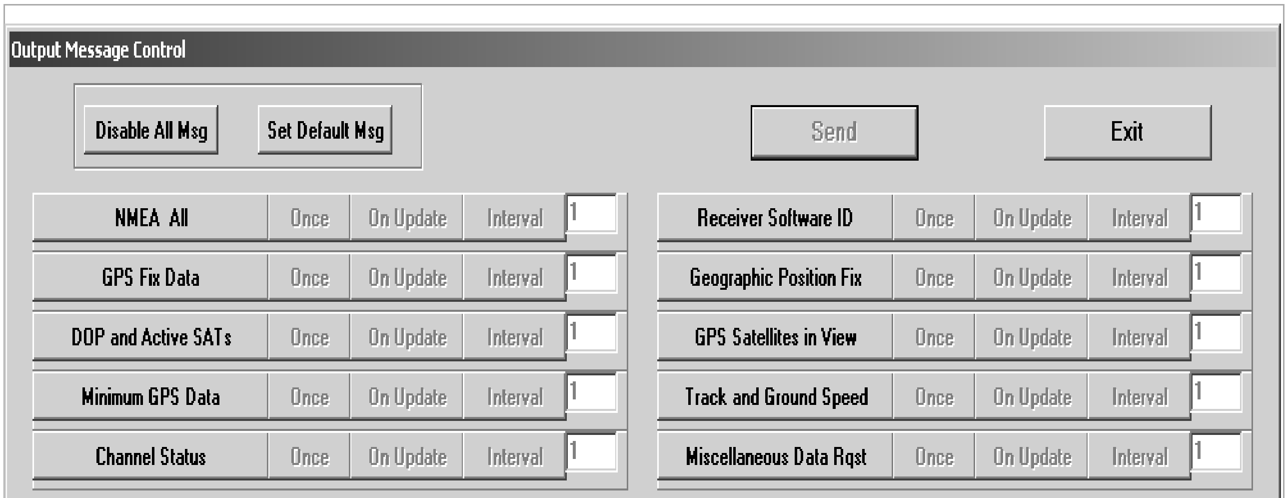
NMEA Mode

Selecting Output Msg Config while in NMEA mode, will open the Output Message Control window, shown below. Pressing the Send button confirms the selections.

The only way to turn off a NMEA message is to select the Disable All Msg button followed by the Send button. Then select the messages and their update modes. Press the Send to confirm the select.

Note: Selecting the window will not show the current output message configuration because the NMEA message set does not include a output log message. Therefore, the tool is not able to poll the receiver and view the current message log configuration.

The receiver will automatically start outputting the messages as defined by the user. The receiver will also store the new settings into non-volatile memory.



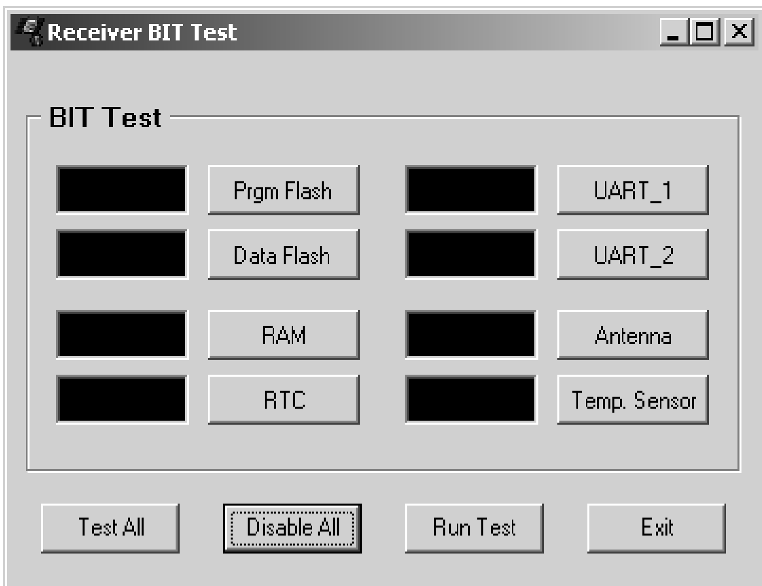
Parameter	Description
Disable All Msg	Turns off all output messages. returns the output message.
Set Default Msg	Returns the output message setting to its factory default settings.
Send	Sends the output message control configuration to the receiver.
Exit	Disables any changes and closes the Output Message Control window.
Messages	Enable each message to be output by the receiver by selecting from the following update modes: Once Outputs the message once On Update Outputs the message only when data has changes Interval Outputs the message at the rate input in the space to the right of this selection (1 = every 1 second).

3.3.4.3 Built-in-Test (BIT)

This selection allows the user to request a Built-in-Test. When selected the Receiver BIT Test window, shown below, opens and displays the selectable tests; Program Flash, Data Flash, RAM, RTC, UART_1, UART_2, Antenna Sense and Temperature Sensor. Pressing the Run Test button will start the selected tests. The pass/fail test results will come back and be visible in the area to the left of the selection buttons.

Note: The Antenna Sense circuit is an optional hardware feature, not available on all modules

Note: The UART_2 test checks for data coming in on the port 2 (currenlty not implemented).



Parameter	Description
Prgm Flash	Program Sector of Flash. When selected, a flash program space checksum validation will be performed.
Data Flash	Data Sector of Flash. When selected, a flash data space checksum validation will be performed.
RAM	Random access memory. When selected, operational software will validate that the internal SRAM is functional.
RTC	Real time clock. When selected, successful incrementing of the RTC will validate functionality
UART_1	UART Port 1. When selected, successful receiving and transmitting of data over the serial port 1 will validate functionality.
UART_2	UART Port 2. When selected, successful receiving of data over the serial port 2 will validate functionality.
Antenna	Antenna Sense. When selected, the hardware GPIO will be polled to determine if the circuit is functional, (pass), drawing too much current (short), or drawing no current (open). **Note:** The Antenna Sense Circuit is an optional hardware feature, not available on all modules.
Temp Sensor)	Temperature Sensor. When selected, an in-range temperature reading from the RF IC will validate functionality.
Test All	When selected, will enable all the tests for the user.
Disable All	When selected, will disable all the test enabled by the user.
Run Test	When selected, will run the BIT on all the tests enabled by the user.

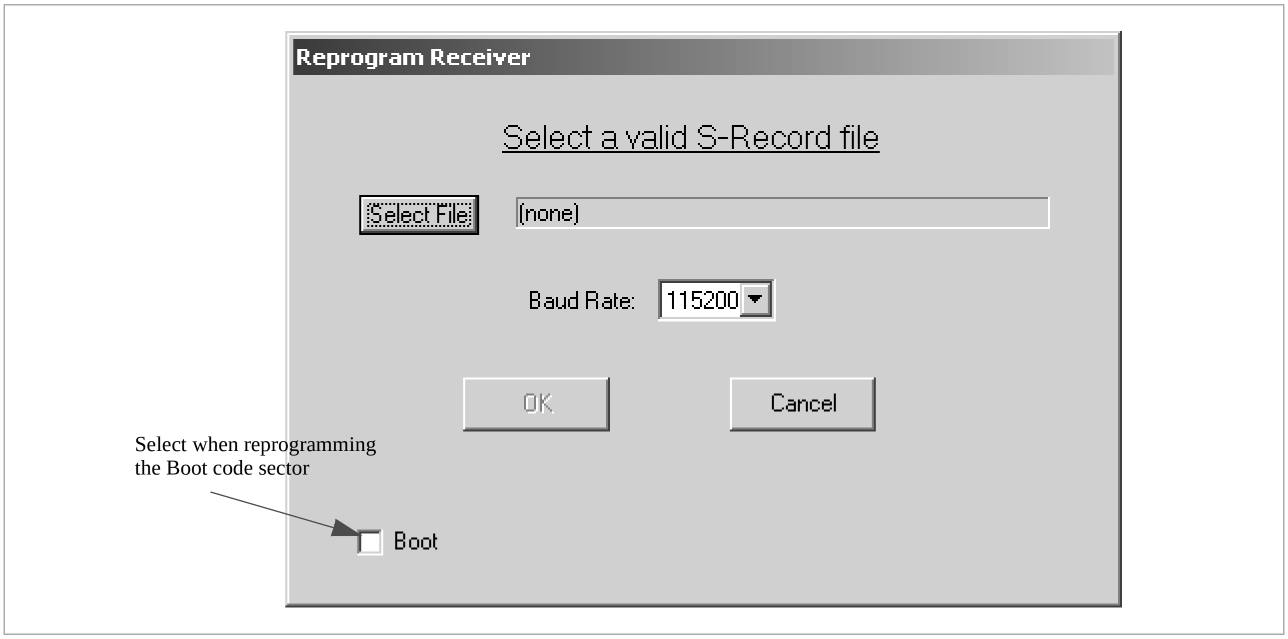
3.3.5 Receiver Modes

The following selections; Program Receiver, Live Receiver Comm and Playback from a File are available from the Main Menu, under *Mode*.

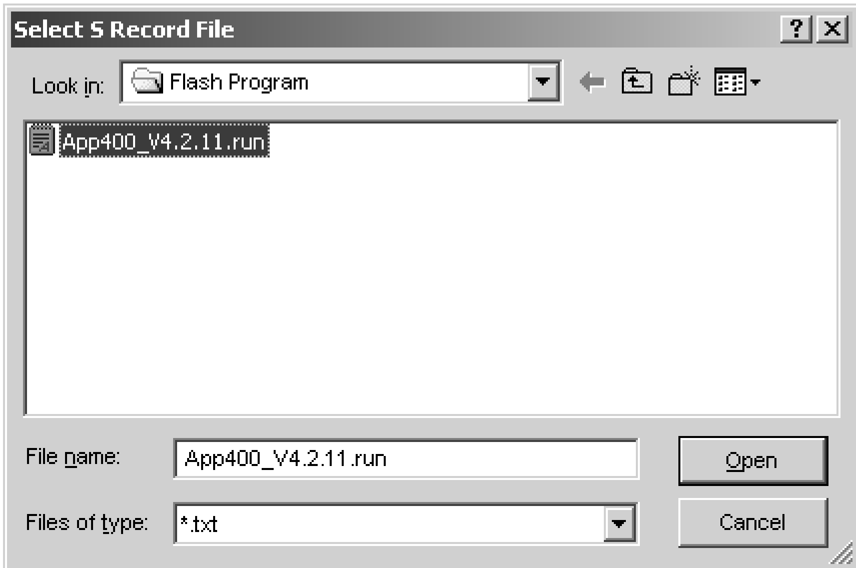
3.3.5.1 Program Receiver (Binary Mode Only)

This selection allows the user to reprogram the receiver. When selected the Reprogram Receiver window, shown below, opens. This window allows the user to select the S-record boot or program code file and the baud rate to reprogram the receiver.

Note: The receiver **MUST** be configured in Binary mode (19200,N,8,1) prior to reprogramming.



Press the Select File button, to open the Select S-Record File window, shown below. Use the browsing function to locate and select the application or boot code file to be uploaded to the receiver.

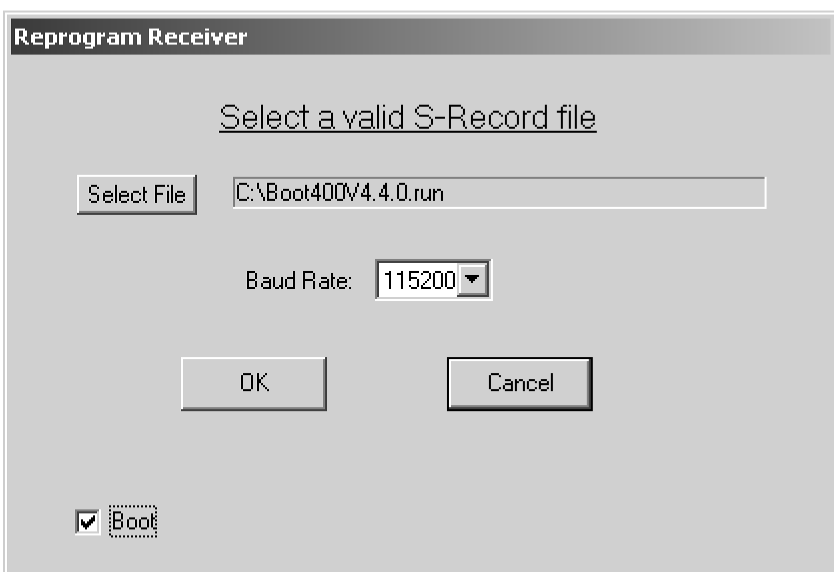


Press the Open button to go back to the Reprogram Receiver, shown below. Verify the file listed to the right of the Select File tab is the correct S-record file.

Select the Baud rates from reprogramming. Baud rates up to 115200 bps can be selected for reprograming.

Note: The reprogramming baud rate selection will not change the receivers baud rate settings.

Press the OK button to start the reprogramming session.

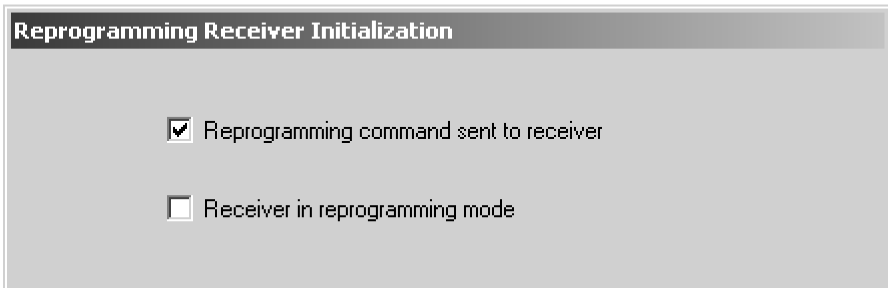


When reprograming the boot sector make sure to check the *Boot* box located in the lower left hand corner.

Note: When updating Boot code, make sure to reprogram the Boot code sector first.

Note: If multiple updates are required, it is necessary to start another program session for each update. Select the Program tab or select Mode - Program Rcvr from the Main Menu to start code sector update.

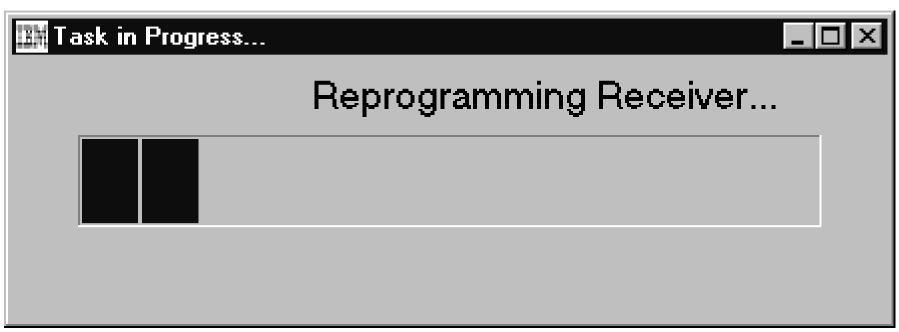
When the OK button is pressed, the Reprogramming Receiver Initialization window, shown below, is displayed while the receiver erases its flash memory.



Once the flash sector erase is complete, the application will automatically start reprogramming the receiver. The Task in Progress window, shown below, is displayed until the upload is complete.

The receiver will automatically start outputting messages, based on the last user configuration settings.

Note: Upon completion of a reprogramming session, select of the Live Comm tab or select Mode - Live Receiver Comm from the Main Menu to start a new session. See “Live Receiver Communication” on page 54 for more details. If the receiver is not outputting messages, cycle power and confirm the version information matches the code uploaded.



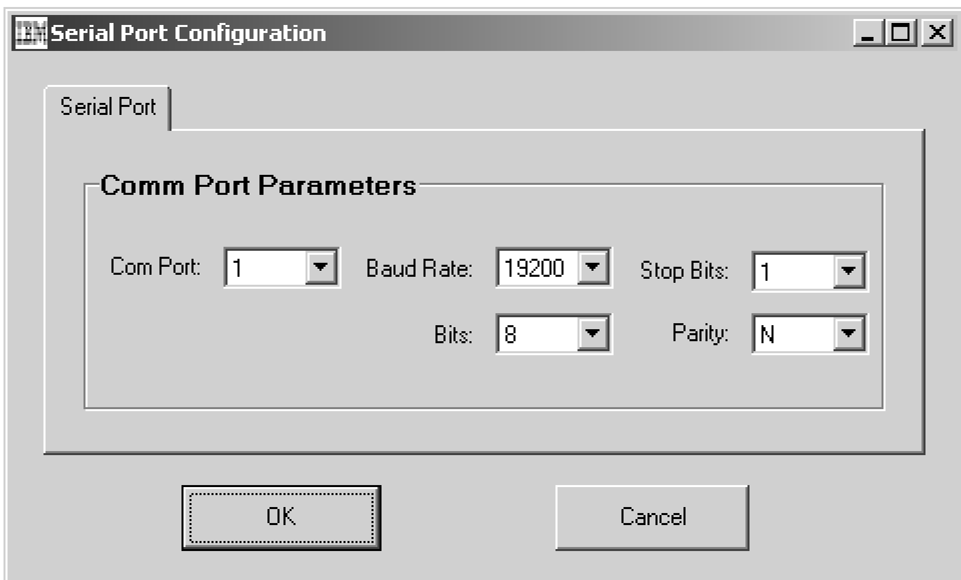
3.3.5.2 Live Receiver Communication

This selection starts a live receiver session by setting up the communication between the Receiver and the PC. This function is also used to make changes to the receivers communication port settings.

When selected the Serial Port Configuration window, shown below, opens. Select the PC serial port settings necessary to communicate to the receiver and press the OK button to confirm the selection. The receiver's default settings are as follows:

Baud	19200 bps
Parity	None
Data Bits	8
Stop Bits	1

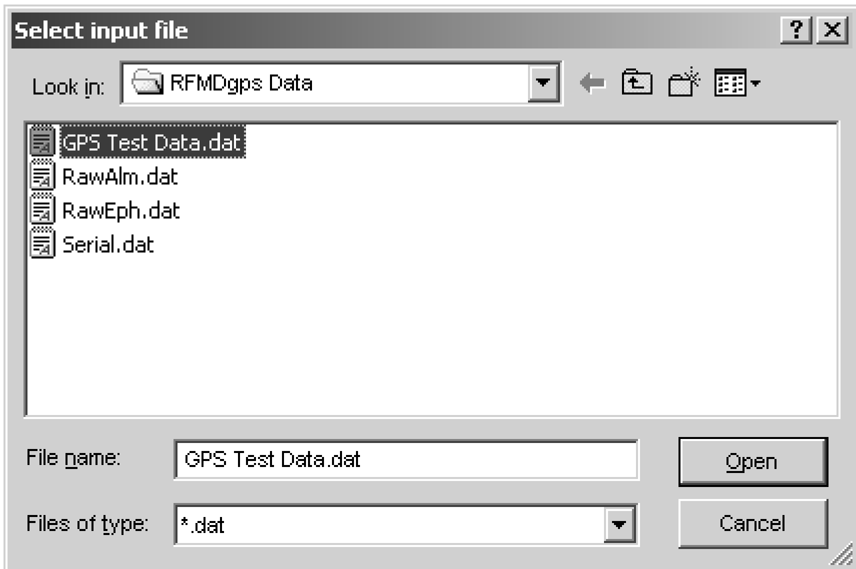
Note: The user entered Comm Port parameters will configure both the Receiver and the PC port settings.



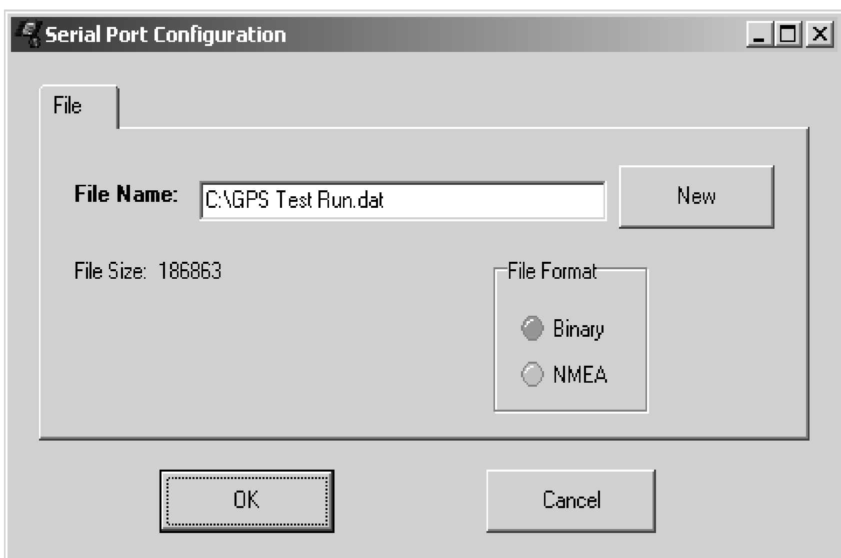
Once the port settings are selected, the Input Format window, shown below, opens. Select the input message format and press "OK" to confirm the selection.

3.3.5.3 Playback from File

This selection allows the user to playback and view a previously saved session. When selected the Select Input File window, shown below, opens allowing the user to select the desired playback file.



Select the playback file then press the Open button. The Serial Port Configuration window, shown below, opens.



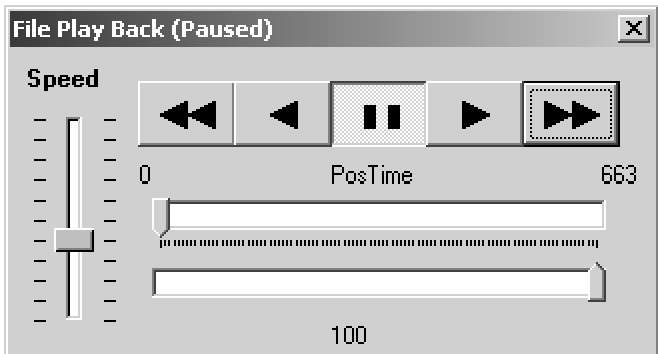
Parameter	Description
File Name	Displays the filename and directory path selected.
File Size	Displays the file size in bytes.
File Format	Displays the file message protocol format.

Pressing the OK button will open the File Play Back window, shown below.

This window comes up in a paused state. To start the playback session press the paused (depressed) button. The speed can also be controlled with the slide tab on the left of the window.

This window shows the number of bytes in the file and the location that the playback is into the file.

When a playback file is opened, the very top line of the RFMDgps Main window will display the file directory and filename.



3.3.6 Help

The following selections; RFMDgps Help and About are available from the Main Menu, under *Help*.

3.3.6.1 RFMDgps Help

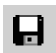
This selection loads the RFMD GPS User Manual (this document) in a pdf format for ease of reference during RFMDgps program operation.

3.3.6.2 About

This selection allows the user to view the RFMDgps version and date information. When selected the About RFMDgps window, shown below, opens. Pressing the OK button will close this window.

3.4 Main Toolbar Selections

The Main toolbar is located in the same row as the large RFMD logo and displays the icons described below.

Icon	Function	Description
	Save to File	Opens the select output file window and allows the user to save data from a current session to a file. See section *3.3.1.1 Log to File* on page 37.
Stop | Pause	Stop - Pause	Stop. Turns On / Off data updates, during a current session. Pause. Toggles between pausing and resuming data updates, during a current session. **Note:** This function has no effect on the data logging functions.
	Play Back	Opens the select input file window and allows the user to select a previously logged data file The serial port configuration window opens, showing the file selected and protocol used. The file play back window will open in a paused state. Starting the playback sessions require the user to press the pause/run button. See section *3.3.5.3 Playback from File* on page 55
	Live Comm	Opens the serial port configuration window and allows the user to start a session and configure the PC serial port. See section *3.3.5.2 Live Receiver Communication* on page 54.
	Program Receiver	Opens the reprogram receiver window and allows the user to reprogram the receiver with a valid S-Record file. See section *3.3.5.1 Program Receiver (Binary Mode Only)* on page 51. **Note: Receiver must be in Binary mode (19200,N,8,1) for reprogramming.**
	Initialize Receiver	Opens either the Binary initialization window, if the receiver is in Binary mode, or the receiver initialization window, if the receiver is in NMEA mode. Allows the user to initialize the receiver with position, velocity and time data. See sections *3.3.3.2 Initialize Receiver* on page 44.
	Hot Start	Hot Start. Commands a hot start, software reset. See section *Hot Start* on page 43.
	Warm Start	Warm Start. Commands a warm start, clears all RAM data. See section *Warm Start* on page 43.
	Cold Start	Cold Start. Commands a cold start, clears all RAM, RTC and position data. See section *Cold Start* on page 43.
Idle	Current Mode Indication	Displays the current receiver mode. Toggles between; Idle, Live Comm, Program Unit and Read from a File.

3.5 Right Mouse Button Selections

Clicking on the right mouse button, while in the main window area, will bring up the following selections:

Function	Description
Autoscale	Autoscales the position data in the ground track window.
Clear Data	Clears the position data in the ground track window.
Save as BMP	Saves the open window information as a bit map file.
Save to clip board	Saves the open window information to the clip board.

3.6 Troubleshooting

The following step are provide to help address minor problems that you may experience with the RFMDgps evaluation tool. If further help is required, please contact the RFMD support desk.

3.6.1 RFMDgps Program Locks-Up

If the RFMDgps evaluation tool locks up and is not recoverable through a system reboot. Perform the following steps:

1. Select the Windows Start Menu.
2. Select Run. Type REGEDIT into the *Open:* field.
3. Open the file path: Current_User\software\RFMDgps
4. Delete all the contents in the RFMDgps directory.
5. Close the Registry window and re-run the RFMDgps program. The RFMDgps setup window will be displayed.

3.6.2 Configure Receiver back to Factory (ROM) Defaults

If the RFMDgps evaluation tool is seeing messages coming in on the serial port, but is unable to decode them you may want to set the receiver back to its facoty default setting. This will enable the tool to reestablish communication.

To set the receiver back to its factory settings, perform the following steps.

1. Turn off the Evaluation Unit power switch.
2. Press and hold switch SW3, see *Figure 2.1: GPS Evaluation Unit Circuit Board Diagram* on page 16.
3. While holding the switch down, turn on the Evaluation Unit power switch.
4. Release the switch. The unit will now be in its factory default state (Binary,19200,N,8,1).

4. Message Protocols and Formats

This section describes the communication protocols used by the RFMD GPS receiver. Serial port 1 supports Binary or national marine electronics association (NMEA)-0183 messages. The Binary messages are described in *Section 4.1* on page 61. The NMEA-0183 messages are described in *Section 4.2* on page 126.

Serial port 2 supports Radio Technical Commission for Maritime Services (RTCM) messages. RTCM SC-104 Differential GPS (DGPS) correction messages are described in *Section 4.3* on page 147.

4.1 Binary Messages

This section describes the Binary messages supported by the RFMD GPS receiver.

Binary is the receiver default input/output communication setting. The Binary messages are transmitted and received across serial port 1 with the following parameters:

Baud:	19200 bps
Data Bits:	8
Parity:	None
Stop Bits:	1

The output Binary messages are defined in section *4.1.1 Binary Output Messages* on page 63. The input Binary messages are defined in section *4.1.2 Binary Input Messages* on page 96.

Note: The following definitions apply and are followed throughout the Binary message definition.

Scale Factor is the number by which the receiver multiplies the parameter to give the true value. Scaling allows the computer to perform high precision calculations using integer numbers.
Bits are represented in the format byte#.bit#. For example: 38.4 is bit 4 of byte 38.

Source Data is the location where the receiver obtains valid information. The following is a list of sources where the receiver can obtain valid data:

0	Invalid (Data is Invalid)
1	ROM (Read Only Memory)
2	EEPROM (Electrically Erasable Programmable ROM)
3	RAM (Random Access Memory)
4	User (User Entered Data)
5	RTC (Real Time Clock)
6	NAV (Navigation Data)

The Binary data messages consist of a variable number of Binary characters. Each message begins with the ASCII characters “$IBM” and are terminated with an “*” followed by the checksum. Every message has the following structure:

Field Name	Field Format	Field Description
MSG START	$IBM	Denotes the start of a Binary message.
TALKER ID	I/O	One letter that indicates input or output.
MSG ID	XXX	Three letters that identify the Binary message.
MSG LENGTH	XX	Message length is represented by two Binary bytes.
MSG BODY	N	A variable number of bytes of Binary data.
ASTERISK	“*”	The checksum delimiter.
CHECKSUM	CS	Two ASCII characters that denote the hexadecimal value of the checksum. (Exclusive-Or of the bytes between the dollar sign, “$”, and the asterisk, “*”). **Note:** All ASCII characters must use upper case letters.
MSG END	<CR><LF>	Carriage return, <CR>, and line feed, <LF>, terminate the message.

4.1.1 Binary Output Messages

The following table lists supported Binary output messages.

The receiver's output message configuration can be changed using the Binary input message, ILOG. See "Message ILOG: Message Log Control" on page 121.

Binary Message	Description	Default	See Page
ONVD	Navigation solution data.	On	64
OSAT	Visible satellites.	On Update (typical 30 second updates)	67
OCHS	Channel status.	On	68
ODGS	Differential GPS (DGPS) status.	Off	69
ODGC	Differential GPS (DGPS) configuration.	Off	70
ONOC	Navigation operational configuration.	Once at power-up and/or reset	71
ONVC	Navigation validity configuration.	Once at power-up and/or reset	72
ONPC	Navigation platform configuration.	Off	73
OCSC	Cold start configuration.	Once at power-up and/or reset	74
OEMA	Elevation mask angle configuration.	Once at power-up and/or reset	75
ODTM	Map datum select.	Once at power-up and/or reset	76
ODTU	User datum definition.	Off	77
OTMP	UTC time mark pulse.	On	78
OALD	Download almanac data.	Off	79
OEPD	Download ephemeris data.	Off	81
OUTD	Download UTC/IONO data.	Off	87
OSHM	Satellite health masking configuration.	Off	90
OSID	Receiver software ID.	Once at power-up and/or reset	91
OBIT	Built-in-test results.	Off	92
OFSH	Command flash upload (ACK).	Off	94
OBID	Receiver boot code ID.	Once at power-up and/or reset	95

4.1.1.1 Message ONVD: Navigation Solution Data

This message outputs the receiver's estimate of navigation solution for time and position data.

The navigational validity settings of this message can be changed using the Binary input message, INVC. See "Message INVC: Navigation Validity Configuration" on page 101.

The polar navigation bit is used to indicate that the receiver is too close to the north or south pole to estimate longitude. Earth centered earth fixed (ECEF) position data should be used when operating near the poles.

Byte(s)	Description	Units	Range		Scale Factor[1]
			Min	Max	
1:4	Message start: $IBM.				
5:8	Message ID: ONVD.				
9:10	Message length: 168 bytes.				
GPS Time					
11:14	GPS seconds from epoch.	seconds	0	604,799	1
15:18	GPS nanoseconds from epoch.	nanoseconds	0	9999 99999	1
19:20	GPS week number.	weeks	0	current week	1
21:22	Reserved.				
Coordinated Universal Time (UTC)					
23:26	UTC nanoseconds.	nanoseconds	0	99999 9999	1
27:28	UTC year.	year	1980	2099	1
29	UTC month.	months	1	12	1
30	UTC day.	days	1	31	1
31	UTC hours.	hours	0	23	1
32	UTC minutes.	minutes	0	59	1
33	UTC seconds.	seconds	0	59	1
34	Reserved.				
Geodetic Position					
35:42	Latitude.	radians	0	$\pm \pi/2$	DF
43:50	Longitude.	radians	0	$\pm \pi$	DF
51:54	Altitude (height above ellipsoid).	meters	-305	18,000	SF
55:58	Ground speed (velocity).	meters/second	0	515	SF
59:62	Heading (course).	radians	0	2π	SF
63:66	Climb rate.	meters/second			SF
67:70	Geoidal separation.	meters			SF

1. The Scale factor is the number by which the receiver multiplies the parameter to give the true value.
   DF: IEEE Double float
   SF: IEEE Single float

Byte(s)	Description	Units	Range		Scale Factor[1]
			Min	Max	
Earth Centered Earth Fixed (ECEF) Position					
75:82	ECEF X position.	meters			DF
83:90	ECEF Y position.	meters			DF
91:98	ECEF Z position.	meters			DF
99:102	ECEF X velocity.	meters/second	0	515	SF
103:106	ECEF Y velocity.	meters/second	0	515	SF
107:110	ECEF Z velocity.	meters/second	0	515	SF
111:114	Reserved.				
Clock Errors					
115:122	Clock bias.	meters	0	299,792	DF
123:130	Clock drift.	meters/second			DF
131:134	Clock bias variance.	$meters^2$			
135:138	Clock drift variance.	$(meters/second)^2$			
139:142	HPE variance.	meters			
143:146	VPE variance.	meters			
147:150	HVE variance.	meters/second			
151:154	User time count.	lsb = 10 ms			
Navigation Solution Validity					
155.0	GPS time valid. 1 true 0 false		0	1	
155.1	Navigation solution valid. 1 true 0 false		0	1	
155.2	DGPS solution valid. 1 true 0 false		0	1	
155.3	Least squares estimate (LSE) navigation. 1 true 0 false		0	1	
155.4	Kalman navigation. 1 true 0 false		0	1	
155.5	Self-survey navigation (not supported). 1 true 0 false		0	1	

1. The Scale factor is the number by which the receiver multiplies the parameter to give the true value.
DF: IEEE Double float
SF: IEEE Single float

Byte(s)	Description	Units	Range		Scale Factor[1]
			Min	Max	
155.6	Stationary navigation (not supported). 1 true 0 false		0	1	
155.7	2D navigation. 1 true 0 false		0	1	
156.0	3D navigation. 1 true 0 false		0	1	
156.1	Propagated solution. 1 true 0 false		0	1	
156.2	Polar navigation. 1 true 0 false		0	1	
156.3	Altitude required (3D navigation only). 1 true 0 false		0	1	
156.4:156.7	Reserved.				
Datum and Satellites Used					
157:158	Datum ID.		0-188	200-204	
159:160	Number of satellites used.		0	12	
Dilution of Precision					
161:162	Geometric dilution of precision (GDOP).		0	2^{16}	100
163:164	Position dilution of precision (PDOP).		0	2^{16}	100
165:166	Time dilution of precision (TDOP).		0	2^{16}	100
167:168	Horizontal dilution of precision (HDOP).		0	2^{16}	100
169:170	Vertical dilution of precision (VDOP).		0	2^{16}	100
171:178	Reserved.				
179	* Checksum delimiter.				
180:181	CS.				
182:183	Message end. Carriage return <CR> and line feed <LF> terminate the message.				

1. The Scale factor is the number by which the receiver multiplies the parameter to give the true value.
   DF: IEEE Double float
   SF: IEEE Single float

4.1.1.2 Message OSAT: Visible Satellites

This message outputs a list of satellites visible to the receiver, given a clear view of the sky, along with their azimuths and elevations. The Dilutions of Precision (DOPs) provided is calculated based on the satellites used to determine the navigation solution.

Byte(s)	Description	Units	Range		Scale Factor[1]
			Min	Max	
1:4	Message start: $IBM.				
5:8	Message ID: OSAT.				
9:10	Message length: 60 bytes.				
Dilution of Precision					
11:12	Geometric dilution of precision (GDOP).		0	2^{16}	100
13:14	Position dilution of precision (PDOP).		0	2^{16}	100
15:16	Horizontal dilution of precision (HDOP).		0	2^{16}	100
17:18	Vertical dilution of precision (VDOP).		0	2^{16}	100
19:20	Time dilution of precision (TDOP).		0	2^{16}	100
Visible Satellites					
21 + (x*4): 22 + (x*4)	Satellite azimuth.	degrees	-180	180	
23 + (x*4)	Satellite elevation.	degrees	0	90	
24 + (x*4)	Satellite PRN.		1	32	1
69	Number of visible satellites.		1	12	1
70	IODE: Issue of data ephemeris.		0	255	1
71	* Checksum delimiter.				
72:73	CS Two ASCII characters denoting the hexadecimal value of the checksum.				
74:75	Message end. Carriage return <CR> and line feed <LF> terminate the message.				

1. The Scale Factor is the number by which the receiver multiplies the parameter to give the true value.
2. ‘x’ represents the number of satellites tracked (0-11).

4.1.1.3 Message OCHS: Channel Status

For each satellite tracked, this message outputs the receiver's channel status information, giving the user an indication of signal strength and measurement validity.

Byte(s)[1]	Description	Units	Range	
			Min	Max
1:4	Message start: $IBM.			
5:8	Message ID: OCHS.			
9:10	Message length: 60 bytes.			
GPS Time				
11:14	GPS seconds from epoch.	seconds	0	604,799
15:18	GPS nanoseconds from epoch.	nanoseconds	0	99999 9999
19:20	GPS week number.	weeks	0	current week
21:22	Reserved.			
Channel Summary Data (per satellite)				
23 + (x * 4): 24 + (x * 4)	Carrier to Noise ratio (C/N0). **Note:** Use the following formula to convert this number: dB Hz = 10 log (C/N0C/N0) + 16		16	2500
25 + (x * 4)	Satellite pseudorandom noise (PRN).		1	32
26.0 + (x * 4)	Satellite measurement use. 1 true 0 false		0	1
26.1 + (x * 4)	Ephemeris available. 1 true 0 false		0	1
26.2 + (x * 4)	Measurement valid. 1 true 0 false		0	1
26.3 + (x * 4)	Differential GPS (DGPS) corrections available. 1 true 0 false		0	1
26.4 + (x * 4): 26.7+ (x * 4)	Reserved.			
71	* Checksum delimiter.			
72:73	CS Two ASCII characters denoting the hexadecimal value of the checksum.			
74:75	Message end. Carriage return <CR> and line feed <LF> terminate the message.			

1. ‘x’ represents the number of satellites tracked (0-11).

4.1.1.4 Message ODGS: Differential GPS (DGPS) Status

This message outputs the receiver's DGPS status information, based on the last set of corrections received from the DGPS transceiver.

Byte(s)[1]	Description	Units	Range	
			Min	Max
1:4	Message start: $IBM.			
5:8	Message ID: ODGS.			
9:10	Message length: 52 bytes.			
DGPS Satellite Status				
11 + (x * 4): 12 + (x * 4)	Age of Correction.	seconds	0	255
13 + (x * 4)	Satellite PRN.		1	32
14.0 + (x * 4)	Correction Used. 1 true 0 false		0	1
14.1 + (x * 4)	Correction Available. 1 true 0 false		0	1
14.2 + (x * 4)	Issue of Data (IOD) match. 1 true 0 false		0	1
14.3 + (x * 4): 14.4 + (x * 4)	User Differential Range Error (UDRE). 00 ≤ 1 meter 01 > 1 meter and ≤ 4 meters 10 > 4 meters and ≤ 8 meters 11 > 8 meters		00	11
14.5 + (x * 4): 14.7 + (x * 4)	Reserved.			
DGPS Station Status				
59:60	Station ID.			
61	Station Healthy. 1 true 0 false		0	1
62	Number of Corrections.		0	12
63	* Checksum delimiter.			
64:65	CS Two ASCII characters denoting the hexadecimal value of the checksum.			
66:67	Message end. Carriage return <CR> and line feed <LF> terminate the message.			

1. 'x' represents the number of satellites tracked (0-11).

4.1.1.5 Message ODGC: Differential GPS (DGPS) Configuration

This message outputs the receiver's settings for DGPS. The DGPS enable indication and the timeout period definition are defined below.

The contents of this message can be changed using the Binary input message IDGC. See "Message IDGC: Differential GPS (DGPS) Configuration" on page 99.

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message start: $IBM.			
5:8	Message ID: ODGC.			
9:10	Message length: 8 bytes.			
DGPS Configuration				
11:14	Source. A complete list of Source Data is located in Section *4.1 Binary Messages* on page 61.		0	6
15:16	DGPS timeout.	seconds	0	255
17.0	DGPS enabled. 1 true 0 false		0	1
17.1	DARC enabled. 1 true 0 false **Note:** Both the DARC and DGPS enabled bits must be selected to support DARC DGPS. The UDRE value will be changed to a value of 2 (binary 10).		0	1
17.2:18	Reserved.			
19	* Checksum delimiter.			
20:21	CS Two ASCII characters denoting the hexadecimal value of the checksum.			
22:23	Message end. Carriage return <CR> and line feed <LF> terminate the message.			

4.1.1.6 Message ONOC: Navigation Operational Configuration

This message outputs the receiver's current operational settings for ground track aesthetics. The minimum signal strength settings are also output.

The contents of this message can be changed using the Binary input message INOC. See "Message INOC: Navigation Operational Configuration" on page 100.

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message start: $IBM.			
5:8	Message ID: ONOC.			
9:10	Message length: 8 bytes.			
Operational Configuration				
11:14	Source. A complete list of Source Data is located in Section 4.1 Binary Messages on page 61.		0	6
15.0	Ground track smooth enabled. 1 true 0 false		0	1
15.1	Position pinning enabled. 1 true 0 false		0	1
15.2:16	Reserved.			
17:18	Minimum carrier to noise (C/N0) threshold. **Note:** Use the following formula to convert this number to dB-Hz. dB-Hz = 10 log (CN0) + 16		16	2500
19	* Checksum delimiter.			
20:21	CS Two ASCII characters denoting the hexadecimal value of the checksum.			
22:23	Message end. Carriage return <CR> and line feed <LF> terminate the message.			

4.1.1.7 Message ONVC: Navigation Validity Configuration

This message outputs the receiver's current navigation validity settings.

The contents of this message can be changed using the Binary input message INVC. See “Message INVC: Navigation Validity Configuration” on page 101.

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message start: $IBM.			
5:8	Message ID: ONVC.			
9:10	Message length: 20 bytes.			
Validity Configuration				
11:14	Source. A complete list of Source Data is located in Section 4.1 Binary Messages on page 61.		0	6
15:18	Maximum expected horizontal position error (EHPE).	meters		
19:22	Maximum expected vertical position error (EVPE).	meters		
23:26	Maximum geometric dilution of precision (GDOP).		0	255
27:28	Minimum number of satellites required. 0 The receiver decides.		0	12
29.0	Altitude use required. 1 True. The receiver is forced to use 3D navigation only. 0 False. The receiver decides whether to use 2D or 3D navigation.		0	1
29.1	DGPS required. 1 true 0 Use if available.		0	1
29.2:30	Reserved.			
31	* Checksum delimiter.			
32:33	CS Two ASCII characters denoting the hexadecimal value of the checksum.			
34:35	Message end. Carriage return <CR> and line feed <LF> terminate the message.			

4.1.1.8 Message ONPC: Navigation Platform Configuration

This message outputs the receiver's current platform setting. This setting indicates whether the receiver is stationary, in use by a pedestrian, or operating in a car, boat or plane.

The contents of this message can be changed using the Binary input message INPC. See “Message INPC: Navigation Platform Configuration” on page 102.

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message Start: $IBM.			
5:8	Message ID: ONPC.			
9:10	Message length: 8 bytes.			
Platform Configuration				
11:14	Source. A complete list of Source Data is located in Section 4.1 Binary Messages on page 61.		0	6
15:18	Platform class. 0 Unknown 1 Stationary 2 Pedestrian 3 Marine/lake 4 Marine/sea 5 Automotive 6 Airborne		0	6
19	* Checksum delimiter.			
20:21	CS Two ASCII characters denoting the hexadecimal value of the check-sum.			
22:23	Message end. Carriage return <CR> and line feed <LF> terminate the mes-sage.			

4.1.1.9 Message OCSC: Cold Start Configuration

This message outputs the receiver's settings for cold start. The cold start enable indication and the timeout period definition are defined below.

The contents of this message can be changed using the Binary input message ICSC. See “Message ICSC: Cold Start Configuration” on page 103.

The cold start timer increments whenever the receiver is not in a valid navigation state. Once the timeout period is reached, the receiver zeros out its position, velocity and time data. The receiver then starts a rigorous, “search-the-sky” algorithm to find visible satellites.

Note: The cold start function is used as a fail-safe mechanism for receivers that maintain battery power. If for some reason the receiver is powered off, and then relocated a large distance away (greater than 100 km), a cold start timeout function would be necessary to automatically force a cold start. When the receiver is powered up and it has valid time and stored position information, it will generate a visible satellite list and start its search. It will continue this search indefinitely or until an external source either issues a cold start reset or provides initialization data.

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message start: $IBM.			
5:8	Message ID: OCSC.			
9:10	Message length: 8 bytes.			
Cold Start Configuration				
11:14	Source. A complete list of Source Data is located in Section 4.1 Binary Messages on page 61.		0	6
15:16	Cold start timeout.	seconds	0	
17.0	Cold start enabled. 1 true 0 false		0	1
17.1:18	Reserved.			
19	* Checksum delimiter.			
20:21	CS Two ASCII characters denoting the hexadecimal value of the checksum.			
22:23	Message end. Carriage return <CR> and line feed <LF> terminate the message.			

4.1.1.10 Message OEMA: Elevation Mask Angle Configuration

The receiver tracks visible satellites down to zero degrees (the horizon), in order to collect ephemeris data as early as possible. However, the receiver only uses satellites above the elevation mask angle setting in determining its measurement solution.

The contents of this message can be changed using the Binary input message IEMA. See “Message IEMA: Elevation Mask Angle Configuration” on page 104.

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message start: $IBM.			
5:8	Message ID: OEMA.			
9:10	Message length: 8 bytes.			
Elevation Mask Angle Configuration				
11:14	Source. A complete list of Source Data is located in Section 4.1 Binary Messages on page 61.		0	6
15:16	Elevation mask angle.	degrees	0	90
17:18	Reserved.			
19	* Checksum delimiter.			
20:21	CS Two ASCII characters denoting the hexadecimal value of the checksum.			
22:23	Message end. Carriage return <CR> and line feed <LF> terminate the message.			

4.1.1.11 Message ODTM: Map Datum Select

This message outputs the receiver's map datum selection. The default setting is zero and indicates that the basic reference frame and geometric figure of the earth provided by the World Geodetic Survey of 1984 is in use. A list of the available Map Datums is provided in *Appendix B: Map Datum Definitions* on page 159.

The contents of this message can be changed using the Binary input message IDTM. See “Message IDTM: Map Datum Select” on page 105.

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message start: $IBM.			
5:8	Message ID: ODTM.			
9:10	Message length: 8 bytes.			
11:14	Source. A complete list of Source Data is located in Section 4.1 Binary Messages on page 61.		0	6
15:16	Map datum ID. See *Appendix B: Map Datum Definitions* on page 159 for additional information. 0 WGS-84		0	188
17:18	Reserved.			
19	* Checksum delimiter.			
20:21	CS Two ASCII characters denoting the hexadecimal value of the checksum.			
22:23	Message end. Carriage return <CR> and line feed <LF> terminate the message.			

4.1.1.12 Message ODTU: User Datum Definition

This message outputs the datum axis offsets as defined by the user.

The contents of this message can be changed using the Binary input message IDTU. See “Message IDTU: User Datum Definition” on page 106.

Byte(s)	Description	Units	Range		Scale Factor[1]
			Min	Max	
1:4	Message start: $IBM.				
5:8	Message ID: ODTU.				
9:10	Message length: 44 bytes.				
11:18	Semi-major axis.	meters			DF
19:26	Inverse flattening.	meters			DF
27:34	WGS-84 datum, offset dX.	meters			DF
35:42	WGS-84 datum, offset dY.	meters			DF
43:50	WGS-84 datum, offset dZ.	meters			DF
51:52	User datum ID.		200	204	
53:54	Reserved.				
55	* Checksum delimiter.				
56:57	CS Two ASCII characters denoting the hexadecimal value of the checksum.				
58:59	Message end. Carriage return <CR> and line feed <LF> terminate the message.				

1. The Scale Factor is the number by which the receiver multiplies the parameter to give the true value.
   DF: IEEE Double Float
   SF: IEEE Single Float

4.1.1.13 Message OTMP: UTC Time Mark Pulse

This message outputs the receiver's time reference. The data provided below is synchronized to the rising-edge of the time mark pulse.

Byte(s)	Description	Units	Range		Scale Factor[1]
			Min	Max	
1:4	Message start: $IBM.				
5:8	Message ID: OTMP.				
9:10	Message length: 20 bytes.				
UTC Time					
11:14	UTC nanoseconds.	nanoseconds	0	999999999	1
15:16	UTC year.	year	1980	2099	1
17	UTC month.	months	1	12	1
18	UTC day.	days	1	31	1
19	UTC hours.	hours	0	23	1
20	UTC minutes.	minutes	0	59	1
21	UTC seconds.	seconds	0	59	1
22	Reserved.				
Delta UTC Time					
23:26	Delta UTC nanoseconds.	nanoseconds	0	999999999	1
27:28	Delta UTC seconds.	seconds	0	59	1
UTC Time Validity					
29.0	Time mark valid. 1 true 0 false		0	1	
29.1:30	Reserved.				
31	* Checksum delimiter.				
32:33	CS Two ASCII characters denoting the hexadecimal value of the checksum.				
34:35	Message end. Carriage return <CR> and line feed <LF> terminate the message.				

1. The scale factor is the number by which the receiver multiplies the parameter to give the true value.

4.1.1.14 Message OALD: Download Almanac Data

This message outputs the receiver's almanac data. The almanac data block is define in the section below.

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message start: $IBM.			
5:8	Message ID: OALD.			
9:10	Message length: 56 bytes.			
11:14	Source. A complete list of Source Data is located in Section 4.1 Binary Messages on page 61.		0	6
15:18	Almanac data valid. 1 true 0 false		0	1
19:58	Almanac data block (see section *Almanac Data Block* on page 79).			
59:60	Issue of data clock/almanac (IODC).			
61	Satellite PRN.		1	32
62	Reserved.			
63:66	Time of almanac (TOA).			
67	* Checksum delimiter.			
68:69	CS Two ASCII characters denoting the hexadecimal value of the check-sum.			
70:71	Message end. Carriage return <CR> and line feed <LF> terminate the message.			

Almanac Data Block

The almanac block contains ten 32-bit words. Each 32-bit word aligns with the 30-bit word from the GPS Data Format, subframes 4 and 5, starting at the least significant bit (LSb). The two most significant bits (MSb) of the 32-bit word align with bits 29 and 30 of the previous subframe word. (Refer to “Global Positioning System Standard Positioning Service Signal Specification”, 2nd Edition. June 2, 1995.)

Table 4-1. Almanac Data Block (Sheet 1 of 2)

Number of Bit(s)	Description	Units	Range		Scale Factor[1]	Notes
			Min	Max		
2	Prior subframe word bits for parity computation.					
24	TLM - telemetry.					
6	P: parity.					
2	Prior subframe word bits for parity computation.					
22	HOW: hand over word.					
2	t - non-information bearing bits used for parity computation.					

1. The scale factor is the number by which the receiver multiplies the parameter to give the true value.
2. Parameters are two’s complement, with the sign bit (+ or -) occupying the most significant bit.

Table 4-1. Almanac Data Block (Sheet 2 of 2) (Continued)

Number of Bit(s)	Description	Units	Range		Scale Factor[1]	Notes
			Min	Max		
6	P: parity.					
2	Prior word bits for parity computation.					
2	Data ID.					
6	Satellite (SV) ID.					
16	e - eccentricity.	dimensionless			2^{-21}	
6	P: parity.					
2	Prior word bits for parity computation.					
8	$t_{oa:}$ reference time of Almanac.	seconds		602,112	2^{12}	
16	δ_i: (relative to i_o = 0.30 semi-circles)	semi-circles			2^{-19}	2
6	P: parity.					
2	Prior word bits for parity computation.					
16	OMEGADOT: rate of right ascension.	semi-circles/sec			2^{-38}	2
8	Satellite (SV) health.					
6	P: parity.					
2	Prior word bits for parity computation.					
24	$(A)^{1/2}$: square root of the semi-major axis.	$meters^{1/2}$			2^{-11}	2
6	P: parity.					
2	Prior word bits for parity computation.					
24	$(OMEGA)_0$: longitude of ascending node of orbit plane at weekly epoch.	semi-circles			2^{-23}	2
6	P: parity.					
2	Prior word bits for parity computation.					
24	ω: argument of perigee.	semi-circles			2^{-23}	2
6	P: parity.					
2	Prior word bits for parity computation.					
24	M_0: mean anomaly at reference time.	semi-circles			2^{-23}	2
6	P: parity.					
2	Prior word bits for parity computation.					
8	a_{f0}: Satellite (SV) clock bias.	seconds			2^{-20}	2
11	a_{f1}: Satellite (SV) clock rate.	sec/sec			2^{-38}	2
3	a_{f0}: Satellite (SV) clock bias.	seconds			2^{-20}	2
2	t: non-information bearing bits used for Parity computa-tion.					
6	P: Parity.					

1. The scale factor is the number by which the receiver multiplies the parameter to give the true value.
2. Parameters are two's complement, with the sign bit (+ or -) occupying the most significant bit.

4.1.1.15 Message OEPD: Download Ephemeris Data

This message outputs the receiver's ephemeris data. The ephemeris data block is defined in the section below.

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message start: $IBM.			
5:8	Message ID: OEPD.			
9:10	Message length: 144 bytes.			
11:14	Source. A complete list of Source Data is located in Section 4.1 Binary Messages on page 61.		0	6
15:18	Ephemeris data valid. 1 true 0 false		0	1
19:22	Time when ephemeris data is obsolete.	seconds		
SubFrame 1				
23:62	Ephemeris data (see Table 4-2, “Ephemeris Data Block SubFrame 1,” on page 82).			
63:64	Issue of data clock/ephemeris (IODE).			
65	Satellite PRN.		1	32
66	Reserved.			
SubFrame 2				
67:106	Ephemeris data (see *Table 4-3: Ephemeris Data Block SubFrame 2* on page 83).			
107:108	Issue of data clock/ephemeris (IODE).			
109	Satellite PRN.		1	32
110	Reserved.			
SubFrame 3				
111:150	Ephemeris Data (see *Table 4-4: Ephemeris Data Block SubFrame 3* on page 84).			
151:152	Issue of data clock/ephemeris (IODE).			
153	Satellite PRN.		1	32
154	Reserved.			
155	* Checksum delimiter.			
156:157	CS Two ASCII characters denoting the hexadecimal value of the checksum.			
158:159	Message end. Carriage return <CR> and line feed <LF> terminate the message.			

Ephemeris Data Block

The Ephemeris block contains ten 32-bit words. Each 32-bit word aligns with the 30-bit word from the GPS Data Format, subframes 1, 2 and 3, starting at the Least Significant Bit (LSB). The two Most Significant BIts (MSB) of the 32-bit word align with bits 29 and 30 of the previous subframe word. (Refer to “Global Positioning System Standard Positioning Service Signal Specifications”, 2nd Edition. June 2, 1995.)

Table 4-2. Ephemeris Data Block SubFrame 1

Number of Bit(s)	Description	Units	Range		Scale Factor[1]	Notes
			Min	Max		
2	Prior subframe word bits for parity computation.					
24	TLM: telemetry.					
6	P: parity.					
2	Prior word bits for parity computation.					
22	HOW: hand over word.					
2	t: non-information bearing bits used for parity computation.					
6	P: parity.					
2	Prior word bits for parity computation.					
10	Week number (WN)	weeks			1	
2	Reserved.					
4	User Range Accuracy (URA) Index.					
6	Satellite (SV) Health.	discrete			1	
2	IODC: Issue of Data Clock.					
6	P: parity.					
2	Prior word bits for parity computation.					
24	Reserved.					
6	P: parity					
2	Prior word bits for parity computation.					
24	Reserved.					
6	P: parity.					
2	Prior word bits for parity computation.					
24	Reserved.					
6	P: parity.					
2	Prior word bits for parity computation.					
16	Reserved.					
8	T_{GD}	seconds			2^{-31}	2
6	P: parity.					
2	Prior word bits for parity computation.					
8	IODC: Issue of data clock.					

1. The scale factor is the number by which the receiver multiplies the parameter to give the true value.
2. Parameters are two’s complement, with the sign bit (+ or -) occupying the most significant bit.

Table 4-2. Ephemeris Data Block SubFrame 1 (Continued)

Number of Bit(s)	Description	Units	Range		Scale Factor[1]	Notes
			Min	Max		
16	t_{0C}	seconds		604,784	2^{4}	
6	P: parity.					
2	Prior word bits for parity computation.					
8	a_{f2}	seconds/seconds^2			2^{-55}	2
16	a_{f1}	seconds/seconds			2^{-43}	2
6	P: parity.					
2	Prior word bits for parity computation.					
8	a_{f0}	seconds			2^{-31}	2
2	t: non-information bearing bits used for parity computation.					
6	P: parity.					

1. The scale factor is the number by which the receiver multiplies the parameter to give the true value.
2. Parameters are two’s complement, with the sign bit (+ or -) occupying the most significant bit.

Table 4-3. Ephemeris Data Block SubFrame 2

Number of Bit(s)	Description	Units	Range		Scale Factor[1]	Notes
			Min	Max		
2	Prior word bits for parity computation.					
24	TLM: telemetry.					
6	P: parity.					
2	Prior word bits for parity computation.					
22	HOW: hand over word.					
2	t: non-information bearing bits used for parity computation.					
6	P: parity.					
2	Prior word bits for parity computation.					
8	IODE: issue of data ephemeris.					
16	C_{rs}: amplitude of sine harmonic correction term to the orbit radius.	meters			2^{-5}	2
6	P: parity.					
2	Prior word bits for parity computation.					
16	Δ_n: mean motion difference from computed value.	semi-circ/second			2^{-43}	2
8	M_0: mean anomaly at reference time.	semi-circles			2^{-31}	2
6	P: parity.					
2	Prior word bits for parity computation.					
24	M_0: mean anomaly at reference time.	semi-circles			2^{-31}	2

1. The scale factor is the number by which the receiver multiplies the parameter to give the true value.
2. Parameters are two’s complement, with the sign bit (+ or -) occupying the most significant bit.

Table 4-3. Ephemeris Data Block SubFrame 2 (Continued)

Number of Bit(s)	Description	Units	Range		Scale Factor[1]	Notes
			Min	Max		
6	P: parity.					
2	Prior word bits for parity computation.					
16	C_{uc}: amplitude of cosine harmonic correction term to the argument of latitude.	radians			2^{-29}	2
8	e: eccentricity.	dimensionless		0.03	2^{-33}	
6	P: parity.					
2	Prior word bits for parity computation.					
24	e: eccentricity.	dimensionless		0.03	2^{-33}	
6	P: parity.					
2	Prior word bits for parity computation.					
16	C_{us}: amplitude of sine harmonic correction term to the argument of latitude.	radians			2^{-29}	2
8	$(A)^{1/2}$: square root of the semi-major axis.	$meters^{1/2}$			2^{-19}	
6	P: parity.					
2	Prior word bits for parity computation.					
24	$(A)^{1/2}$: square root of the semi-major axis.	$meters^{1/2}$			2^{-19}	
6	P: parity.					
2	Prior word bits for parity computation.					
16	t_{oe}: reference time ephemeris.	seconds		604,784	2^4	
1	Reserved.					
5	Spare.					
2	t: non-information bearing bits used for parity computation.					
6	P: parity.					

1. The scale factor is the number by which the receiver multiplies the parameter to give the true value.
2. Parameters are two's complement, with the sign bit (+ or -) occupying the most significant bit.

Table 4-4. Ephemeris Data Block SubFrame 3

Number of Bit(s)	Description	Units	Range		Scale Factor[1]	Notes
			Min	Max		
2	Prior word bits for parity computation.					
24	TLM: telemetry.					
6	P: parity.					
2	Prior word bits for parity computation.					
22	HOW: hand over word.					

1. The scale factor is the number by which the receiver multiplies the parameter to give the true value.
2. Parameters are two's complement, with the sign bit (+ or -) occupying the most significant bit.

Table 4-4. Ephemeris Data Block SubFrame 3 (Continued)

Number of Bit(s)	Description	Units	Range		Scale Factor[1]	Notes
			Min	Max		
2	t: non-information bearing bits used for parity computation.					
6	P: parity.					
2	Prior word bits for parity computation.					
16	C_{ic}: amplitude of the cosine harmonic correction term to the angle of inclination.	radians			2^{-29}	2
8	(OMEGA) $_0$: longitude of the ascending node of the orbit plane at the weekly epoch.	semi-circles			2^{-31}	2
6	P: parity.					
2	Prior word bits for parity computation.					
24	(OMEGA) $_0$: longitude of the ascending node of the orbit plane at the weekly epoch.	semi-circles			2^{-31}	2
6	P: parity.					
2	Prior word bits for parity computation.					
16	C_{is}: amplitude of the sine harmonic correction term to the angle of inclination.	radians			2^{-29}	2
8	i_0: inclination angle at reference time.	semi-circles			2^{-31}	2
6	P: parity.					
2	Prior word bits for parity computation.					
24	i_0: inclination angle at reference time.	semi-circles			2^{-31}	2
6	P: parity.					
2	Prior word bits for parity computation.					
16	C_{rc}: amplitude of the sine harmonic correction term to the orbit radius.	meters			2^{-5}	2
8	ω: argument of perigee.	semi-circles			2^{-31}	2
6	P: parity.					
2	Prior word bits for parity computation.					
24	ω: argument of perigee.	semi-circles			2^{-31}	2
6	P: parity.					
2	Prior word bits for parity computation.					
24	OMEGA DOT: rate of right ascension.	semi-circ/second			2^{-43}	2
6	P: parity.					
2	Prior word bits for parity computation.					
8	IODE: issue of data ephemeris.					

1. The scale factor is the number by which the receiver multiplies the parameter to give the true value.
2. Parameters are two's complement, with the sign bit (+ or -) occupying the most significant bit.

Table 4-4. Ephemeris Data Block SubFrame 3 (Continued)

Number of Bit(s)	Description	Units	Range		Scale Factor[1]	Notes
			Min	Max		
14	IDOT: rate of inclination angle.	semi-circ/second			2^{-43}	2
2	t: non-information bearing bits used for parity computation.					
6	P: parity.					

1. The scale factor is the number by which the receiver multiplies the parameter to give the true value.
2. Parameters are two’s complement, with the sign bit (+ or -) occupying the most significant bit.

4.1.1.16 Message OUTD: Download UTC/IONO Data

This message outputs the receiver's UTC/IONO data. The UTC/IONO data block is defined in the section below.

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message start: $IBM.			
5:8	Message ID: OUTD.			
9:10	Message length: 53 bytes.			
11:14	Source. A complete list of Source Data is located in Section 4.1 Binary Messages on page 61.		0	6
15	UTC/IONO data valid. 1 true 0 false		0	1
16:55	UTC/IONO data block (see section *UTC/IONO Data Block* on page 87).			
56:57	Issue of data clock (IODC).			
58	Satellite PRN.		1	32
59	Reserved.			
60:63	Time of time (t_{ot}).			
64	* Checksum delimiter.			
65:66	CS Two ASCII characters denoting the hexadecimal value of the check-sum.			
67:68	Message end. Carriage return <CR> and line feed <LF> terminate the mes-sage.			

UTC/IONO Data Block

The UTC/IONO block contains ten 32-bit words. Each 32-bit word aligns with the 30-bit word from the GPS data format, subframe 4, starting at the least significant bit (LSb). The two most significant bits (MSb) of the 32-bit word align with bits 29 and 30 of the previous subframe word. (Refer to “Global Positioning System Standard Positioning Service Signal Specification”, 2nd Edition. June 2, 1995.)

Table 4-5. UTC/IONO Data Block SubFrame 4

Number of Bit(s)	Description	Units	Range		Scale Factor[1]	Notes
			Min	Max		
2	Prior subframe word bits for parity computation.					
24	TLM: telemetry.					
6	P: parity.					
2	Prior word bits used for parity computation.					
22	HOW: hand over word.					

1. The scale factor is the number by which the receiver multiplies the parameter to give the true value.
2. Parameters are two’s complement, with the sign bit (+ or -) occupying the most significant bit.

Table 4-5. UTC/IONO Data Block SubFrame 4 (Continued)

Number of Bit(s)	Description	Units	Range		Scale Factor[1]	Notes
			Min	Max		
2	t: non-information bearing bits used for parity computation.					
6	P: parity.					
2	Prior word bits used for parity computation.					
2	Data ID.					
6	Satellite (SV) ID.					
8	α_0: coefficient of a cubic equation for the amplitude of vertical delay (1 of 4).	seconds			2^{-30}	2
8	α_1: coefficient of a cubic equation for the amplitude of vertical delay (2 of 4).	sec/semi-circle			2^{-27}	2
6	P: parity.					
2	Prior word bits used for parity computation.					
8	α_2: coefficient of a cubic equation for the amplitude of vertical delay (3 of 4).	sec/semi-circles^2			2^{-24}	2
8	α_3: coefficient of a cubic equation for the amplitude of vertical delay (4 of 4).	sec/semi-circles^3			2^{-24}	2
8	β_0: coefficient of a cubic equation representing the period model (1 of 4).	seconds			2^{11}	2
6	P: parity.					
2	Prior word bits used for parity computation.					
8	β_1: coefficient of a cubic equation representing the period model (2 of 4).	sec/semi-circle			2^{14}	2
8	β_2: coefficient of a cubic equation representing the period model (3 of 4).	sec/semi-circles^2			2^{16}	2
8	β_3: coefficient of a cubic equation representing the period model (4 of 4).	sec/semi-circles^3			2^{16}	2
6	P: parity.					
2	Prior word bits used for parity computation.					
24	A_1: polynomial coefficient 1.	sec/sec			2^{-50}	2
6	P: parity					
2	Prior word bits used for parity computation.					
24	A_0: polynomial coefficient 1.	seconds			2^{-30}	2
6	P: parity.					
2	Prior word bits used for parity computation.					
8	A_0: polynomial coefficient 1.	seconds			2^{-30}	2
8	t_{ot}: reference time for UTC data.	seconds		602,112	2^{12}	
8	WN_t: week number.	weeks			1	
6	P: parity.					

1. The scale factor is the number by which the receiver multiplies the parameter to give the true value.
2. Parameters are two's complement, with the sign bit (+ or -) occupying the most significant bit.

Table 4-5. UTC/IONO Data Block SubFrame 4 (Continued)

Number of Bit(s)	Description	Units	Range		Scale Factor[1]	Notes
			Min	Max		
2	Prior word bits used for parity computation.					
8	Δt_{LS}: spare.	seconds			1	
8	WN_{LSF}: week number at the end of which the leap second is effective.	weeks			1	
8	DN: day number at the end of which the leap second becomes effective (right justified).	days	1	7	1	
6	P: parity.					
2	Prior word bits used for parity computation.					
8	Δt_{LSF}: delta time due to leap seconds.	seconds			1	2
14	Spare.					
2	t: non-information bearing bits used for parity computation.					
6	P: parity.					

1. The scale factor is the number by which the receiver multiplies the parameter to give the true value.
2. Parameters are two's complement, with the sign bit (+ or -) occupying the most significant bit.

4.1.1.17 Message OSHM: Satellite Health Masking Configuration

This message outputs the receiver's satellite health masking. The receiver does not use any satellites that are marked as unhealthy, either set in the satellite data stream or by the user. A satellite health masked as true denotes an invalid satellite and is not used by the receiver.

The contents of this message can be changed using the Binary input message ISHM. See “Message ISHM: Satellite Health Masking Configuration” on page 118.

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message start: $IBM.			
5:8	Message ID: OSHM.			
9:10	Message length: 12 bytes.			
11:14	Source. A complete list of Source Data is located in Section 4.1 Binary Messages on page 61.		0	6
15:18	Store nonvolatile (NV) memory. 1 true 0 false		0	1
Satellite Health Masking				
19:22	Satellite PRN health masked. 1 true. Denotes an invalid satellite. 0 false		1	32
23	* Checksum delimiter.			
24:25	CS Two ASCII characters denoting the hexadecimal value of the checksum.			
26:27	Message end. Carriage return <CR> and line feed <LF> terminate the message.			

4.1.1.18 Message OSID: Receiver Software ID

This message outputs the receiver's software version information.

Byte(s)	Description	Units	Range	
			Min	Max
1-4	Message start: $IBM.			
5:8	Message ID: OSID.			
9:10	Message length: 8 bytes.			
11	Release version.			
12	Major revision.			
13	Minor revision.			
14	Year.		2000	2099
15	Month.		1	12
16	Day.		1	31
17:18	Reserved.			
19	* Checksum delimiter.			
20:21	CS Two ASCII characters denoting the hexadecimal value of the checksum.			
22:23	Message end. Carriage return <CR> and line feed <LF> terminate the message.			

4.1.1.19 Message OBIT: Built-In-Test Results (ACK)

This message is an acknowledgement, providing the receiver's Built-In-Test results. This message will only be output when specific tests are requested using the Binary input message IBIT, Command Built-In-Test. See “Message IBIT: Command Built-In-Test” on page 124.

Note: This message can not be configured using the Binary input message ILOG to output periodically. See “Message ILOG: Message Log Control” on page 121.

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message start: IBM.			
5:8	Message ID: OBIT.			
9:10	Message length: 32 bytes.			
11	Reserved			
12	RAM (embedded) test. 0 not selected 1 not tested 2 pass 3 fail		0	2
13	RTC test. 0 not selected 1 not tested 2 pass 3 fail		0	2
14	UART1 test. 0 not selected 1 not tested 2 pass 3 fail		0	2
15	UART2 test. 0 not selected 1 not tested 2 pass 3 fail		0	2
16:20	Reserved			
21	Antenna sense test. 0 not selected 1 not tested 2 pass 3 fail 4 antenna open 5 antenna short		0	2
22	Reserved			
23	Temperature sensor test 0 not selected 1 not tested 2 pass 3 fail		0	2
24	Reserved			

Byte(s)	Description	Units	Range	
			Min	Max
25	FLASH Program sector. 0 not selected 1 not tested 2 pass 3 fail		0	2
26	FLASH Data sector. 0 not selected 1 not tested 2 pass 3 fail		0	2
27:41	Reserved			
42	Reset 0 not selected 6 reset requested		0	6
43	* Checksum delimiter.			
44:45	CS Two ASCII characters denoting the hexadecimal value of the check-sum.			
46:47	Message end. Carriage return <CR> and line feed <LF> terminate the mes-sage.			

4.1.1.20 Message OFSH: Command Flash Upload (ACK)

This message acknowledges that a Flash Upload message, IFSH, has been received. See “Message IFSH: Command Flash Upload” on page 120.

Note: This message can not be configured using the Binary input message ILOG to output periodically. See “Message ILOG: Message Log Control” on page 121.

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message start: $IBM.			
5:8	Message ID: OFSH.			
9:10	Message length: 8 bytes.			
11:14	Action. 3 Ready. Send S-record file. 4 Failure. See Parameter list. 5 Success. Reprogram complete. 6 Invalid code. Code size does not match device.		0	6
15:18	Parameter. 1 Unsupported request 2 Unsupported sector 5 Unsupported baud rate 14 Failed - Checksum 15 Failed - Incomplete word 16 Failed - Unknown sector 17 Failed - Unknown boot sector 18 Failed - Write		1	18
19	* Checksum delimiter.			
20:21	CS Two ASCII characters denoting the hexadecimal value of the checksum.			
22:23	Message end. Carriage return <CR> and line feed <LF> terminate the message.			

4.1.1.21 Message OBID: Boot Code ID

This message outputs the receiver's software boot code version information. This message is only output when the receiver is powered up.

Note: This message is hard-coded, it can not be turned off or reconfigured using the Binary input message, ILOG. See “Message ILOG: Message Log Control” on page 121.

Byte(s)	Description	Units	Range	
			Min	Max
1-4	Message start: $IBM.			
5:8	Message ID: OBID.			
9:10	Message length: 8 bytes.			
11	Release version.			
12	Major revision.			
13	Minor revision.			
14	Year.		2000	2099
15	Month.		1	12
16	Day.		1	31
17:18	Reserved.			
19	* Checksum delimiter.			
20:21	CS Two ASCII characters denoting the hexadecimal value of the checksum.			
22:23	Message end. Carriage return <CR> and line feed <LF> terminate the message.			

4.1.2 Binary Input Messages

The following table lists supported Binary Input Messages.

Binary Message	Description	See Page
INIT	Navigation initialization.	97
IDGC	Differential GPS (DGPS) configuration.	99
INOC	Navigation operational configuration.	100
INVC	Navigation validity configuration.	101
INPC	Navigation platform configuration.	102
ICSC	Cold start configuration.	103
IEMA	Elevation mask angle configuration.	104
IDTM	Map datum select.	105
IDTU	User datum definition	106
IALD	Command almanac upload.	107
IEPD	Command ephemeris upload.	109
IUTD	Command UTC/IONO upload.	115
ISHM	Satellite health masking configuration.	118
IRST	Command reset.	119
IFSH	Command flash upload.	120
ILOG	Message log control.	121
IIOC	Input/output port configuration.	122
IMPC	Message protocol configuration.	123
IBIT	Command built-in-test.	124

4.1.2.1 Message INIT: Navigation Initialization

This message allows the user to initialize the receiver with the necessary Position/Velocity/ Time (PVT) data to enable fast acquisition.

Byte(s)	Description	Units	Range		Scale Factor
			Min	Max	
1:4	Message start: $IBM.				
5:8	Message ID: INIT.				
9:10	Message length: 76 bytes.				
Geodetic Position					
11:18	Latitude.	radians	0	$\pm\pi$ / 2	
19:26	Longitude.	radians	0	$\pm\pi$	
27:30	Altitude (height above ellipsoid).	meters	-305	18,000	SF
31:50	Reserved.				
UTC Time Data					
51:54	UTC nanoseconds.	nanoseconds	0	9999 99999	
55:56	UTC year.	year	1980	2099	
57	UTC month.	months	1	12	
58	UTC day.	days	1	31	
59	UTC hours.	hours	0	23	
60	UTC minutes.	minutes	0	59	
61	UTC seconds.	seconds	0	59	
62	Reserved.				
GPS Time					
63:66	GPS seconds from epoch.	seconds			
67:70	GPS nanoseconds from epoch.	nanoseconds			
71:72	GPS week number.	weeks			
73:74	Reserved.				
Data Validity					
75.0	Geodetic position valid. 1 true 0 false		0	1	
75.1	Altitude valid. 1 true 0 false		0	1	
75.2	Mean sea level altitude valid. 1 true 0 false		0	1	
75.3	Ground speed valid. 1 true 0 false		0	1	

Byte(s)	Description	Units	Range		Scale Factor
			Min	Max	
75.4	Heading valid. 1 true 0 false		0	1	
75.5	Climb rate valid. 1 true 0 false		0	1	
75.6:76	Reserved.				
Time Validity					
77.0	UTC time valid. 1 true 0 false		0	1	
77.1	GPS time valid. 1 true 0 false		0	1	
77.2:77.7	Reserved.				
Update Parameters					
78.0	Use after reset. 1 true 0 false		0	1	
78.1:78.7	Reserved				
Source Data					
79:82	Position source. A complete list of Source Data is located in Section 4.1 Binary Messages on page 61.		4	4	
83:86	Time source. A complete list of Source Data is located in Section 4.1 Binary Messages on page 61.		4	4	
87	* Checksum delimiter.				
88:89	CS Two ASCII characters denoting the hexadecimal value of the checksum.				
90:91	Message end. Carriage return <CR> and line feed <LF> terminate the message.				

4.1.2.2 Message IDGC: Differential GPS (DGPS) Configuration

This message allows the user to enable/disable the use of DGPS corrections and set the time-out period for use of aged corrections.

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message start: $IBM.			
5:8	Message ID: IDGC.			
9:10	Message length: 4 bytes.			
DGPS Configuration				
11:14	Source. A complete list of Source Data is located in Section 4.1 Binary Messages on page 61.		4	4
15:16	DGPS time-out. The default is 120 seconds.	seconds	0	255
17.0	DGPS enabled. 1 true (default) 0 false		0	1
17.1	DARC enabled. 1 true 0 false **Note:** Both the DARC and DGPS enabled bits must e selected to support a DARC DGPS UDRE change to a value of 2 (binary 10).		0	1
17.2:18	Reserved.			
19	* Checksum delimiter.			
20:21	CS Two ASCII characters denoting the hexadecimal value of the check-sum.			
22:23	Message end. Carriage return <CR> and line feed <LF> terminate the mes-sage.			

4.1.2.3 Message INOC: Navigation Operational Configuration

This message allows the user to set the receiver's operational configuration settings for ground track aesthetics and minimum signal strength required.

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message start: $IBM.			
5:8	Message ID: INOC.			
9:10	Message length: 8 bytes.			
Operational Configuration				
11:14	Source. A complete list of Source Data is located in Section 4.1 Binary Messages on page 61.		4	4
15.0	Ground track smooth enabled. 1 true (default) 0 false		0	1
15.1	Position pinning enabled. 1 true (default) 0 false		0	1
15.2:16	Reserved.			
17:18	Minimum carrier to noise (C/N0) threshold. **Note:** Use the following formula to convert this number to dB-Hz. dB-Hz = 10 log (CN0) + 16		16	2500
19	* Checksum delimiter.			
20:21	CS Two ASCII characters denoting the hexadecimal value of the checksum.			
22:23	Message end. Carriage return <CR> and line feed <LF> terminate the message.			

4.1.2.4 Message INVC: Navigation Validity Configuration

This message allows the user to configure the receiver's navigational validity criteria. The settings defined below will determine when the receiver can post a valid navigation mode (DGPS, 3D or 2D).

The receiver's estimate of navigation solution for time and position data is provided in the Binary output message, ONVD. See "Message ONVD: Navigation Solution Data" on page 64.

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message start: $IBM.			
5:8	Message ID: INVC.			
9:10	Message length: 20 bytes.			
Validity Configuration				
11:14	Source. A complete list of Source Data is located in Section 4.1 Binary Messages on page 61.		4	4
15:18	Maximum expected horizontal position error (EHPE). The default is 100 meters.	meters		
19:22	Maximum expected vertical position error (EVPE). The default is 150 meters.	meters		
23:26	Maximum geometric dilution of precision (GDOP). The default is 35.		0	255
27:28	Minimum number of satellites required. 0 receiver decides how many satellites are required (default).		0	12
29.0	Altitude use required. 1 true. The receiver is forced to use 3D navigation only. 0 false. The receiver decides whether to use 2D or 3D navigation. (default).		0	1
29.1	DGPS Required. 1 true 0 use if available (default)		0	1
29.2:30	Reserved.			
31	* Checksum delimiter.			
32:33	CS Two ASCII characters denoting the hexadecimal value of the checksum.			
34:35	Message end. Carriage return <CR> and line feed <LF> terminate the message.			

4.1.2.5 Message INPC: Navigation Platform Configuration

This message allows the user to set the receiver's platform class: stationary, pedestrian, lake, sea, automotive, or airborne. This allows the system to adjust dynamic limits to achieve optimum navigation performance.

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message start: $IBM.			
5:8	Message ID: INPC.			
9:10	Message length: 8 bytes.			
Platform Configuration				
11:14	Source. A complete list of Source Data is located in Section 4.1 Binary Messages on page 61.		4	4
15:18	Platform Class. 0 Unknown 1 Stationary 2 Pedestrian 3 Marine/lake 4 Marine/sea 5 Automotive (default) 6 Airborne		0	6
19	* Checksum delimiter.			
20:21	CS Two ASCII characters denoting the hexadecimal value of the checksum.			
22:23	Message end. Carriage return <CR> and line feed <LF> terminate the message.			

4.1.2.6 Message ICSC: Cold Start Configuration

This message allows the user to enable a cold start and set the time-out period.

The cold start timer increments whenever the receiver is not in a valid navigation state. Once the time-out period is reached, the receiver zeros out its position, velocity and time data. The receiver then starts its rigorous, “search-the-sky” algorithm to find visible satellites.

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message start: $IBM.			
5:8	Message ID: ICSC.			
9:10	Message length: 8 bytes.			
Cold Start Configuration				
11:14	Source. A complete list of Source Data is located in Section 4.1 Binary Messages on page 61.		4	4
15:16	Cold start time-out. The default is 300 seconds.	seconds		
17.0	Cold start enabled. 1 true (default) 0 false		0	1
17.1:18	Reserved.			
19	* Checksum delimiter.			
20:21	CS Two ASCII characters denoting the hexadecimal value of the check-sum.			
22:23	Message end. Carriage return <CR> and line feed <LF> terminate the mes-sage.			

4.1.2.7 Message IEMA: Elevation Mask Angle Configuration

This message allows the user to set the elevation mask angle for use in the navigation solution.

The receiver tracks visible satellites down to zero degrees (horizon), in order to collect ephemeris data as early as possible. However, the receiver only uses satellites above the elevation mask angle setting in determining its measurement solution.

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message start: $IBM.			
5:8	Message ID: IEMA.			
9:10	Message length: 8 bytes.			
Elevation Mask Angle Configuration				
11:14	Source. A complete list of Source Data is located in Section 4.1 Binary Messages on page 61.		4	4
15:16	Elevation mask angle. The default is five degrees.	degrees	0	90
17:18	Reserved.			
19	* Checksum delimiter.			
20:21	CS Two ASCII characters denoting the hexadecimal value of the checksum.			
22:23	Message end. Carriage return <CR> and line feed <LF> terminate the message.			

4.1.2.8 Message IDTM: Map Datum Select

This message allows the user to modify the map datum selection.

A list of map datums is provided in *Appendix B: Map Datum Definitions* on page 159. The default setting is zero and indicates that the basic reference frame and geometric figure of the earth provided by the world geodetic survey of 1984 will be used.

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message Start: $IBM.			
5:8	Message ID: IDTM.			
9:10	Message Length: 8 bytes.			
11:14	Source. A complete list of Source Data is located in Section 4.1 Binary Messages on page 61.		4	4
15:16	Map datum ID. 0 WGS-84 (default) **Note:** See *Appendix B: Map Datum Definitions* on page 159 for additional information.		0	188
17:18	Reserved.			
19	* Checksum delimiter.			
20:21	CS Two ASCII characters denoting the hexadecimal value of the check-sum.			
22:23	Message end. Carriage return <CR> and line feed <LF> terminate the mes-sage.			

4.1.2.9 Message IDTU: User Datum Definition

This message allows the user to set the elliptical data for a user defined datum.

User datum offsets are measured from the basic reference frame and geometric figure of the earth provided by the world geodetic survey of 1984 (WGS-84).

Byte(s)	Description	Units	Range		Scale[1]
			Min	Max	
1:4	Message start: $IBM.				
5:8	Message ID: IDTU.				
9:10	Message length: 44 bytes.				
11:18	Semi-major axis.	meters			
19:26	Inverse flattening.	meters			DF
27:34	WGS-84 datum, offset dX.	meters			DF
35:42	WGS-84 datum, offset dY.	meters			DF
43:50	WGS-84 datum, offset dZ.	meters			DF
51:52	User datum ID.		200	204	
53:54	Reserved.				
55	* Checksum delimiter.				
56:57	CS Two ASCII characters denoting the hexadecimal value of the checksum.				
58:59	Message end. Carriage return <CR> and line feed <LF> terminate the message.				

1. The scale factor is the number by which the receiver multiplies the parameter to give the true value.
   DF: IEEE Double float
   SF: IEEE Single float

4.1.2.10 Message IALD: Command Almanac Upload

This message allows the user to upload new almanac data to the receiver.

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message start: $IBM.			
5:8	Message ID: IALD.			
9:10	Message length: 56 bytes.			
11:14	Source. A complete list of Source Data is located in Section 4.1 Binary Messages on page 61.		4	4
15:18	Almanac data valid. 1 true 0 false		0	1
19:58	Almanac data block (see section *Almanac Data Block* on page 107).			
59:60	Issue of data clock/almanac (IODC).			
61	Satellite PRN.		1	32
62	Reserved.			
63:66	Time of almanac.			
67	* Checksum delimiter.			
68:69	CS Two ASCII characters denoting the hexadecimal value of the check-sum.			
70:71	Message end. Carriage return <CR> and line feed <LF> terminate the mes-sage.			

Almanac Data Block

The Almanac block contains ten 32-bit words. Each 32-bit word aligns with the 30-bit word from the GPS data format, subframes 4 and 5, starting at the least significant bit (LSB). The two most significant bits (MSB) of the 32-bit word align with bits 29 and 30 of the previous subframe word. (Refer to “Global Positioning System Standard Positioning Service Signal Specification”, 2nd Edition. June 2, 1995.)

Table 4-6. Almanac Data Block

Number of Bit(s)	Description	Units	Range		Scale Factor[1]	Notes
			Min	Max		
2	Prior subframe word bits for parity computation.					
24	TLM - telemetry.					
6	P: Parity.					
2	Prior subframe word bits for parity computation.					
22	HOW: Hand over word.					
2	t - non-information bearing bits used for parity computa-tion.					

1. The scale factor is the number by which the receiver multiplies the parameter to give the true value.
2. Parameters are two’s complement, with the sign bit (+ or -) occupying the most significant bit.

Table 4-6. Almanac Data Block (Continued)

Number of Bit(s)	Description	Units	Range		Scale Factor[1]	Notes
			Min	Max		
6	P: parity.					
2	Prior word bits for parity computation.					
2	Data ID.					
6	Satellite (SV) ID.					
16	e: Eccentricity.	dimensionless			2^{-21}	
6	P: parity.					
2	Prior word bits for parity computation.					
8	$t_{oa:}$ reference time of Almanac.	seconds		602,112	2^{12}	
16	δ_i: (relative to i_o = 0.30 semi-circles)	semi-circles			2^{-19}	2
6	P: parity.					
2	Prior word bits for parity computation.					
16	OMEGADOT: rate of right ascension.	semi-circles/sec			2^{-38}	2
8	Satellite (SV) health.					
6	P: Parity.					
2	Prior word bits for parity computation.					
24	$(A)^{1/2}$: square root of the semi-major axis.	$meters^{1/2}$			2^{-11}	2
6	P: parity.					
2	Prior word bits for parity computation.					
24	$(OMEGA)_0$: longitude of ascending node of orbit plane at weekly epoch.	semi-circles			2^{-23}	2
6	P: parity.					
2	Prior word bits for parity computation.					
24	Ω: Argument Of perigee.	semi-circles			2^{-23}	2
6	P: Parity.					
2	Prior word bits for parity computation.					
24	M_0: Mean anomaly at reference time.	semi-circles			2^{-23}	2
6	P: Parity.					
2	Prior word bits for parity computation.					
8	a_{f0}: Satellite (SV) clock bias.	seconds			2^{-20}	2
11	a_{f1}: Satellite (SV) clock rate.	sec/sec			2^{-38}	2
3	a_{f0}: Satellite (SV) clock bias.	seconds			2^{-20}	2
2	t: Non-information bearing bits used for parity computation.					
6	P: Parity.					

1. The scale factor is the number by which the receiver multiplies the parameter to give the true value.
2. Parameters are two's complement, with the sign bit (+ or -) occupying the most significant bit.

4.1.2.11 Message IEPD: Command Ephemeris Upload

This message allows the user to upload new ephemeris data to the receiver.

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message start: $IBM.			
5:8	Message ID: IEPD.			
9:10	Message length: 144 bytes.			
11:14	Source. A complete list of Source Data is located in Section 4.1 Binary Messages on page 61.		4	4
15:18	Ephemeris data valid. 1 true 0 false		0	1
19:22	Time when ephemeris data is obsolete.	seconds		
SubFrame 1				
23:62	Ephemeris data (see *Table 4-7: Ephemeris Data Block SubFrame 1* on page 110).			
63:64	Issue of data clock/ephemeris (IODE).			
65	Satellite PRN.		1	32
66	Reserved.			
SubFrame 2				
67:106	Ephemeris data (see *Table 4-8: Ephemeris Data Block SubFrame 2* on page 111).			
107:108	Issue of data clock/ephemeris (IODE).			
109	Satellite PRN.		1	32
110	Reserved.			
SubFrame 3				
111:150	Ephemeris Data (see *Table 4-9: Ephemeris Data Block SubFrame 3* on page 112).			
151:152	Issue of data clock/ephemeris (IODE).			
153	Satellite PRN.		1	32
154	Reserved.			
155	* Checksum delimiter.			
156:157	CS Two ASCII characters denoting the hexadecimal value of the check-sum.			
158:159	Message end. Carriage return <CR> and line feed <LF> terminate the mes-sage.			

Ephemeris Data Block

The ephemeris block contains ten 32-bit words. Each 32-bit word aligns with the 30-bit word from the GPS data format, subframes 1, 2 and 3, starting at the least significant bit (LSb). The two most significant bits (MSb) of the 32-bit word align with bits 29 and 30 of the previous subframe word. (Refer to “Global Positioning System Standard Positioning Service Signal Specifications”, 2nd Edition. June 2, 1995.)

Table 4-7. Ephemeris Data Block SubFrame 1

Number of Bit(s)	Description	Units	Range		Scale Factor[1]	Notes
			Min	Max		
2	Prior subframe word bits for parity computation.					
24	TLM: telemetry.					
6	P: parity.					
2	Prior word bits for parity computation.					
22	HOW: hand over word.					
2	t: non-information bearing bits used for parity computation.					
6	P: parity.					
2	Prior word bits for parity computation.					
10	Week number (WN)	weeks			1	
2	Reserved.					
4	User Range Accuracy (URA) Index.					
6	Satellite (SV) Health.	discrete			1	
2	IODC: Issue of Data Clock.					
6	P: parity.					
2	Prior word bits for parity computation.					
24	Reserved.					
6	P: parity					
2	Prior word bits for parity computation.					
24	Reserved.					
6	P: parity.					
2	Prior word bits for parity computation.					
24	Reserved.					
6	P: parity.					
2	Prior word bits for parity computation.					
16	Reserved.					
8	T_{GD}	seconds			2^{-31}	2
6	P: parity.					
2	Prior word bits for parity computation.					
8	IODC: Issue of Data Clock.					

1. The scale factor is the number by which the receiver multiplies the parameter to give the true value.
2. Parameters are two’s complement, with the sign bit (+ or -) occupying the most significant bit.

Table 4-7. Ephemeris Data Block SubFrame 1 (Continued)

Number of Bit(s)	Description	Units	Range		Scale Factor[1]	Notes
			Min	Max		
16	t_{0C}	seconds		604,784	2^{4}	
6	P: parity.					
2	Prior word bits for parity computation.					
8	a_{f2}	seconds/seconds^{2}			2^{-55}	2
16	a_{f1}	seconds/seconds			2^{-43}	2
6	P: parity.					
2	Prior word bits for parity computation.					
8	a_{f0}	seconds			2^{-31}	2
2	t: non-information bearing bits used for parity computation.					
6	P: parity.					

1. The scale factor is the number by which the receiver multiplies the parameter to give the true value.
2. Parameters are two's complement, with the sign bit (+ or -) occupying the most significant bit.

Table 4-8. Ephemeris Data Block SubFrame 2

Number of Bit(s)	Description	Units	Range		Scale Factor[1]	Notes
			Min	Max		
2	Prior word bits for parity computation.					
24	TLM: telemetry.					
6	P: parity.					
2	Prior word bits for parity computation.					
22	HOW: hand over word.					
2	t: non-information bearing bits used for parity computation.					
6	P: parity.					
2	Prior word bits for parity computation.					
8	IODE: issue of data ephemeris.					
16	C_{rs}: amplitude of sine harmonic correction term to the orbit radius.	meters			2^{-5}	2
6	P: parity.					
2	Prior word bits for parity computation.					
16	Δ_{n}: mean motion difference from computed value.	semi-circ/second			2^{-43}	2
8	M_{0}: mean anomaly at reference time.	semi-circles			2^{-31}	2
6	P: parity.					
2	Prior word bits for parity computation.					
24	M_{0}: mean anomaly at reference time.	semi-circles			2^{-31}	2

1. The scale factor is the number by which the receiver multiplies the parameter to give the true value.
2. Parameters are two's complement, with the sign bit (+ or -) occupying the most significant bit.

Table 4-8. Ephemeris Data Block SubFrame 2 (Continued)

Number of Bit(s)	Description	Units	Range		Scale Factor[1]	Notes
			Min	Max		
6	P: parity.					
2	Prior word bits for parity computation.					
16	C_{uc}: amplitude of cosine harmonic correction term to the argument of latitude.	radians			2^{-29}	2
8	e: eccentricity.	dimensionless		0.03	2^{-33}	
6	P: parity.					
2	Prior word bits for parity computation.					
24	e: eccentricity.	dimensionless		0.03	2^{-33}	
6	P: parity.					
2	Prior word bits for parity computation.					
16	C_{us}: amplitude of sine harmonic correction term to the argument of latitude.	radians			2^{-29}	2
8	$(A)^{1/2}$: square root of the semi-major axis.	$meters^{1/2}$			2^{-19}	
6	P: parity.					
2	Prior word bits for parity computation.					
24	$(A)^{1/2}$: square root of the semi-major axis.	$meters^{1/2}$			2^{-19}	
6	P: parity.					
2	Prior word bits for parity computation.					
16	t_{oe}: reference time ephemeris.	seconds		604,784	2^4	
1	Reserved.					
5	Spare.					
2	t: non-information bearing bits used for parity computation.					
6	P: parity.					

1. The scale factor is the number by which the receiver multiplies the parameter to give the true value.
2. Parameters are two's complement, with the sign bit (+ or -) occupying the most significant bit.

Table 4-9. Ephemeris Data Block SubFrame 3

Number of Bit(s)	Description	Units	Range		Scale Factor[1]	Notes
			Min	Max		
2	Prior word bits for parity computation.					
24	TLM: telemetry.					
6	P: parity.					
2	Prior word bits for parity computation.					
22	HOW: hand over word.					

1. The scale factor is the number by which the receiver multiplies the parameter to give the true value.
2. Parameters are two's complement, with the sign bit (+ or -) occupying the most significant bit.

Table 4-9. Ephemeris Data Block SubFrame 3 (Continued)

Number of Bit(s)	Description	Units	Range		Scale Factor[1]	Notes
			Min	Max		
2	t: non-information bearing bits used for parity computation.					
6	P: parity.					
2	Prior word bits for parity computation.					
16	C_{ic}: amplitude of the cosine harmonic correction term to the angle of inclination.	radians			2^{-29}	2
8	(OMEGA) $_0$: longitude of the ascending node of the orbit plane at the weekly epoch.	semi-circles			2^{-31}	2
6	P: parity.					
2	Prior word bits for parity computation.					
24	(OMEGA) $_0$: longitude of the ascending node of the orbit plane at the weekly epoch.	semi-circles			2^{-31}	2
6	P: parity.					
2	Prior word bits for parity computation.					
16	C_{is}: amplitude of the sine harmonic correction term to the angle of inclination.	radians			2^{-29}	2
8	i_0: inclination angle at reference time.	semi-circles			2^{-31}	2
6	P: parity.					
2	Prior word bits for parity computation.					
24	i_0: inclination angle at reference time.	semi-circles			2^{-31}	2
6	P: parity.					
2	Prior word bits for parity computation.					
16	C_{rc}: amplitude of the sine harmonic correction term to the orbit radius.	meters			2^{-5}	2
8	ω: argument of perigee.	semi-circles			2^{-31}	2
6	P: parity.					
2	Prior word bits for parity computation.					
24	ω: argument of perigee.	semi-circles			2^{-31}	2
6	P: parity.					
2	Prior word bits for parity computation.					
24	OMEGA DOT: rate of right ascension.	semi-circ/second			2^{-43}	2
6	P: parity.					
2	Prior word bits for parity computation.					
8	IODE: issue of data ephemeris.					

1. The scale factor is the number by which the receiver multiplies the parameter to give the true value.
2. Parameters are two's complement, with the sign bit (+ or -) occupying the most significant bit.

Table 4-9. Ephemeris Data Block SubFrame 3 (Continued)

Number of Bit(s)	Description	Units	Range		Scale Factor[1]	Notes
			Min	Max		
14	IDOT: rate of inclination angle.	semi-circ/second			2^{-43}	2
2	t: non-information bearing bits used for parity computation.					
6	P: parity.					

1. The scale factor is the number by which the receiver multiplies the parameter to give the true value.
2. Parameters are two’s complement, with the sign bit (+ or -) occupying the most significant bit.

4.1.2.12 Message IUTD: Command UTC/IONO Upload

This message allows the user to upload new UTC/IONO data to the receiver.

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message start: $IBM.			
5:8	Message ID: IUTD.			
9:10	Message length: 56 bytes.			
11:14	Source. A complete list of Source Data is located in Section 4.1 Binary Messages on page 61.		4	4
15:18	UTC/IONO data valid. 1 true 0 false		0	1
19:58	UTC/IONO data block (see *Table 4-10: UTC/IONO Data Block SubFrame 4* on page 115).			
59:60	Issue of time UTC.			
61	Satellite PRN.		1	32
62	Reserved.			
63:66	Time of time (t_{ot}).			
67	* Checksum delimiter.			
68:69	CS Two ASCII characters denoting the hexadecimal value of the checksum.			
70:71	Message end. Carriage return <CR> and line feed <LF> terminate the message.			

UTC/IONO Data Block

The UTC/IONO block contains ten 32-bit words. Each 32-bit word aligns with the 30-bit word from the GPS data format, subframe 4, starting at the least significant bit (LSb). The two most significant bits (MSb) of the 32-bit word align with bits 29 and 30 of the previous subframe word. (Refer to “Global Positioning System Standard Positioning Service Signal Specification”, 2nd Edition. June 2, 1995.)

Table 4-10. UTC/IONO Data Block SubFrame 4

Number of Bit(s)	Description	Units	Range		Scale Factor[1]	Notes
			Min	Max		
2	Prior subframe word bits for parity computation.					
24	TLM: telemetry.					
6	P: parity.					
2	Prior word bits used for parity computation.					
22	HOW: hand over word.					

1. The scale factor is the number by which the receiver multiplies the parameter to give the true value.
2. Parameters are two’s complement, with the sign bit (+ or -) occupying the most significant bit.

Table 4-10. UTC/IONO Data Block SubFrame 4 (Continued)

Number of Bit(s)	Description	Units	Range		Scale Factor[1]	Notes
			Min	Max		
2	t: non-information bearing bits used for parity computation.					
6	P: parity.					
2	Prior word bits used for parity computation.					
2	Data ID.					
6	Satellite (SV) ID.					
8	α_0: coefficient of a cubic equation for the amplitude of vertical delay (1 of 4).	seconds			2^{-30}	2
8	α_1: coefficient of a cubic equation for the amplitude of vertical delay (2 of 4).	sec/semi-circle			2^{-27}	2
6	P: parity.					
2	Prior word bits used for parity computation.					
8	α_2: coefficient of a cubic equation for the amplitude of vertical delay (3 of 4).	sec/semi-circles^2			2^{-24}	2
8	α_3: coefficient of a cubic equation for the amplitude of vertical delay (4 of 4).	sec/semi-circles^3			2^{-24}	2
8	β_0: coefficient of a cubic equation representing the period model (1 of 4).	seconds			2^{11}	2
6	P: parity.					
2	Prior word bits used for parity computation.					
8	β_1: coefficient of a cubic equation representing the period model (2 of 4).	sec/semi-circle			2^{14}	2
8	β_2: coefficient of a cubic equation representing the period model (3 of 4).	sec/semi-circles^2			2^{16}	2
8	β_3: coefficient of a cubic equation representing the period model (4 of 4).	sec/semi-circles^3			2^{16}	2
6	P: parity.					
2	Prior word bits used for parity computation.					
24	A_1: polynomial coefficient 1.	sec/sec			2^{-50}	2
6	P: parity					
2	Prior word bits used for parity computation.					
24	A_0: polynomial coefficient 1.	seconds			2^{-30}	2
6	P: parity.					
2	Prior word bits used for parity computation.					
8	A_0: polynomial coefficient 1.	seconds			2^{-30}	2
8	t_{ot}: reference time for UTC data.	seconds		602,112	2^{12}	
8	WN_t: week number.	weeks			1	
6	P: parity.					

1. The scale factor is the number by which the receiver multiplies the parameter to give the true value.
2. Parameters are two's complement, with the sign bit (+ or -) occupying the most significant bit.

Table 4-10. UTC/IONO Data Block SubFrame 4 (Continued)

Number of Bit(s)	Description	Units	Range		Scale Factor[1]	Notes
			Min	Max		
2	Prior word bits used for parity computation.					
8	Δt_{LS}: spare.	seconds			1	
8	WN_{LSF}: week number at the end of which the leap second is effective.	weeks			1	
8	DN: day number at the end of which the leap second becomes effective (right justified).	days	1	7	1	
6	P: parity.					
2	Prior word bits used for parity computation.					
8	Δt_{LSF}: delta time due to leap seconds.	seconds			1	2
14	Spare.					
2	t: non-information bearing bits used for parity computation.					
6	P: parity.					

1. The scale factor is the number by which the receiver multiplies the parameter to give the true value.
2. Parameters are two's complement, with the sign bit (+ or -) occupying the most significant bit.

4.1.2.13 Message ISHM: Satellite Health Masking Configuration

This message allows the user to mask satellites as unhealthy, forcing the receiver to build a custom satellite visibility list. A satellite health masked as true denotes an invalid satellite and will not be used by the receiver.

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message start: $IBM.			
5:8	Message ID: ISHM.			
9:10	Message length: 12 bytes.			
11:14	Source. A complete list of Source Data is located in Section 4.1 Binary Messages on page 61.		4	4
15:18	Store nonvolatile (NV) memory. 1 true 0 false		0	1
Satellite Health Masking				
19:22	Satellite PRN health masked. 1 true. Denotes an invalid satellite. 0 false (default) **Note:** 19.0 represents PRN01, 22.7 represents PRN32.		1	32
23	* Checksum delimiter.			
24:25	CS Two ASCII characters denoting the hexadecimal value of the checksum.			
26:27	Message end. Carriage return <CR> and line feed <LF> terminate the message.			

4.1.2.14 Message IRST: Command Reset

This message allows the user to force a reset based on the criteria selected.

Clearing RAM will invalidate the position and ephemeris data stored in RAM memory. Clearing the real time clock (RTC) will invalidate the data from the RTC device, until the receiver goes into a valid navigational state. Clearing the position will invalidate position data in flash. Clearing the ephemeris will invalidate ephemeris data in flash.

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message start: $IBM.			
5:8	Message ID: IRST.			
9:10	Message length: 6 bytes.			
Reset Control				
11:14	Reset. 0 Reset Immediate 1 Reset Later		0	1
Reset Sectors				
15.0	Clear RAM. 1 true 0 false		0	1
15.1	Reserved.			
15.2	Reserved.			
15.3	Clear Real Time Clock. 1 true 0 false		0	1
15:4	Reserved.			
15.5	Clear Position. 1 true 0 false		0	1
15.6	Clear UTC/IONO. 1 true 0 false		0	1
15.7	Clear SV Health. 1 true 0 false		0	1
16.0	Clear Ephemeris. 1 true 0 false		0	1
16.1:16.7	Reserved.			
17	* Checksum delimiter.		0	1
18:19	CS Two ASCII characters denoting the hexadecimal value of the checksum.			
20:21	Message end. Carriage return <CR> and line feed <LF> terminate the message.			

4.1.2.15 Message IFSH: Command Flash Upload

This message allows the user to upload new boot or main (application) code to the receiver using a valid S-record file. The following steps should be taken when reprogramming the receiver:

1. Verify the receiver is configured in Binary mode.
   Baud: 19200 bps
   Data Bits: 8
   Parity: None
   Stop Bits: 1
2. Send IFSH message. Change Baud rate to 115200 (optional step).
3. Skip steps 4-7, if Boot Code reprogramming is not required.

Note: Boot code reprogramming must be done prior to Main code reprogramming.

4. Send IFSH message. Erase and Program, Boot Code.
5. Receive OFSH message. Ready, send S-record file.
6. Send Boot Code S-record file over serial port 1 (UART1).
7. Receive OFSH message. Success.
8. Skip steps 9-12, if Main Code reprogramming is not required.
9. Send IFSH message. Erase and Program, Main Code.
10. Receive OFSH message. Ready, send S-record file.
11. Send Main Code S-record file over serial port 1 (UART1).
12. Receive OFSH message. Success.

The receiver will automatically start output Binary messages at the default rate specified in step 1 above.

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message start: $IBM.			
5:8	Message ID: IFSH.			
9:10	Message length: 8 bytes.			
11:14	Action. 1 Erase and Program. 2 Change Baud rate.		1	2
15:18	Parameter. 3 Boot Code 4 Main Code 6 1200 bps 7 2400 bps 8 4800 bps 9 9600 bps 10 19200 bps 11 38400 bps 12 57600 bps (Binary only) 13 115200 bps (Binary only)		3	13
19	* Checksum delimiter.			
20:21	CS Two ASCII characters denoting the hexadecimal value of the check-sum.			
22:23	Message end. Carriage return <CR> and line feed <LF> terminate the message.			

4.1.2.16 Message ILOG: Message Log Control

This message allows the user to select messages to be output by the receiver. Message rate and frequency are also selectable

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message start: $IBM.			
5:8	Message ID: ILOG.			
9:10	Message length: 16 bytes.			
Message Parameters				
11:14	Message output period. 0 off 1 once 2 always		0	2
15:18	Message output mode. 0 on update 1 continuous		0	1
19:22	Message ID *. 00 Binary All 1000 ONVD 1001 Reserved 1002 OSAT 1003 OCHS 1004 ODGS 1005 ODGC 1006 ONOC 1007 ONVC 1008 ONPC 1009 OCSC 1010 OEMA 1011 ODTM 1012 ODTU 1013 OTMP 1014 OALD 1015 OEPD 1016 OUTD 1017 OSHM 2000 OSID 2001 OBIT 2002 OFSH * When set to zero and when the message output period (bits 11:14) equals zero, disables all messages. When set to zero and when the message output period (bits 11:14) equals one or two, the receiver will use its ROM defaults.		0 1000	1017 2002
23:26	Message rate.	seconds	0	
27	* Checksum delimiter.			
28:29	CS Two ASCII characters denoting the hexadecimal value of the check-sum.			
30:31	Message end. Carriage return <CR> and line feed <LF> terminate the mes-sage.			

4.1.2.17 Message IIOC: Input/Output Port Configuration

This message allows the user to set the input/output parameters for the receiver's two serial ports.

Note: Port 2 is hardware configured to receive messages, the transmit signal is not available on this port.

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message start: $IBM.			
5:8	Message ID: IIOC.			
9:10	Message length: 20bytes.			
Port Settings				
11:14	Port selection. 0 not defined 1 LPORT1 (default) 2 LPORT2		0	2
15:18	Baud rate. 0 Reserved 1 Reserved 2 Reserved 3 1200 4 2400 5 4800 6 9600 7 14400 8 19200 (default) 9 28800 10 38400 11 57600 (Binary only) 12 115200 (Binary only)		3	12
19:22	Parity. 0 none (default) 1 even 2 odd		0	2
23:26	Data bits. 0 Reserved 1 Reserved 2 7 bits 3 8 bits (default)		2	3
27:30	Stop bits. 0 1 bit (default) 1 Reserved 2 2 bits		0	2
31	* Checksum delimiter.			
32:33	CS Two ASCII characters denoting the hexadecimal value of the check-sum.			
34:35	Message end. Carriage return <CR> and line feed <LF> terminate the message.			

4.1.2.18 Message IMPC: Message Protocol Configuration

This message allows the user to change the protocol setting for the receiver.

Note: Port 2 is hardware configured to receive messages, the transmit signal is not available on this port.

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message start: $IBM.			
5:8	Message ID: IMPC.			
9:10	Message length: 16 bytes.			
Protocol Configuration				
11:14	Port. 1 Port 1 (default) 2 Port 2		1	2
15:18	Receive type. 0 none 1 Binary (default) 2 NMEA (V2.3, V3.0) 3 DGPS (RTCM) 4 OEM 5-8 Reserved 9 NMEA (V2.0)		0	9
19:22	Send type. 0 none 1 Binary (default) 2 NMEA (V2.3, V3.0) 3 Reserved 4 OEM 5-8 Reserved 9 NMEA (V2.0)		0	9
23:26	Trash disposition. 0 dump (default) 1 save			
27	* Checksum delimiter.			
28:29	CS Two ASCII characters denoting the hexadecimal value of the check-sum.			
30:31	Message end. Carriage return <CR> and line feed <LF> terminate the mes-sage.			

4.1.2.19 Message IBIT: Command Built-In-Test

This message allows the user to command a built-in test. The results of the test are output using the Binary message, OBIT. See “Message OBIT: Built-In-Test Results (ACK)” on page 92.

Byte(s)	Description	Units	Range	
			Min	Max
1:4	Message start: $IBM.			
5:8	Message ID: IBIT.			
9:10	Message length: 4 bytes.			
11.0	Reserved.			
11.1	RAM (embedded) test. 0 skip 1 request		0	1
11.2	RTC test. 0 skip 1 request		0	1
11.3	UART1 test. 0 skip 1 request		0	1
11.4	UART2 test. 0 skip 1 request		0	1
11.5:12.1	Reserved.			
12.2	Antenna sense test. 0 skip 1 request		0	1
12.3	Reserved.			
12.4	Temperature sensor test. 0 skip 1 request		0	1
12.5	Reserved			
12.6	FLASH Program sector. 0 skip 1 request		0	1
12.7	FLASH Data sector. 0 skip 1 request		0	1
13.0:14.6	Reserved			
14.7	Reset. 0 skip 1 request		0	1

Byte(s)	Description	Units	Range	
			Min	Max
15	* Checksum delimiter			
16:17	CS Two ASCII characters denoting the hexadecimal value of the checksum.			
18:19	Message end. Carriage return <CR> and line feed <LF> terminate the message.			

4.2 NMEA Messages

This section describes the national marine electronics association (NMEA) messages supported by the RFMD GPS receiver.

NMEA mode can be enabled by using the Binary input message protocol configuration (IMPC) and selecting NMEA as the receive and send type.

The NMEA standard communication settings are as follows:

- Baud 4800 bits per second (bps)
- Data bits 8
- Parity none
- Stop bits 1

The output NMEA messages are defined in *Section 4.2.1* on page 127. The input NMEA messages are defined in *Section 4.2.2* on page 140.

NMEA-0183 is a well-established industry standard protocol, initially written for marine electronics communication. This ASCII interface was created by the national marine electronics association and defines both the communication interface and the data format. Only a subset of these messages applies to GPS. The NMEA-0183 message structure complies with versions 2.00 (not defined in this document), 2.30 (March 1, 1998) and 3.00 (July 1, 2000) standards described below.

The NMEA data messages consist of a variable number of ASCII characters. Each message begins with a “$”, followed by a source ID and message ID. The data block is a series of variable length fields, delimited by commas. Each message terminates with an “*”, followed by the checksum, carriage return, and line feed.

Field Name	Field Format	Field Description
MSG START	$	Denotes the start of an NMEA message.
TALKER ID	-	The letters that define the information source. GP denotes a GPS source and PIBM denotes a proprietary user source.
MESSAGE	XXX	Three letters that identify the NMEA message.
COMMAS	“,”	Commas serve as delimiters for the data fields.
DATA	N--N	The data block is a series of data fields containing all of the data to be transmitted. Data fields may be of variable length and are preceded by commas that serve as delimiters.
ASTERISK	“*”	The checksum delimiter.
CHECKSUM	CS	Two ASCII characters that denote the hexadecimal value of the checksum. **Note:** The checksum is the absolute value calculated by exclusive-ORing the eight data bits (no start or stop bits) of each character in the sentence, between but excluding the “$” and “*”. The hexadecimal value of the most significant and least significant four bits of the result is converted to two ASCII characters (0:9, upper case A:F) for transmission. The most significant character is transmitted first.
MSG END	<CR><LF>	Carriage return <CR> and line feed <LF> terminate the message.

4.2.1 NMEA Output Messages

The following table lists supported NMEA output messages.

NMEA Message	Description	Default	See Page
GGA	GPS fix data.	On	128
GLL	Geographic position: latitude and longitude.	Off	129
GSA	GPS DOP and active satellites.	On	130
GSV	GPS satellites in view.	On	131
RMC	Recommended minimum specific GPS transit data.	On	132
SID	Software version (IBM Proprietary).	On at power-up and at reset	133
VTG	Track made good and ground speed.	Off	134
BTO	Built-in test results.	Off	135
CHS	Channel status data.	On	137

4.2.1.1 Message GGA: GPS Fix Data

This message outputs the receiver's time, position and fix related data.

Example:

$GPGGA,132618.00,3359.9999,N,11800.0001,W,1,08,0.0,43.5,M,-33.5,M,,*66

Field #	Description	Units	Range		Format
			Min	Max	
	Source ID and Message ID: $GPGGA.				
1	UTC time when last navigating.				hhmmss.ss
2	Latitude.	degreemin.dec			xxxx.xxxx
3	Latitude direction. N north S south				N
4	Longitude.	degreemin.dec			xxxxx.xxxx
5	Longitude direction. E east W west				E
6	GPS quality indicator. 0 fix not available 1 GPS fix valid 2 Differential GPS (DGPS) fix valid				x
7	Number of satellites used.	00 to 12			xx
8	Horizontal dilution of precision (HDOP).				x.x
9	Altitude, mean sea level (geoid).		-305	18000	x.x
10	Units of altitude.	meters			M
11	Geoidal separation. Represented by the following equation, where MSL is the mean sea-level surface below the WGS-84 ellipsoid surface: MSL = (WGS-84 earth ellipsoid surface) - (MSL Geoid Surface)				x.x
12	Units of geoidal separation.	meters			M
13	Age of differential GPS data. This is the number of seconds since the last type 1 or type 9 update.	seconds			x.x
14	Differential reference station ID.		0000	1023	xxxx
	* Checksum delimiter.				*
	CS Two ASCII characters denoting the hexadecimal value of the checksum.				CS
	Message end. Carriage return <CR> and line feed <LF> terminate the message.				

4.2.1.2 Message GLL: Geographic Position Fix

This message outputs the receiver's position, time and status data.

Example:

$GPGLL,3359.9999,N,11800.0001,W,134006.00,A,A*7E

Field #	Description	Units	Range		Format
			Min	Max	
	Source ID and Message ID: $GPGLL.				
1	Latitude.	degreemin.dec			xxxx.xxxx
2	Latitude direction. N north (+) S south (-)				N
3	Longitude.	degreemin.dec			xxxxx.xxxx
4	Longitude direction. E east (+) W west (-)				E
5	Coordinated Universal Time (UTC) time when last navigating.	hour/min/sec			hhmmss.ss
6	Positioning system status. A data valid V data not valid				A
7	Mode indicator. A autonomous D differential N data not valid				A
	* Checksum delimiter.				*
	CS Two ASCII characters denoting the hexadecimal value of the checksum.				CS
	Message end. Carriage return <CR> and line feed <LF> terminate the message.				

4.2.1.3 Message GSA: GPS DOP and Active Satellites

This message outputs the receiver's operating mode, lists the satellites used in the navigational solution, and displays the DOP values for the satellites used in the solution.

Example:

$GPGSA,A,3,06,13,17,22,05,26,10,23,,,,,1.82,1.54,0.98*0B

Field #	Description	Units	Range		Format
			Min	Max	
	Source ID and Message ID: $GPGSA.				
1	Mode. M Manual. Forced 3D navigation. A Automatic. The receiver decides whether to use 2D or 3D navigation.				M
2	Mode. 1 fix not available 2 2D navigation. 3 3D navigation.		1	3	x
3	PRN numbers of satellites used in solution (null for unused fields).		1	32	xx,xx,xx,xx, xx,xx,xx,xx, xx,xx,xx,xx
4	Position dilution of precision.				x.xx
5	Horizontal dilution of precision.				x.xx
6	Vertical dilution of precision.				x.xx
	* Checksum delimiter.				*
	CS Two ASCII characters denoting the hexadecimal value of the checksum.				CS
	Message end. Carriage return <CR> and line feed <LF> terminate the message.				

4.2.1.4 Message GSV: GPS Satellites in View

This message outputs the number of satellites in view and, for each satellite, its ID number, elevation, azimuth and carrier to noise ratio.

Each message defines a maximum of four satellites in view. Additional satellite data is sent in a second or third message. The total number of messages being transmitted and the number of the message being transmitted are indicated in fields one and two.

Example:

$GPGSV,3,1,10,06,69,337,47,17,42,282,49,23,40,206,48,30,32,194,00*71

$GPGSV,3,2,10,10,28,043,51,26,25,095,50,22,23,307,50,05,16,179,49*7B

$GPGSV,3,3,10,13,16,059,50,24,01,070,00*74

Field #	Description	Units	Range		Format
			Min	Max	
	Source ID and Message ID: $GPGSV.				
1	Total number of GSV messages being transmitted.		1	9	x
2	Message number.		1	9	x
3	Total number of satellites in view.		1	12	xx
4	Satellite ID number (PRN).		1	32	xx
5	Elevation.	degrees	0	90	xx
6	Azimuth.	degrees True	000	359	xxx
7	Carrier to noise ratio (C/N0). Null when not tracking.	dB Hz	00	99	xx
8	Satellite ID number (PRN).		1	32	xx
9	Elevation.	degrees	0	90	xx
10	Azimuth.	degrees True	000	359	xxx
11	Carrier to Noise ratio (C/N0). Null when not tracking.	dB Hz	00	99	xx
12	Satellite ID number (PRN).		1	32	xx
13	Elevation.	degrees	0	90	xx
14	Azimuth.	degrees True	000	359	xxx
15	Carrier to noise ratio (C/N0). Null when not tracking.	dB Hz	00	99	xx
16	Satellite ID number (PRN).		1	32	xx
17	Elevation.	degrees	0	90	xx
18	Azimuth.	degrees True	000	359	xxx
19	Carrier to Noise ratio (C/N0). Null when not tracking.	dB Hz	00	99	xx
	* Checksum delimiter.				*
	CS Two ASCII characters denoting the hexadecimal value of the checksum.				CS
	Message end. Carriage return <CR> and line feed <LF> terminate the message.				

4.2.1.5 Message RMC: Recommended Minimum Specific GPS Data

This message outputs the receiver's time, date, position, course and speed data.

Example:

$GPRMC,132618.00,A,3359.9999,N,11800.00,W,0.00,0.00,010900,0.00,E,A*15

Field #	Description	Units	Range		Format
			Min	Max	
	Source ID and Message ID: $GPRMC.				
1	UTC of position fix.	hour/min/sec			hhmmss.ss
2	Status. A data valid V data invalid				A
3	Latitude.	degreemin.dec			xxxx.xxxx
4	Latitude direction. N north (+) S south (-)				N
5	Longitude.	degreemin.dec			xxxxx.xxxx
6	Longitude direction. E east (+) W west (-)				E
7	Speed over ground.	knots			x.xx
8	Heading (course over ground).	degrees true	-180	+180	x.xx
9	Date.	day/month/year			ddmmyy
10	Magnetic variation.	degrees			x.xx
11	Magnetic variation indicator. E east W west				E
12	Mode indicator. A autonomous D differential N data not valid				A
	* Checksum delimiter.				*
	CS Two ASCII characters denoting the hexadecimal value of the checksum.				CS
	Message end. Carriage return <CR> and line feed <LF> terminate the message.				

4.2.1.6 Message SID: Software Version

This message outputs the receiver's software version information.

Example:

$PIBMSID,03,02,05,00,09,01*44

Field #	Description	Units	Range		Format
			Min	Max	
	Source ID and Message ID: $PIBMSID.				
1	Software version.				xx
2	Major revision.				xx
3	Minor revision.				xx
4	Revision year.	year	00	99	xx
5	Revision month.	month	01	12	xx
6	Revision day.	day	00	31	xx
	* Checksum delimiter.				*
	CS Two ASCII characters denoting the hexadecimal value of the checksum.				CS
	Message end. Carriage return <CR> and line feed <LF> terminate the message.				

4.2.1.7 Message VTG: Track Made Good and Ground Speed

This message outputs the receiver's actual course and speed data relative to ground.

Example:

$GPVTG,0.00,T,0.00,M,0.00,N,0.00,K,A*23

Field #	Description	Units	Range		Format
			Min	Max	
	Source ID and message ID: $GPVTG.				
1	True course over ground.	degrees			x.xx
2	True course indicator. T true				T
3	Magnetic course over ground.	degrees			x.xx
4	Magnetic course indicator. M Magnetic				M
5	Speed over ground.	knots			x.xx
6	Nautical speed indicator. N knots				N
7	Speed over ground.				x.xx
8	Speed indicator. K km/hr				K
9	Mode indicator. A autonomous D differential N data not valid				A
	* Checksum delimiter.				*
	CS Two ASCII characters denoting the hexadecimal value of the checksum.				CS
	Message end. Carriage return <CR> and line feed <LF> terminate the message.				

4.2.1.8 Message BTO: Built-In Test Results

This message is a output response to a User requested BTI (Command Built-In Test) message. The receiver outputs Built-In Test results based on the User test selections.

Field #	Description	Units	Range		Format
			Min	Max	
	Source ID and Message ID: $PIBMBTO.				
1	Reserved.				X
2	RAM (embedded) test results. P pass F fail N not tested X no test requested				P
3	RTC test results. P pass F fail N not tested X no test requested				P
4	UART1 test results. P pass F fail N not tested X no test requested				P
5	UART2 test results. P pass F fail N not tested X no test requested				P
6:10	Reserved.				X
11	Antenna sense test results. P pass S short O open N not tested X no test requested				P
12	Reserved.				X
13	Temperature sensor test results. P pass F fail N not tested X no test requested				P
14	Reserved.				X
15	FLASH Program sector. P pass F fail N not tested X no test requested				P

Field #	Description	Units	Range		Format
			Min	Max	
16	FLASH Data sector. P pass F fail N not tested X no test requested				P
17:31	Reserved.				
32	Reset. R reset required X no reset required				R
	* Checksum delimiter.				*
	CS Two ASCII characters denoting the hexadecimal value of the checksum.				CS
	Message end. Carriage return <CR> and line feed <LF> terminate the message.				

4.2.1.9 Message CHS: Channel Status Data

For each satellite tracked, this message outputs the receiver's channel status information, giving the user an indication of signal strength and measurement validity.

Field #	Description	Units	Range		Format
			Min	Max	
	Source ID and Message ID: $PIBMCHS.				
1	Sequence number.				x
2	GPS seconds from epoch.	seconds	0	604,799	xxxx
3	GPS nanoseconds from epoch.	nanoseconds	0	99999 9999	xxxxxxxxx
4	GPS week number.	weeks	0	current week	xxxx
5	Satellite pseudorandom noise (PRN).		1	32	xx
6	Carrier to Noise ratio (C/N0). **Note:** Use the following formula to convert this number: dB Hz = 10 log (C/N0) + 16		0	36	xx
7	Channel status bit. N No PRN S Searching (PRN present) V Measurement valid (Tracking) E Ephemeris data collected U Measurement used (Navigating) D DGPS corrections used				V
8	Satellite pseudorandom noise (PRN).		1	32	xx
9	Carrier to Noise ratio (C/N0). **Note:** Use the following formula to convert this number: dB Hz = 10 log (C/N0) + 16		0	36	xx
10	Channel status bit. N No PRN S Searching (PRN present) V Measurement valid (Tracking) E Ephemeris data collected U Measurement used (Navigating) D DGPS corrections used				V
11	Satellite pseudorandom noise (PRN).		1	32	xx
12	Carrier to Noise ratio (C/N0). **Note:** Use the following formula to convert this number: dB Hz = 10 log (C/N0) + 16		0	36	xx
13	Channel status bit. N No PRN S Searching (PRN present) V Measurement valid (Tracking) E Ephemeris data collected U Measurement used (Navigating) D DGPS corrections used				V

Field #	Description	Units	Range		Format
			Min	Max	
14	Satellite pseudorandom noise (PRN).		1	32	xx
15	Carrier to Noise ratio (C/N0). **Note:** Use the following formula to convert this number: dB Hz = 10 log (C/N0) + 16		0	36	xx
16	Channel status bit. N No PRN S Searching (PRN present) V Measurement valid (Tracking) E Ephemeris data collected U Measurement used (Navigating) D DGPS corrections used				V
	* Checksum delimiter.				
	CS Two ASCII characters denoting the hexadecimal value of the checksum.				
	Message end. Carriage return <CR> and line feed <LF> terminate the message.				

4.2.1.10 Message MDR: Miscellaneous Data Request

This message outputs miscellaneous data and time since last navigation information as defined below.

Field #	Description	Units	Range		Format
			Min	Max	
	Source ID and Message ID: $PIBMMDR.				
1	Date and time.	year/month/day/ hour/minutes/ seconds			yymmddh-hmmss.ss
2	Heading (course over ground).	degrees true	0	+360	xxx.xx
3	Speed over ground.	meters/second			xxx.xx
4	Expected horizontal position error (EHPE).	meters			xxxx.xx
5	Expected vertical position error (EVPE).	meters			xxxx.xx
6	Delay since last navigation.	hours/minutes/ seconds			hhmmss.ss
7	Antenna Sense Status. C Connected (active antenna interface is operational) O Open (active antenna interface has an open circuit) S Short (active antenna interface has a short circuit) F Failed (active antenna interface is unknown)				C
	* Checksum delimiter.				*
	CS Two ASCII characters denoting the hexadecimal value of the checksum.				CS
	Message end. Carriage return <CR> and line feed <LF> terminate the message.				

4.2.2 NMEA Input Messages

The following table lists supported NMEA Input Messages.

NMEA Message	Description	See Page
INT	Receiver initialization.	141
IOC	Input/output port configuration.	142
LOG	Message log control.	143
MPC	Message protocol configuration.	144
RST	Command reset.	145
BTI	Command built-in test.	146

4.2.2.1 Message INT: Receiver Initialization

This message allows the user to initialize the receiver's position, velocity, and time (PVT) data and to command a software reset.

Example:

$PIBMINT,235338.00,31,8,2000,3400.00,N,11800.00,W,100.0000,N*08

Field #	Description	Units	Range		Format
			Min	Max	
	Source ID and Message ID: $PIBMINT.				
1	UTC time.	hourminsec. decimal			hhmmss.ss
2	UTC day.				xx
3	UTC month.				xx
4	UTC year.				xxxx
5	Latitude.	degreemin. decimal			xxxx.xx
6	Latitude direction. N north (+) S south (-)				N
7	Longitude.	degreemin. decimal			xxxxx.xx
8	Longitude direction. E east (+) W west (-)				E
9	Altitude (height above ellipsoid).	meters			xxx.xx
10	Software reset. R reset N no reset				R
	* Checksum delimiter.				*
	CS Two ASCII characters denoting the hexadecimal value of the checksum.				CS
	Message end. Carriage return <CR> and line feed <LF> terminate the message.				

4.2.2.2 Message IOC: Input/Output Port Configuration

This message allows the user to set the input/output parameters for the receiver's two serial ports.

Example:

$PIBMIOC,1,08,0,3,0*75

Field #	Description	Units	Range		Format
			Min	Max	
	Source ID and Message ID: $PIBMIOC.				
1	Port. 1 port 1 2 port 2		1	2	x
2	Baud rate. 0 Reserved 01 Reserved 02 Reserved 03 1200 04 2400 05 4800 06 9600 07 14400 08 19200 09 28800 10 38400 11 57600 (Binary only) 12 115200 (Binary only)	bps	03	12	xx
3	Parity. 0 none 1 even 2 odd		0	2	x
4	Data bits. 0 Reserved 1 Reserved 2 7 bits 3 8 bits	bits	0	3	x
5	Stop bits. 0 1 bit 1 Reserved 2 2 bits	bits	0	2	x
	* Checksum delimiter.				*
	CS Two ASCII characters denoting the hexadecimal value of the checksum.				CS
	Message end. Carriage return <CR> and line feed <LF> terminate the message.				

4.2.2.3 Message LOG: Message Log Control

This message allows the user to select messages to be output by the receiver. Message rate and frequency are also selectable.

Example:

$PIBMLOG,00,2,0,01*51

Field #	Description	Units	Range		Format
			Min	Max	
	Source ID and Message ID: $PIBMLOG.				
1	Message ID *. 000 NMEA All 100 SID 101 GGA 102 GLL 103 GSA 104 GSV 105 RMC 106 VTG 107 Reserved 108 BTO 109 CHS 110 MDR * When set to zero and when the message output period (field 2) equals zero, disables all output messages. When set to zero and when the message output period (field 2) equals 1 or 2, the receiver will use its ROM defaults.		000 100	110	xxx
2	Period. 0 never (turns off message) 1 once (query) 2 always		0	2	x
3	Mode. 0 on update 1 continuous		0	1	x
4	Rate. A rate of “10”, for example, indicates that the message will be output once every 10 seconds.	seconds	01	99	xx
	* Checksum delimiter.				*
	CS Two ASCII characters denoting the hexadecimal value of the checksum.				CS
	Message end. Carriage return <CR> and line feed <LF> terminate the message.				

4.2.2.4 Message MPC: Message Protocol Configuration

This message allows the user to change the protocol setting for the receiver.

Note: Port 2 is hardware configured to receive messages. Transmitting messages through this port requires a hardware change to the receiver module.

Example:

$PIBMMPC,1,1,1,0*49

Field #	Description	Units	Range		Format
			Min	Max	
	Source ID and Message ID: $PIBMMPC.				
1	Port. 1 port 1 2 port 2				x
2	Receive message type. 0 none 1 Binary (default) 2 NMEA (V2.3, V3.0) 3 DGPS (RTCM) 4 OEM 5-8 Reserved 9 NMEA (V2.0)		0	9	x
3	Transmit message type. 0 none 1 Binary (default) 2 NMEA (V2.3, V3.0) 3 Reserved 4 OEM 5-8 Reserved 9 NMEA (V2.0)		0	9	x
4	Save data in trash bin? 0 no 1 yes		0	1	x
	* Checksum delimiter.				*
	CS Two ASCII characters denoting the hexadecimal value of the checksum.				CS
	Message end. Carriage return <CR> and line feed <LF> terminate the message.				

4.2.2.5 Message RST: Command Reset

This message allows the user to force a hot, warm or cold start reset.

Example:

$PIBMRST,C*2C

Field #	Description	Units	Range		Format
			Min	Max	
	Source ID and Message ID: $PIBMRST.				
1	Type of reset. H Hot start: commands a software reset. (Almanac, ephemeris, time and frequency standard parameters are maintained). W Warm start: clears all RAM data. (Almanac, position, time and frequency standard parameters are maintained). C Cold start: clears all RAM, RTC and position data. (Almanac and frequency standard parameters are maintained).				C
	* Checksum delimiter.				*
	CS Two ASCII characters denoting the hexadecimal value of the checksum.				CS
	Message end. Carriage return <CR> and line feed <LF> terminate the message.				

4.2.2.6 Message BTI: Command Built-In Test

This message allows the user to command a built-in test. The results of the test are output using message BTO (Built-in-Test Results) defined on page TBD.

Field #	Description	Units	Range		Format
			Min	Max	
	Source ID and Message ID: $PIBMBTI.				
1.0	Reserved.				
1.1	RAM (embedded) test. 0 skip 1 request		0	1	
1.2	RTC test. 0 skip 1 request		0	1	
1.3	UART1 test. 0 skip 1 request		0	1	
1.4	UART2 test. 0 skip 1 request		0	1	
1.5:1.9	Reserved.				
1.10	Antenna sense test. 0 skip 1 request		0	1	
1.11	Reserved.				
1.12	Temperature sensor test. 0 skip 1 request		0	1	
1.13	Reserved.				
1.14	FLASH Program sector. 0 skip 1 request		0	1	
1.15	FLASH Data sector. 0 skip 1 request		0	1	
1.16:1.30	Reserved.				
1.31	Reset. 0 skip 1 request		0	1	
	* Checksum delimiter.				*
	CS Two ASCII characters denoting the hexadecimal value of the checksum.				CS
	Message end. Carriage return <CR> and line feed <LF> terminate the message.				

4.3 Differential GPS (DGPS) Messages

This section describes the DGPS messages supported by the RFMD GPS receiver. Serial Port 2 is configured to receive RTCM SC-104 messages only, and has a default serial input communication setting with the follow parameters:

- Baud 9600 bps
- Data bits 8
- Parity none
- Stop bits 1

Radio Technical Commission for Maritime Services (RTCM) is the recommended standard for differential Navstar GPS service developed by RTCM special committee 104. Measurement correction data is provided for the following GPS errors, common to the reference station and the user:

- Satellite ephemeris prediction errors
- Satellite clock prediction errors
- Ionospheric delay errors
- Tropospheric delay errors
- Selective availability errors

In addition to measurement correction data, the standard also provides for almanac and health data. The data is separated into following types:

- data that varies in its frequency of transmission
- data that varies by the user for whom it is intended
- error correction data
- almanac data.

The message format contains the following 2-word header for each frame. Each frame is N+2 words long, N words containing the data of the message. N varies with the message type and within a message type.

Number of Bits	Description	Units	Range		Scale Factor
			Min	Max	
First Word					
8	Preamble.				
6	Frame ID/MSG Type. 64 all zeros		1	64	1
10	Station ID.		0	1023	1
6	Parity. See ICD-GPS 200.				
Second Word					
13	Modified Z-Count.	0.6 sec	0	3599.4	
3	Sequence Number.		0	7	1
5	Length of Frame (N+2).	1 Word	2	33	
3	Station Health.	states	1	8	
6	Parity. See ICD-GPS 200.				

4.3.1 RTCM SC-104 DGPS Input Messages

The following table lists the supported RTCM SC-104 input messages.

Message Number	Description	See Page
1	Differential GPS Corrections.	148
2	Delta Differential GPS Corrections.	149
9	Partial Satellite Set Differential Corrections.	150

4.3.1.1 RTCM Message Type 1: Differential GPS Corrections

This is the primary message type, which provides the pseudo range correction for any user receiver GPS measurement time. This message contains data for all satellites in view of the reference station.

Number of Bits	Description	Units	Range		Scale Factor[1]	Notes
			Min	Max		
30	Header: 1st Word.					
30	Header: 2nd Word.					
1	Scale Factor. 0 #0 = 0.02 m or 0.002 m/s 1 #1 = 0.32 m or 0.032 m/s	2 states				
2	UDRE. 00 #0 $\leq$ 1m 01 #1 > 1m and $\leq$ 4m 10 #2 > 4m and $\leq$ 8 m 11 #3 > 8 m	4 states				
5	Satellite ID. (SV 32 = 00000)		1	32		
16	PRC (τ_0)	0.02 or 0.32 m	-655.34 or -10485.44 m	+655.34 or +10485.44 m		
8	RRC	0.002 or 0.032 m/s	-0.254 or -4.064 m/s	+0.254 or +4.064 m/s		2
8 / (40 x # SV corrections)	Issue of Data See ICD-GPS 200.					
8 x (# SV corrections), mod 3	Fill.	bits	0, 8, or 16			
# data words x 6	Parity. See ICD-GPS 200.					

1. The Scale Factor is the number by which the receiver multiplies the parameter to give the true value.
2. Parameters are two's complement, with the sign bit (+ or -) occupying the most significant bit.

4.3.1.2 RTCM Message Type 2: Delta Differential GPS Corrections

This message is provided for situations where the receiver may not immediately decode new satellite ephemerides in the satellite data. Since the reference station should be designed to immediately decode the new ephemerides, there could be periods of time when the receiver and the reference station are using different ephemerides. This could result in position errors, particularly after a satellite upload.

This message contains the difference in the pseudo range and range rate corrections caused by the change in satellite navigation data.

Number of Bits	Description	Units	Range		Notes
			Min	Max	
30	Header:1st Word.				
30	Header:2nd Word.				
1	Scale Factor. 0 #0 = 0.02 m or 0.002 m/s 1 #1 = 0.32 m or 0.032 m/s	2 states			
2	UDRE. 00 #0 ≤ 1m 01 #1 > 1m and ≤ 4m 10 #2 > 4m and ≤ 8 m 11 #3 > 8 m	4 states			
5	Satellite ID. SV 32=00000)		1	32	
16	Delta PRC (τ_0)	0.02 or 0.32 m	-655.34 or -10485.44 m	+655.34 or +10485.44 m	
8	Delta RRC.	0.002 or 0.032 m/s	-0.254 or -4.064 m/s	+0.254 or +4.064 m/s	1
8/(40x # SV corrections)	Issue of Data. See ICD-GPS 200				
8x(# SV corrections), mod 3	Fill	bits	0, 8, or 16		
# data words x 6	Parity. See ICD-GPS 200				

1. Parameters are two’s complement, with the sign bit (+ or -) occupying the most significant bit.

4.3.1.3 RTCM Message Type 9: Partial Satellite Set Differential GPS Corrections

This message serves the same purpose as the Type 1 Message. It contains the primary differential corrections. However, it does not require a complete satellite set.

Number of Bits	Description	Units	Range		Notes
			Min	Max	
Number of Bits	Parameter	Scale Factor / Units	Range		
30	Header: 1st Word.				
30	Header: 2nd Word.				
1	Scale Factor. 0 #0 = 0.02 m or 0.002 m/s 1 #1 = 0.32 m or 0.032 m/s	2 states			
2	UDRE. 00 #0 ≤ 1m 01 #1 > 1m and ≤ 4m 10 #2 > 4m and ≤ 8 m 11 #3 > 8 m	4 states			
5	Satellite ID. (SV 32=00000)		1	32	
16	PRC (τ_0)	0.02 or 0.32 m	-655.34 or -10485.44 m	+655.34 or +10485.44 m	
8	RRC.	0.002 or 0.032 m/s	-0.254 or -4.064 m/s	+0.254 or +4.064 m/s	1
8/(40x # SV corrections)	Issue of Data. See ICD-GPS 200.				
8x(# SV corrections), mod 3	Fill.	bits	0, 8, or 16		
# data words x 6	Parity. See ICD-GPS 200				

1. Parameters are two’s complement, with the sign bit (+ or -) occupying the most significant bit.

5. Glossary

Almanac	Library of coarse satellite orbital characteristics used to calculate satellite rise times, set times, angles of elevation, etc. Almanac data is valid for 181 days.
Altitude	The antenna height measured in meters. Referenced as the distance above mean sea level or above the earth ellipsoid.
Azimuth	The angular displacement in the horizontal plane between the point of observation and the greenwich meridian. For GPS satellites, azimuth is measured clockwise from true north.
Baud	One bit per second.
Bit	The smallest data element in a binary-coded message.
Byte	A group of eight bits of Binary data or one ASCII character.
Carrier to Noise Ratio (CNo)	Quantitative relationship between the useful and non-useful part of the received satellite signal.
Cold Start	The receiver has valid almanac and frequency standard parameters available in memory. The receiver enters this mode if cold start has been enabled by the user (default is on) and the receiver is unable to track satellites for the set cold start timeout period. A cold start is a rigorous, "search the sky", channel search.
COM1, COM2	The two serial data ports through which the PC controller communicates with the receiver.
Constellation	A group of GPS satellites visible to the receiver. The size of a usable constellation is a minimum of three satellites. A valid position update may be computed from either of the following: • four satellites with altitude required enabled (3D). • three satellites with altitude required disabled (2D).
Coordinated Universal Time (UTC)	Greenwich mean time corrected for the polar motion of the earth and for seasonal variations in the earth's rotation.
Default	Any presumed and/or preset condition prior to user modification.
Dilution of Precision (DOP)	A measure of quality of the GPS derived position and time estimates, based on the geometry of the satellite constellation. A smaller DOP indicates better geometry which yields a better solution. Generally, the more spread out the satellites, the lower the DOP. The DOPs used for GPS satellite tracking are as follows: HDOP: Horizontal dilution of precision. PDOP: Position dilution of precision. GDOP: Geometric dilution of precision.
ECEF	Earth Center/Earth Fixed.
EEPROM	Electrically Erasable Programmable Read Only Memory.
EHPE	Expected Horizontal Position Error.

Elevation Angle — The angle made by the line-of-sight range to the satellite and the horizontal plane of the receiver antenna. Thus, the elevation angle is 90 degrees when the satellite is overhead and zero degrees when it first appears on the horizon. Satellites whose maximum elevation angle is less than five degrees are not good candidates for providing an accurate position update.

Ephemeris — Tabulation of accurate data describing position and health of the satellites over a 24-hour period. The data is uploaded from a ground control station to the satellites every 12 hours. The GPS satellites transmits its own ephemeris data to the GPS receiver. The receiver will collect ephemeris data for each satellite being tracked. Ephemeris data collection takes approximately 30 seconds and requires continuous, uninterrupted satellite tracking.

EVPE — Expected Vertical Position Error.

Filename — The identity or name of a file. Filenames are assigned to files when they are first opened. They can be any combination of letters and numbers that are eight characters or less, followed by a period (.) and zero to three characters known as the extension.

Geoidal Separation — The difference between the WGS-84 earth ellipsoid and mean-sea-level (geoid).

Geometric Dilution of Precision (GDOP) — A measure of the quality of the GPS derived position and time estimates, based on the geometry of the satellite constellation. A smaller DOP indicates better geometry which yields a better solution.

Geometry (of satellites) — The spatial relationships of the GPS satellites with respect to each other and the receiver.

Global Positioning System (GPS) — The NAVSTAR global positioning system, consisting of orbiting satellites, a network of ground control stations, and user positioning and navigation equipment. When fully operational, the system will have 21 satellites in six orbital planes about 20,200 kilometers above the earth. Three additional satellites will be strategically stationed in orbit as spares in the event of online satellite malfunctions.

Heading — Direction in which the receiver is proceeding. Heading is referenced to true north.

Hot Start — The receiver has the following data available in memory: position, velocity, time, ephemeris, almanac and frequency standard parameters. The receiver enters this mode following a software reset.

Initialize — To enter key operating constants into the receiver, enabling it to start producing accurate positioning and/or navigation data. The constants are latitude, longitude, time, date and altitude.

IODC — Issue of Data Clock.

IODE — Issue of Data Ephemeris.

Latitude — The identification of a point on the earth's surface located along a parallel plane. Angular distance measured North or South of the equator.

Local Time Offset — The number of hours by which the local time differs from universal time coordinated (UTC).

Longitude	The identification of a point on the earth's surface located along a meridian plane. Angular distance measured East or West of the Prime Meridian.
LSB	Least significant bit.
LSE	Least squares estimate.
MSB	Most Significant Bit.
Multipath	Error caused by the interference of a signal that has reached the receiver antenna by two or more different paths. Usually caused by one path being bounced or reflected.
Nanosecond (ns)	A billionth (0.000000001) of a second.
Nautical Mile (Knot)	Knot is a rate equal to 1 nautical mile per hour. In the U.S., one nautical mile (nm) is equal to 1852 meters (6076.115 feet).
Navigation Modes	The two basic navigation modes of the receiver are 3D and 2D. 3D-navigation is when altitude data is used and 2D-navigation is when the altitude data is held or set to a fixed value.
NMEA	National Maritime Electronics Association.
Platform Class	A specific range of constants applied to the navigation filter that characterizes the motion dynamics of the receiver, in which four states for acceleration are suggested: sea (high, low), static (stationary), land, air. The constants enhance the receiver's ability to model the real-time position.
PPM	Parts per million.
PPS	Pulse per second.
Pseudorandom Noise (PRN)	GPS satellite generated noise used to fingerprint and identify the satellites. An identification number of 1 through 32 is assigned to the noiseprint of each GPS satellite.
Pseudorange	As it applies to GPS, the distance from an orbiting satellite to a GPS receiver. The pseudorange is calculated by measuring the time it takes for the satellite transmission to reach the GPS receiver and then dividing the result by the speed of light.
PVT	Position/ Velocity/ Time.
RAM	Random Access Memory.
ROM	Read Only Memory.
RTC	Real Time Clock.
Satellite Almanac	Data file that contains orbit information on all satellites, clock corrections, and atmospheric delay parameters. It is transmitted by a GPS satellite to a GPS receiver, where it facilitates rapid satellite acquisition within the GPS receiver. Almanac data must be available before GPS navigation can begin. Almanac data is stored and updated to the receiver's Flash memory.

Satellite Health Describes the operational status and/or quality of measurement data from a satellite.

Selective Availability (SA) A policy adopted by the department of defense to introduce intentional clock noise into the GPS satellite signals to degrade their accuracy for civilian use.

Speed Over Ground (SOG) Speed relative to the ocean floor or land.

Static Mode The time recovery mode of the receiver when stationary, thus limiting velocity to zero and solving for position, altitude and time.

Time Mark A one pulse per second (PPS) signal that occurs on the leading edge of each second.

Time Offset The time difference between local time and UTC.

Track The path that the receiver has taken to reach the current position.

UDRE User Differential Range Error.

URA User Range Accuracy.

UTC Coordinated Universal Time (UTC).

Warm Start The receiver has the following data either available in memory or provided by the user at initialization: position, velocity, time, almanac and frequency standard parameters. The receiver enters this mode on start-up when battery back-up power is maintained.

WGS-84 Datum The ellipsoidal representation of the earth's surface. The basic reference frame and geometric figure for the earth provided by the world geodetic survey of 1984. The datum is used by the GPS satellites.

2D GPS A navigation mode whereby latitude, longitude and time are computed from three satellites using a fixed value for altitude.

3D GPS A navigation mode whereby latitude, longitude, altitude and time are computed from four satellites.

6. References

1. NMEA-0183 Standard for Interfacing Marine Electronic Devices, version 2.1. Defines the hardware and software requirements for a NMEA-0183 data interface.
2. EIA RS-232C Specification. Defines the hardware and software requirements for an RS-232 data interface.
3. RTCM-104 Specification. Defines the record structure for the standard RTCM-104 messages used for differential GPS correction data:
4. RTCM Special Committee No. 104, RTCM Recommended Standards for Differential NAVSTAR GPS Service, Version 2.0, Washington, D.C.
5. Radio Technical Commission for Maritime Services.
6. ICD-GPS-200 Specification. Defines the GPS satellite data format.

7. Appendix A: Antenna Specifications

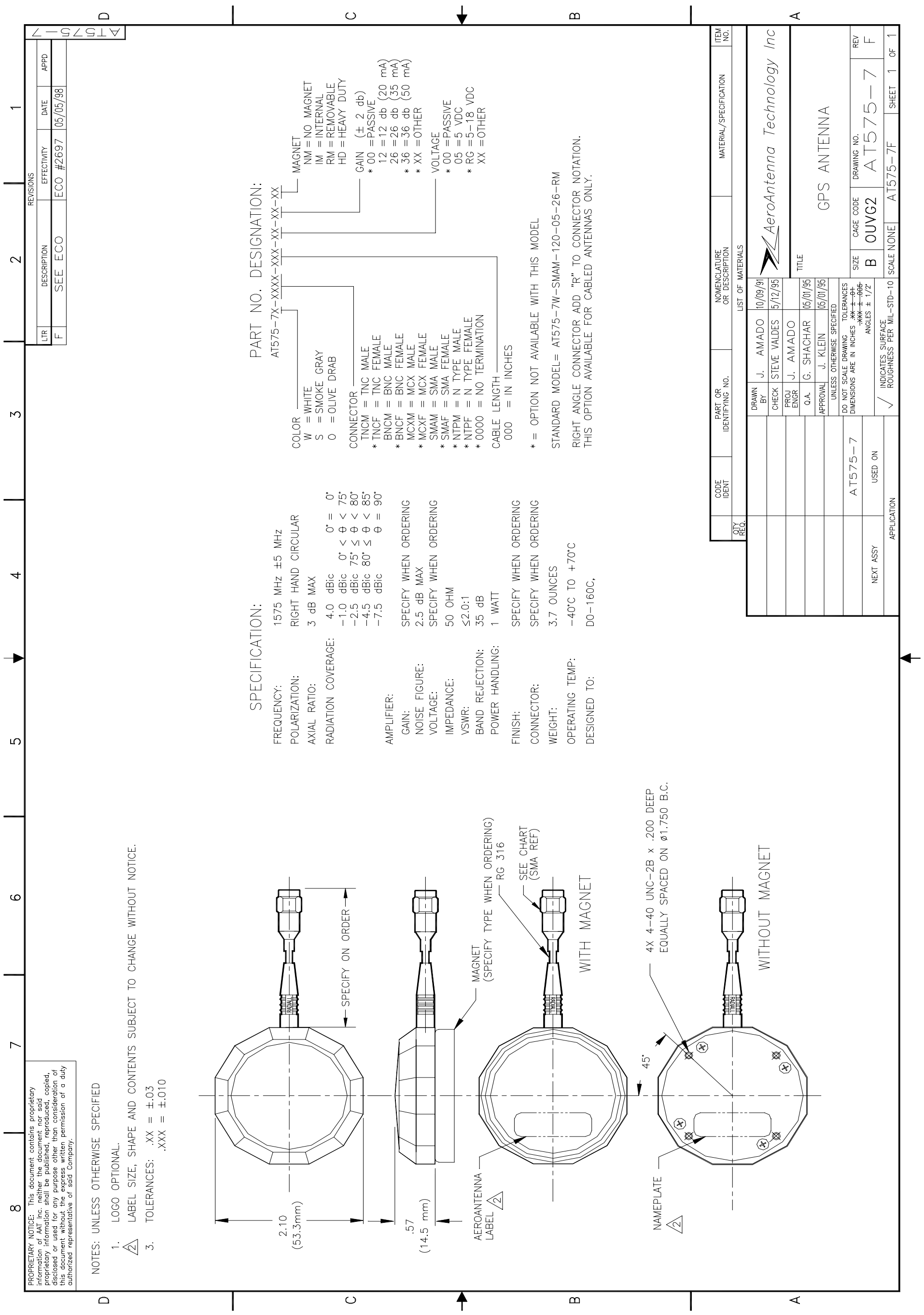
The AeroAntenna Technology Inc. active GPS antenna is provided as part of the RFMD GPS Receiver Evaluation Kit. The antenna data sheet is provided below, in Figure 7-1 on page 158.

Note: The antenna must have a minimum of 30 dB gain, exclusive of all cable losses and it must have a minimum amplifier filter noise bandwidth of 20 MHz.

Table 7-1. GPS Active Antenna Specifications

Frequency	1575 MHz ± 5 MHz
Antenna Polarization	Right hand circularly polarized
Temperature	-40° C to +95° C
Impedance	50 Ω
VSWR	≤ 2.0:1
Voltage	3-5 VDC, 50 mA (maximum)
Antenna Gain*	3 dBic Typical @ 90 degree elevation
Amplifier Gain	30 dB (minimum) Note: Typical cable loss of approximately 0.42 dB/ft.
Amplifier Filter Noise Bandwidth	> 20 MHz at the 3 dB points
Noise Figure	< 2.5 dB
Connector Type	SMA Male **Note:** The GPS Receiver has a MCX female RF connector.
Cable Length	9 feet

Figure 7-1. AeroAntenna Technology Inc. GPS Antenna Data Sheet



8. Appendix B: Map Datum Definitions

Table 8-1. Reference Ellipsoids

Number	Name	Semi-Major Axis	Inverse Flattening
1	Airy	6377563.396000	299.324965
2	Modified Airy	6377340.189000	299.324965
3	Australian National	6378160.000000	298.250000
4	Bessel 1841	6377397.155000	299.152813
5	Clarke 1866	6378206.400000	294.978698
6	Clarke 1880	6378249.145000	293.465000
7	Everest 1830	6377276.345000	300.801700
8	Everest 1948	6377304.063000	300.801700
9	Fischer 1960	6378166.000000	298.300000
10	Modified Fischer 1960	6378155.000000	298.300000
11	Fischer 1968	6378150.000000	298.300000
12	GRS 1980	6378137.000000	298.257222
13	Helmert 1906	6378200.000000	298.300000
14	Hough	6378270.000000	297.000000
15	International	6378388.000000	297.000000
16	Krassovsky	6378245.000000	298.300000
17	South American 1969	6378160.000000	298.250000
18	WGS 60	6378165.000000	298.300000
19	WGS 66	6378145.000000	298.250000
20	WGS 72	6378135.000000	298.260000
21	WGS 84	6378137.000000	298.257224
22	Bessel 1841 (Nambia)	6377483.865000	299.152813
23	Everest 1956	6377301.243000	300.801700
24	Everest 1969	6377295.664000	300.801700
25	Everest (Sabah & Sarawak)	6377298.556000	300.801700
26	SGS 85	6378136.000000	298.257000

Note: This data is taken from DoD world geodetic system 1984, DMA TR 8350.2-B, December 1, 1987, second printing. Includes september 1, 1991 updates.

Table 8-2. Map Datums (Sheet 1 of 8)

Datum ID	Description	Reference Ellipsoid	dx	dy	dz
0	WGS 84 - Default	21	0	0	0
1	Adindan - MEAN FOR Ethiopia, Sudan	6	-166	-15	204
2	Adindan - Burkina Faso	6	-118	-14	218

Table 8-2. Map Datums (Sheet 2 of 8)

Datum ID	Description	Reference Ellipsoid	dx	dy	dz
3	Adindan - Cameroon	6	-134	-2	210
4	Adindan - Ethiopia	6	-165	-11	206
5	Adindan - Mali	6	-123	-20	220
6	Adindan - Senegal	6	-128	-18	224
7	Adindan - Sudan	6	-161	-14	205
8	Afgooye - Somalia	16	-43	-163	45
9	Ain el Abd 1970 - Bahrain	15	-150	-251	-2
10	Ain el Abd 1970 - Saudi Arabia	15	-143	-236	7
11	Anna 1 Astro 1965 - Cocos Islands	3	-491	-22	435
12	Antigua Island Astro 1943 Antigua (Leeward Islands)	6	-270	13	62
13	Arc 1950 MEAN FOR Botswana, Lesotho, Malawi, Swaziland, Zaire, Zambia, Zimbabwe	6	-143	-90	-294
14	Arc 1950 - Botswana	6	-138	-105	-289
15	Arc 1950 - Burundi	6	-153	-5	-292
16	Arc 1950 - Lesotho	6	-125	-108	-295
17	Arc 1950 - Malawi	6	-161	-73	-317
18	Arc 1950 - Swaziland	6	-134	-105	-295
19	Arc 1950 - Zaire	6	-169	-19	-278
20	Arc 1950 - Zambia	6	-147	-74	-283
21	Arc 1950 - Zimbabwe	6	-142	-96	-293
22	Arc 1960 - MEAN FOR Kenya, Tanzania	6	-160	-6	-302
23	Ascension Island 1958 Ascension Island	15	-191	103	51
24	Astro Beacon E 1945 - Iwo Jima	15	145	75	-272
25	Astro DOS 71/4 - St Helena Island	15	-320	550	-494
26	Astro Tern Island (FRIG) 1961 Tern Island	15	114	-116	-333
27	Astronomical Station 1952 Marcus Island	15	124	-234	-25
28	Australian Geodetic 1966 Australia & Tasmania	3	-133	-48	148
29	Australian Geodetic 1984 Australia & Tasmania	3	-134	-48	149
30	Ayabelle Lighthouse - Djibouti	6	-79	-129	145
31	Bellevue (IGN) Efate & Erromango Islands	15	-127	-769	472
32	Bermuda 1957 - Bermuda	5	-73	213	296

Table 8-2. Map Datums (Sheet 3 of 8)

Datum ID	Description	Reference Ellipsoid	dx	dy	dz
33	Bissau - Guinea - Bissau	15	-173	253	27
34	Bogota Observatory - Columbia	15	307	304	-318
35	Bukit Rimpah Indonesia (Banka & Belitung Islands)	4	-384	664	-48
36	Camp Area Astro Antarctica (McMurdo Camp Area)	15	-104	-129	239
37	Campo Inchauspe - Argentina	15	-148	136	90
38	Canton Astro 1966 - Phoenix Islands	15	298	304	-375
39	Cape - South Africa	6	-136	108	-292
40	Cape Canaveral - Bahamas, Florida	5	-2	151	181
41	Carthage - Tunisia	6	-263	6	431
42	Chatham Island Astro 1971 New Zealand (Chatham Island)	15	175	-38	113
43	Chua Astro - Paraguay	15	-134	229	-29
44	Corrego Alegra - Brazil	15	-206	172	-6
45	Debola - Guinea	6	-83	37	124
46	Djakarta (Batvia) Indonesia (Sumatra)	4	-377	681	-50
47	DOS 1968 New Georgia Islands (Gizo Island)	15	230	-199	-752
48	Easter Island 1967 - Easter Island	15	211	147	111
49	European 1950 MEAN FOR Austria, Belgium, Denmark, Finland, France, West Germany, Gibraltar, Greece, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzer-land	15	-87	-98	-121
50	European 1950 MEAN FOR Austria, Denmark, France, West Germany, Netherlands, Switzerland	15	-87	-96	-120
51	European 1950 MEAN FOR Iraq, Israel, Jordan, Lebanon, Kuwait, Saudi Arabia, Syria	15	-103	-106	-141
52	European 1950 - Cyprus	15	-104	-101	-140
53	European 1950 - Egypt	15	-130	-117	-151
54	European 1950 England, Channel Islands, Ireland, Scotland, Shetland Islands	15	-86	-96	-120
55	European 1950 - Finland, Norway	15	-87	-95	-120
56	European 1950 - Greece	15	-84	-95	-130
57	European 1950 - Iran	15	-117	-132	-164
58	European 1950 - Italy (Sardinia)	15	-97	-103	-120
59	European 1950 - Italy (Sicily)	15	-97	-88	-135

Table 8-2. Map Datums (Sheet 4 of 8)

Datum ID	Description	Reference Ellipsoid	dx	dy	dz
60	European 1950 - Malta	15	-107	-88	-149
61	European - Portugal, Spain	15	-84	-107	-120
62	European 1979 MEAN FOR Austria, Finland, Netherlands, Norway, Spain, Sweden, Switzerland	15	-86	-98	-119
63	Fort Thomas 1955 Nevis, St Kitts (Leeward Islands)	6	-7	215	225
64	Gan 1970 - Republic of Maldives	15	-133	-321	50
65	Geodetic Datum 1949 - New Zealand	15	84	-22	209
66	Graciosa Base SW 1948 Azores (Faial, Graciosa, Pico, Sao Jorge, Terceira)	15	-104	167	-38
67	Guam 1963 - Guam	5	-100	-248	259
68	Gunung Segara - Indonesia (Kalimantan)	4	-403	684	41
69	GUX 1 Astro - Guadalcanal Island	15	252	-209	-751
70	Herat North - Afghanistan	15	-333	-222	114
71	Hjorsey 1955 - Iceland	15	-73	46	-86
72	Hong Kong 1963 - Hong Kong	15	-156	-271	-189
73	Hu-Tzu-Shan - Taiwan	15	-637	-549	-203
74	Indian - Bangladesh	7	282	726	254
75	Indian - India, Nepal	23	295	736	257
76	Indian 1954 - Thailand, Vietnam	7	218	816	297
77	Indian 1975 - Thailand	7	209	818	290
78	Ireland 1965 - Ireland	2	506	-122	611
79	ISTS 061 Astro 1968 South Georgia Islands	15	-794	119	-298
80	ISTS 073 Astro 1969 - Diego Garcia	15	208	-435	-229
81	Johnston Island 1961 - Johnston Island	15	189	-79	-202
82	Kandawala - Sri Lanka	7	-97	787	86
83	Kerguelen Island 1949 Kerguelen Island	15	145	-187	103
84	Kertau 1948 - West Malaysia & Singapore	8	-11	851	5
85	Kusaie Astro 1951 - Caroline Islands	15	647	1777	-1124
86	L.C. 5 Astro 1961 - Cayman Brac Island	5	42	124	147
87	Leigon - Ghana	6	-130	29	364
88	Liberia 1964 - Liberia	6	-90	40	88
89	Luzon Philippines (Excluding Mindanao)	5	-133	-77	-51
90	Luzon - Philippines (Mindanao)	5	-133	-79	-72

Table 8-2. Map Datums (Sheet 5 of 8)

Datum ID	Description	Reference Ellipsoid	dx	dy	dz
91	Mahe 1971 Mahe Island	6	41	-220	-134
92	Massawa - Ethiopia (Eritrea)	4	639	405	60
93	Merchich - Morocco	6	31	146	47
94	Midway Astro 1961 - Midway Islands	15	912	-58	1227
95	Minna - Cameroon	6	-81	-84	115
96	Minna - Nigeria	6	-92	-93	122
97	Montserrat Island Astro 1958 Montserrat (Leeward Islands)	6	174	359	365
98	M"Poraloko - Gabon	6	-74	-130	42
99	Nahrwan - Oman (Masirah Island)	6	-247	-148	369
100	Nahrwan - Saudi Arabia	6	-243	-192	477
101	Nahrwan - United Arab Emirates	6	-249	-156	381
102	Naparima BWI - Trinidad & Tobago	15	-10	375	165
103	North American 1927 MEAN for antigua, Barbados, Barbuda, Caicos Islands, Cuba, Dominican Republic, Grand Cayman, Jamaica, Turks Islands	5	-3	142	183
104	North American 1927 MEAN for Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua	5	0	125	194
105	North American 1927 - MEAN FOR Canada	5	-10	158	187
106	North American 1927 - MEAN FOR CONUS	5	-8	160	176
107	North American 1927 MEAN FOR CONUS (East of Mississippi River) including Louisiana, Missouri, Minnesota	5	-9	161	179
108	North American 1927 MEAN FOR CONUS (West of Mississippi River)	5	-8	159	175
109	North America 1927 - Alaska	5	-5	135	172
110	North American 1927 Bahamas (Except San Salvador Island)	5	-4	154	178
111	North American 1927 Bahamas (San Salvador Island)	5	1	140	165
112	North American 1927 Canada (Alberta, British Columbia)	5	-7	162	188
113	North American 1927 Canada (Manitoba, Ontario)	5	-9	157	184
114	North American 1927 Canada (New Brunswick, Newfoundland, Nova Scotia, Quebec)	5	-22	160	190
115	North American 1927 Canada (Northwest Territories, Saskatchewan)	5	4	159	188
116	North American 1927 - Canada (Yukon)	5	-7	139	181

Table 8-2. Map Datums (Sheet 6 of 8)

Datum ID	Description	Reference Ellipsoid	dx	dy	dz
117	North American 1927 - Canal Zone	5	0	125	201
118	North American 1927 - Cuba	5	-9	152	178
119	North American 1927 Greenland (Hayes Peninsula)	5	11	114	195
120	North American 1927 - Mexico	5	-12	130	190
121	North American 1983 Alaska, Canada, CONUS	12	0	0	0
122	North American 1983 Central America, Mexico	12	0	0	0
123	Observatorio Metereo 1939 Azores (Corvo & Flores Islands	15	-425	-169	81
124	Old Egyptian 1907 - Egypt	13	-130	110	-13
125	Old Hawaiian MEAN FOR Hawaii, Kauai, Maui, Oahu	5	61	-285	-181
126	Old Hawaiian - Hawaii	5	89	-279	-183
127	Old Hawaiian - Kauai	5	45	-290	-172
128	Old Hawaiian - Maui	5	65	-290	-190
129	Old Hawaiian - Oahu	5	58	-283	-182
130	Oman - Oman	6	-346	-1	224
131	Ord. Survey Great Britain 1936 MEAN FOR England, Isle of Man, Scotland, Shetland Islands, Wales	1	375	-111	431
132	Ord. Survey Great Britain 1936 - England	1	371	-112	434
133	Ord. Survey Great Britain 1936 England, Isle of Man, Wales	1	371	-111	434
134	Ord. Survey Great Britain 1936 Scotland, Shetland Islands	1	384	-111	425
135	Ord. Survey Great Britain 1936 - Wales	1	370	-108	434
136	Pico de las Nieves - Canary Islands	15	-307	-92	127
137	Pitcairn Astro 1967 - Pitcairn Island	15	185	165	42
138	Point 58 MEAN FOR Burkina Faso & Niger	6	-106	-129	165
139	Pointe Noire 1948 - Congo	6	-148	51	-291
140	Porto Santo 1936 Porto Santo, Madeira Islands	15	-499	-249	314
141	Provisional South American 1956 MEAN FOR Bolivia, Chile, Colombia, Ecuador, Guyana, Peru, Venezuela	15	-288	175	-376
142	Provisional South American 1956 - Bolivia	15	-270	188	-388
143	Provisional South American 1956 Chile (Northern, Near 19° South)	15	-270	183	-390

Table 8-2. Map Datums (Sheet 7 of 8)

Datum ID	Description	Reference Ellipsoid	dx	dy	dz
144	Provisional South American 1956 Chile (Southern, Near 43° South)	15	-305	243	-442
145	Provisional South American 1956 - Columbia	15	-282	169	-371
146	Provisional South American 1956 - Ecuador	15	-278	171	-367
147	Provisional South American 1956 - Guyana	15	-298	159	-369
148	Provisional South American 1956 - Peru	15	-279	175	-379
149	Provisional South American - Venezuela	15	-295	173	-371
150	Provisional South Chilean 1963 Chile (South, Near 53° South) (Hito XVIII)	15	16	196	93
151	Puerto Rico Puerto Rico, Virgin Islands	5	11	72	-101
152	Qatar National - Qatar	15	-128	-283	22
153	Qornoq - Greenland (South)	15	164	138	-189
154	Reunion - Mascarene Islands	15	94	-948	-1262
155	Rome 1940 - Italy (Sardinia)	15	-225	-65	9
156	Santo (DOS) 1965 Espirito Santo Island	15	170	42	84
157	Sao Braz Azores (Sao Miguel, Santa Maria Islands)	15	-203	141	53
158	Sapper Hill 1943 - East Falkland Island	15	-355	21	72
159	Schwarzeck - Namibia	22	616	97	-251
160	Selvagem Grande - Salvage Islands	15	-289	-124	60
161	SGS 85 - Soviet Geodetic System 1985	26	3	9	-9
162	South American 1969 MEAN for Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Trinidad & Tobago, Venezuela	17	-57	1	-41
163	South American 1969 - Argentina	17	-62	-1	-37
164	South American 1969 - Bolivia	17	-61	2	-48
165	South American 1969 - Brazil	17	-60	-2	-41
166	South American 1969 - Chile	17	-75	-1	-44
167	South American 1969 - Colombia	17	-44	6	-36
168	South American 1969 - Ecuador	17	-48	3	-44
169	South American 1969 Ecuador (Baltra, Galapagos)	17	-47	27	-42
170	South American 1969 - Guyana	17	-53	3	-47
171	South American 1969 - Paraguay	17	-61	2	-33
172	South American 1969 - Peru	17	-58	0	-44
173	South American 1969 - Trinidad & Tobago	17	-45	12	-33

Table 8-2. Map Datums (Sheet 8 of 8)

Datum ID	Description	Reference Ellipsoid	dx	dy	dz
174	South American 1969 - Venezuela	17	-45	8	-33
175	South Asia - Singapore	10	7	-10	-26
176	Tananarive Observatory 1925 Madagascar	15	-189	-242	-91
177	Timbalai 1948 Brunei, East Malaysia (Sabah, Sarawak)	25	-679	669	-48
178	Tokyo - MEAN FOR Japan, Korea, Okinawa	4	-148	507	685
179	Tokyo - Japan	4	-148	507	685
180	Tokyo - Korea	4	-146	507	687
181	Tokyo - Okinawa	4	-158	507	676
182	Tristan Astro 1968 - Tristan da Cunha	15	-632	438	-609
183	Viti Levu 1916 Fiji (Viti Levu Island)	6	51	391	-36
184	Wake - Eniwetok 1960 - Marshall islands	14	102	52	-38
185	Wake Island Astro 1952 - Wake Atoll	15	276	-57	149
186	WGS 1972 - Global Definition	20	0	0	0
187	Yacare - Uruguay	15	-155	171	37
188	Zanderiji - Suriname	15	-265	120	-358

Revision Log

Revision	Description of Modification
February 11, 2002	Initial release (00).
March 21, 2002	Included Boot code reprogramming.
April 22, 2002	Update to RFMDgps evaluation tool.
May 10, 2002	Include notes defining unsupported sections and messages.
May 24, 2002	Change DLN conditional, DGPS baud rate to 9600bps, update Binary output window.
June 14, 2002	Add field to DLN message and rename to MDR. Remove all references stating DGPS not supported. Change UDRE numbering, 0-3.
July 9, 2002	Add note to power cycle the receiver upon completion of a reprogramming cycle, if the receiver is not outputting messages. Add note defining receiver version information. Remove reference to CHS message for NMEA status updates. Remove 110> Reserved from NMEA LOG message list. Add note to DGPS LED description. Run spell checker. Add note to BIT for UART_2. Highlight SW3 on Evaluation Unit drawing. Add troubleshooting section on how to restoring factory ROM defaults. Add note to DGPS section, no data displayed if not in valid DGPS mode.
July 17, 2002	Update all Built-In-Test messages; Binary (OBIT, IBIT) and NMEA (BTO, BTI).

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