GPSCard™

Command Descriptions Manual

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This manual is a companion to the GPSCard Installation and Operating Manual.

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- Via NovAtel Bulletin Board System (BBS) for 12 channel receivers.
- By return to the factory only for 10 channel receivers.
- Authorization coding supplied by NovAtel GPS Customer Service group.

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Are supplied free of charge during the one-year warranty coverage following initial purchase. An updated manual is also supplied free of charge.

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- are supplied free of charge for 12 channel receivers via the BBS. A nominal charge is applied for each copy of the updated manual that is requested.
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FOREWORD

Purpose

The *GPSCard™ Command Descriptions Manual* is intended to be used as a companion manual to the *GPSCard Installation and Operating Manual*. Once you have completed the initial installation and basic operating introductions, this text will be your primary GPSCard command and logging reference source.

This manual has been written to be independent of the GPSCard model type and is therefore comprehensive including all features of the top-of-the-line 12 channel models. Please bear in mind that if you do not own a top-of-the-line GPSCard, some of the features described in this manual may not be available with your particular model of GPSCard.

Scope

The *GPSCard Command Descriptions Manual* describes each command and log that the GPSCard is capable of accepting or outputting. Sufficient detail is provided so that a systems developer or OEM user can understand the purpose, syntax, and structure of each command or log and be able to effectively communicate with the GPSCard, thus enabling the developer to effectively use and write custom interfacing software for specific needs and applications. The manual is organized into chapters that allow easy access to appropriate information about the GPSCard.

This manual does not address any of the GPSCard hardware attributes or installation information. Please consult the companion to this volume, *GPSCard Installation and Operating Manual*, for hardware or system technical specification information. Furthermore, should you encounter any functional, operational, or interfacing difficulties with the GPSCard, consult the *GPSCard Installation and Operating Manual* for NovAtel warranty and customer support information.

Prerequisites

As this reference manual is focused on the GPSCard commands and logging protocol, it is necessary to ensure that the GPSCard has been properly installed and powered up according to the instructions outlined in the *Installation and Operating Manual* before proceeding.

To use the GPSCard effectively, you should be familiar with the Global Positioning System (GPS) as it applies to positioning, navigation, and surveying applications. For your reference, *Chapter 1* of this manual provides a brief overview of the Global Positioning System.

As this manual covers the full performance capabilities of GPSCard 12 channel cards, your particular model of GPSCard may not have some of the top-of-the-line features described in this text. Feature-tagging symbols have been created to help clarify which commands and logs are basic features versus those that are optional features.

B	Basic features available with all models of GPSCards (10 & 12 channel and Standard & Performance)
11	Features available with x11(R) or xx11(R) models
51	Features available with x51(R) or xx51(R) models
O	Features common only to OEM Series of GPSCards
XII	Features available only with 12 channel GPSCards
R	Real time differential capability available only with xxxR and xxxxR model option
Pf	Features available only with Performance Series of GPSCards
RT20	Features available only with GPSCards equipped with the RT-20 option

WHAT'S NEW IN THIS EDITION

NEW COMMANDS

FRESET	Clears all data which is stored in non volatile memory
POSAVE	Implements position averaging for reference station
RTKMODE	Set-up the RTK mode

MODIFIED COMMANDS

UNLOGALL	Now includes option to disable all logs on a specified port only

NEW LOGS

FRM	Framed Raw Navigation Data
PAV	Positioning Averaging Status
PRTK	Computed Position
RTK	Computed Position – Time Matched
VER	Receiver Hardware and Software Version Numbers
FRW	Framed Raw Navigation Words

MODIFIED LOGS

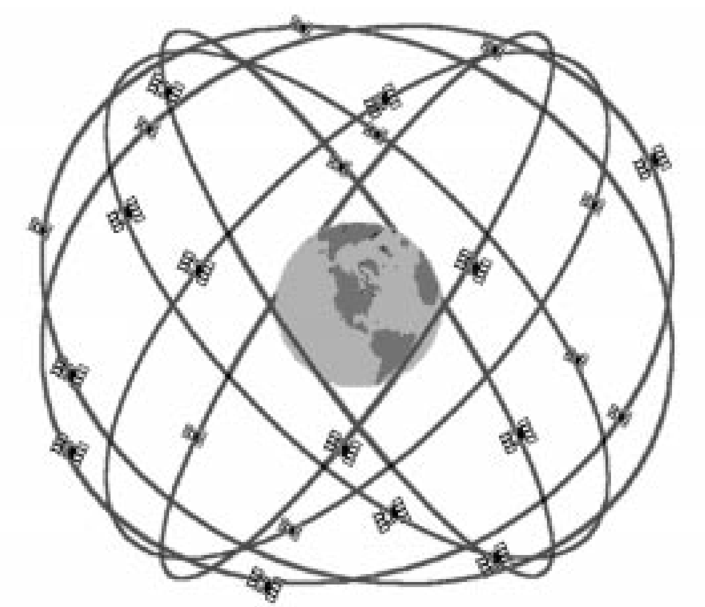
RGEA/B/C	Now includes D messages -- Channel Range Measurements

1 GPS SYSTEM OVERVIEW

The Global Positioning System (GPS) is a satellite navigation system capable of providing a highly accurate, continuous global navigation service independent of other positioning aids. GPS provides 24-hour, all-weather, worldwide coverage with position, velocity and timing information.

The system uses the NAVSTAR (NAVigation Satellite Timing And Ranging) satellites, which consists of 24 operational satellites to provide a GPS receiver with a six-to-twelve satellite coverage at all times. A minimum of four satellites in view allows the GPSCard to compute its current latitude, longitude, and altitude with reference to mean sea level and the GPS system time.

Figure 1-1 NAVSTAR Satellite Orbit Arrangement



GPS SYSTEM DESIGN

The GPS system design consists of three parts:

- The Space segment
- The Control segment
- The User segment

All these parts operate together to provide accurate three-dimensional positioning, timing and velocity data to users worldwide.

THE SPACE SEGMENT

The space segment is composed of the NAVSTAR GPS satellites. The final constellation of the system consists of 24 satellites in six 55° orbital planes, with four satellites in each plane. The orbit period of each satellite is approximately 12 hours at an altitude of 10,898 nautical miles. This provides a GPS receiver with six to twelve satellites in view from any point on earth, at any particular time.

The GPS satellite signal identifies the satellite and provides the positioning, timing, ranging data, satellite status and the corrected ephemerides (orbit parameters) of the satellite to the users. The satellites can be identified either by the Space Vehicle Number (SVN) or the Pseudorandom Code Number (PRN). The NovAtel GPSCard uses the PRN.

The GPS satellites transmit on two L-band frequencies; one centered at 1575.42 MHz (L1) and the other at 1227.60 MHz (L2). The C/A code (Coarse/Acquisition) and the P code (Precision), which are encrypted for military and other authorized users, modulate the L1 carrier. The L2 carrier is modulated only with the P code.

THE CONTROL SEGMENT

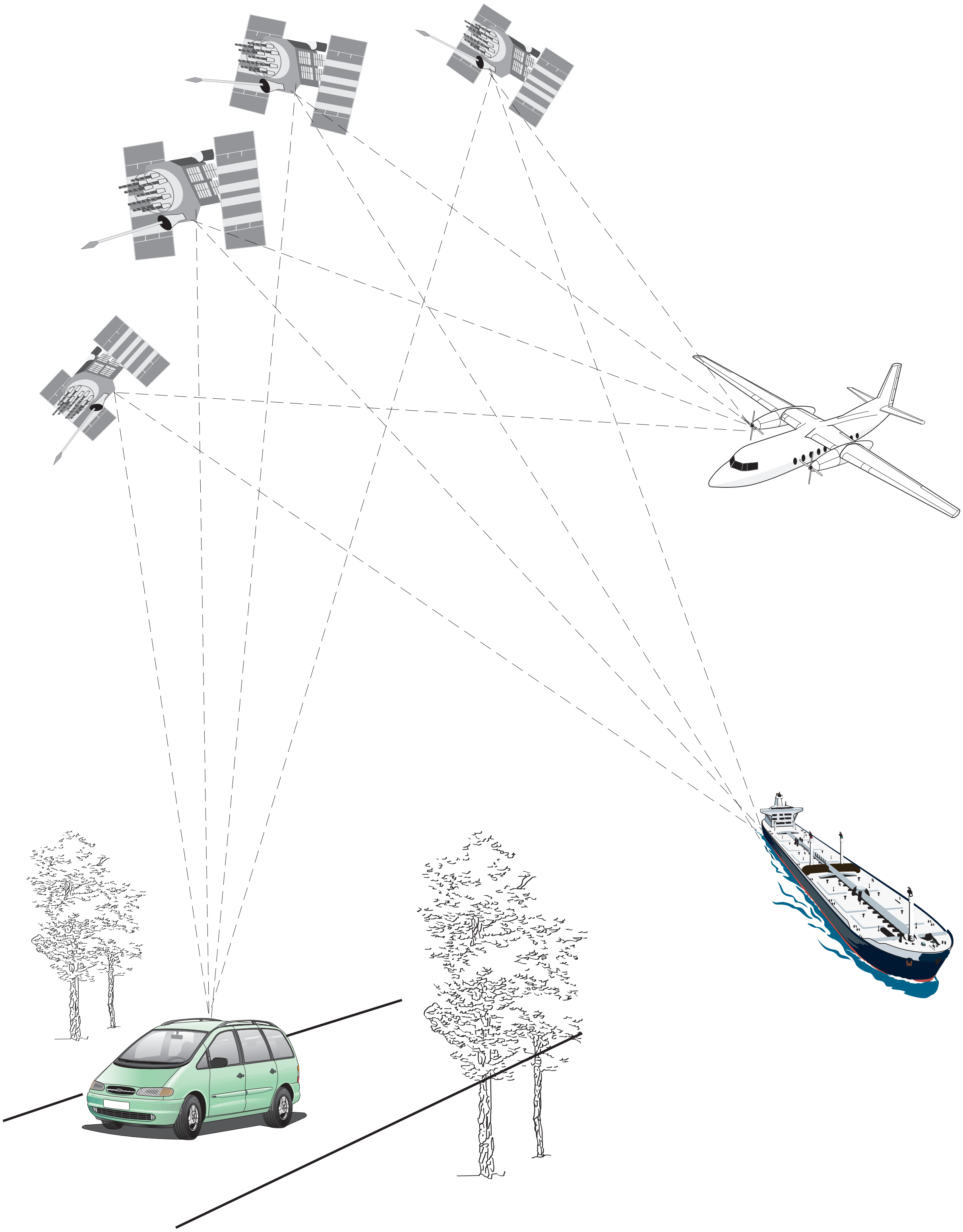
The control segment consists of a master control station, five reference stations and three data up-loading stations. Colorado Springs is the master control station and one of the five reference stations. Hawaii is another one of the reference stations, and Ascension, Diego Garcia and Kwajalein are combined reference and up-loading stations.

The reference stations track and monitor the satellites via their broadcast signals. The broadcast signals contain the ephemeris data of the satellites, the ranging signals, the clock data and the almanac data. These signals are passed to the master control station where the ephemerides are re-computed. The resulting ephemerides corrections and timing corrections are transmitted back to the satellites via the data up-loading stations.

THE USER SEGMENT

The user segment, such as the NovAtel GPSCard receiver, consists of equipment that tracks and receives the satellite signals. The user equipment must be capable of simultaneously processing the signals from a minimum of four satellites to obtain accurate position, velocity and timing measurements. A user can also use the data provided by the satellite signals to accomplish specific application requirements. Please refer to Figure 1-2, page 16, for a graphical representation of the user segment.

Figure 1-2 GPS User Segment



2 COMMAND DESCRIPTIONS

GENERAL

This chapter describes all commands accepted by the GPSCard with the exception of the "Special Data Input Commands". They are listed in alphabetical order. For descriptions of output logs using the LOG command, refer to Chapter 4, page 52. A command/log functional relationship chart is located in Appendix F, page 183.

The GPSCard is capable of responding to over 30 different input commands. You will find that once you become familiar with these commands, the GPSCard offers a wide range in operational flexibility. All commands are accepted through the Console, COM1 and COM2 serial ports. Not all commands or command options are available on all models. Refer to Table 2-1, page 18, for a complete command listing.

There are five basic categories that the GPSCard commands and logs fall into:

- General Status and Control
- Position and Navigation
- Input/Output Control
- Satellite/Channel Control
- Position Filter Control

NOTE: You will find the HELP command a useful tool for inquiring about the various commands available.

The following rules apply when entering commands from a terminal keyboard:

- The commands are not case sensitive.
  e.g. *HELP* or *help*
  e.g. *FIX POSITION* or *fix position*

- All commands and required entries can be separated by a space or a comma.
  e.g. *datum,tokyo*
  e.g. *datum tokyo*
  e.g. *fix,position,51.3455323,-117.289534,1002*
  e.g. *fix position 51.3455323 -117.289534 1002*
  e.g. *com1,9600,n,8,1,n,off*
  e.g. *com1 9600 n 8 1 n off*
  e.g. *log,com1,posa,onchanged*
  e.g. *log com1 posa onchanged*
  e.g. *accept,com2,rtcm*
  e.g. *accept com2 rtcm*

- At the end of a command or command string, press the **Return** key.

- Most command entries do not provide a response to the entered command. Exceptions to this statement are the *VERSION* and *HELP* commands. Otherwise, successful entry of a command is verified by receipt of the COM port prompt (i.e., COM1>, COM2>, or Console>).

Table 2-1 GPSCard Command Summary

Command	Description	Syntax
$ALMA	Injects almanac	(follows NovAtel ASCII log format)
$DCSA	Injects NovAtel format differential corrections	(follows NovAtel ASCII log format)
$IONA	Injects ionospheric refraction corrections	(follows NovAtel ASCII log format)
$RTCA	Injects RTCA format DGPS corrections in ASCII (Type 1)	(follows NovAtel ASCII log format)
$RTCM	Injects RTCM format differential corrections in ASCII (Type 1)	(follows NovAtel ASCII log format)
$UTCA	Injects UTC information	(follows NovAtel ASCII log format)
ACCEPT	Port input control (set command interpreter)	**accept** *port,option*
ASSIGN	Assign a PRN to a channel #	**assign** *channel,prn,doppler, search window*
UNASSIGN	Un-assign a channel	**unassign** *channel*
UNASSIGNALL	Un-assign all channels	**unassignall**
CLOCKADJUST	Adjust 1PPS continuously	**clockadjust** *switch*
COMn	Initialize Serial Port (1 or 2)	**com***n bps,parity,databits,stopbits, handshake,echo*
COMn_DTR	Programmable DTR lead/tail time	**comn_dtr** *control,active,lead,tail*
COMn_RTS	Programmable RTS lead/tail time	**comn_rts** *control,active,lead,tail*
CRESET	Configuration reset to factory default	**creset**
CSMOOTH	Sets carrier smoothing	**csmooth** *value*
DATUM	Choose a DATUM name type	**datum** *option*
USERDATUM	User defined DATUM	**userdatum** *semi-major,flattening,dx,dy,dz, rx,ry,rz, scale*
DGPSTIMEOUT	Sets maximum age of differential data to be accepted and ephemeris delay	**dgpstimeout** *value value*
DYNAMICS	Set receiver dynamics	**dynamics** *option*
ECUTOFF	Set elevation cutoff angle	**ecutoff** *angle*
EXTERNALCLOCK	Sets default parameters of an optional external oscillator	**externalclock** *option*
FIX HEIGHT	Sets height for 2D navigation	**fix height** *height*
FIX POSITION	Set antenna coordinates for reference station	**fix position** *lat,lon,height [station id] [health]*
FIX VELOCITY	Accepts INS xyz (ECEF) input to aid in high velocity reacquisition of SVs	**fix velocity** *vx,vy,vz*
UNFIX	Remove all receiver FIX constraints	**unfix**
FREQUENCY_OUT	Variable frequency output (programmable)	**frequency_out** *n,k*
FRESET	Clears all data which is stored in non volatile memory, and performs hardware reset	**freset**
HELP or ?	On-line command help	**help** *option* or **?** *option*
LOCKOUT	Lock out satellite	**lockout** *prn*
UNLOCKOUT	Restore satellite	**unlockout** *prn*
UNLOCKOUTALL	Restore all satellites	**unlockoutall**
LOG	Choose data logging type	**log** *port,datatype,trigger,[period,offset]*
UNLOG	Kill a data log	**unlog** *port,data type*
UNLOGALL	Kill all data logs	**unlogall**
MAGVAR	Set magnetic variation correction	**magvar** *value*
MESSAGES	Disable error reporting from command interpreter	**messages** *port,option*
POSAVE	Implements position averaging for reference station	**posave** *maxtime, maxhorstd, maxverstd*
RESET	Performs a hardware reset (OEM only)	**reset**

Command	Description	Syntax
RESETRT20	Performs a manual restart of RT20 mode	**resetrt20**
RTCM16T	Enter an ASCII text message to be sent out in the RTCM data stream	**rtcm16t** *ascii message*
RTCMRULE	Set variations of the RTCM bit rule	**rtcmrule** *rule*
RTKMODE	Set up the RTK mode	**rrtkmode** *argument, data range*
SAVECONFIG	Save current configuration in flash memory (OEM only)	**saveconfig**
SEND	Send an ASCII message to any of the communications ports	**send** *port ascii-message*
SENDHEX	Sends non-printable characters in hexadecimal pairs	**sendhex** *port data*
SETCHAN	Sets maximum number of channels for tracking	**setchan** *option*
SETDGPSID	Enter in a reference station ID	**setdgpsid** *option*
SETHEALTH	Override PRN health	**sethealth** *prn,health*
RESETHEALTH	Reset PRN health	**resethealth** *prn*
RESETHEALTHALL	Reset all PRN health	**resethealthall**
SETNAV	Set a destination waypoint	**setnav** *from lat,from lon,to lat, to lon,track offset, from port,to port*
UNDULATION	Choose undulation	**undulation** *separation*
VERSION	Current software level	**version**

NOTES:

1. Commands are not case sensitive (e.g. help or HELP)
2. All commands and required entries can be separated by a space or a comma (command,variable or command variable).
3. A command or command string must be followed by pressing the Return key (CR, LF).
4. Also refer to the Command/Log Functional Relationship chart, page 183, in Appendix F.

When the GPSCard is first powered up, or after a CRESET or FRESET command, all commands will revert to the factory default settings. The saveconfig command can be used to modify the power-on defaults. Use the RCCA log to monitor command and log settings.

Figure 2-1 Factory Default Settings

```
console>log console rcca [Return]
$RCCA,COM1,9600,N,8,1,N,OFF*06
$RCCA,COM2,9600,N,8,1,N,OFF*05
$RCCA,COM1_DTR,HIGH*70
$RCCA,COM2_DTR,HIGH*73
$RCCA,COM1_RTS,HIGH*67
$RCCA,COM2_RTS,HIGH*64
$RCCA,UNDULATION,TABLE*56
$RCCA,DATUM,WGS84*15
$RCCA,USERDATUM,6378137.000,298.257223563,0.000,0.000,0.000,0.000,0.000,0.000,
0.000*6A
$RCCA,SETNAV,DISABLE*5C
$RCCA,MAGVAR,0.000*33
$RCCA,DYNAMICS,HIGH*1B
```

```
$RCCA,UNASSIGNALL*64
$RCCA,ACCEPT,COM1,COMMANDS*5B
$RCCA,ACCEPT,COM2,COMMANDS*58
$RCCA,UNLOCKOUTALL*20
$RCCA,RESETHEALTHALL*37
$RCCA,UNFIX*73
$RCCA,RTCMRULE,6CR*32
$RCCA,RTCM16T,*48
$RCCA,CSMOOTH,20.00*7E
$RCCA,ECUTOFF,0.00*45
$RCCA,FREQUENCY_OUT,DISABLE*12
$RCCA,CLOCKADJUST,ENABLE*47
$RCCA,MESSAGES,ALL,ON*23
$RCCA,SETCHAN,12*34
$RCCA,DGPSTIMEOUT,60,120*4E
$RCCA,SETDGPSID,ALL*18
$RCCA,UNLOGALL*21
```

ACCEPT

B and (R)

The ACCEPT command controls the processing of input data and is primarily used to set the GPSCard's COM port command interpreter for acceptance of various data formats. Each port can be controlled to allow ASCII command processing (default), binary differential data processing, or the command interpreter can be turned off.

Syntax:

ACCEPT port option

Syntax	Range Value	Description	Default
ACCEPT	-	Command	
port	COM1 or COM2	Specifies the COM port to be controlled	
Basic option	NONE COMMANDS	Turn off Command Interpreter Command Interpreter attempts to interpret all incoming data.	commands
"R" option	NONE COMMANDS RTCA RTCM	Turn off Command Interpreter. Command Interpreter attempts to interpret all ASCII data Will also interpret ASCII format differential corrections (DCSA, RTCAA, RTCMA) as received. Interprets RTCA or RTCAB data only (Type 1) Interprets RTCM data only (Types 1,2,9, and 16)	
RT-20 option	NONE COMMANDS RTCA RTCM RT20	Same as "R" option Same as "R" option Same as "R" option Same as "R" option Interprets RTCM data only (RTCM types 1,2,3,9,16, and 59N)	

Example:

```
accept com1,rtcm
```

The command interpreter can process NovAtel-format binary logs (which have a proprietary header) or ASCII logs without receiving an ACCEPT command. ***Therefore, the ACCEPT command is needed only for the RTCA, RTCM, and RT20 logs.*** When using accept RTCM or accept RT20, the interpretation of the RTCM data will follow the rules defined by the RTCMRULE command (refer to the RTCMRULE command, page 40).

In the default processing mode (ACCEPT *port* COMMANDS), input ASCII data received by the specified port will be interpreted and processed as a valid GPSCard command. If the input data cannot be interpreted as a valid GPSCard command, an error message will be echoed from that port (if the command MESSAGES is "ON"). When valid data is accepted and interpreted by the port, it will be processed and acknowledged by echoing the COM port prompt (with the exception of VERSION and HELP commands, which reply with data before the prompt). As well, the accept COMMANDS mode will directly accept, interpret, and process GPSCard differential corrections data formatted in ASCII (DCSA, RTCMA, RTCAA), without any other initialization required. ("R" option required)

In the binary differential data processing modes, (RTCA, RTCM, and RT20), only the applicable data types specified will be interpreted and processed by the specified COM port; no other data will be interpreted. It is important to note that only one out of two COM ports can be specified to accept binary differential correction data. Both ports cannot be set to accept differential data at the same time.

When ACCEPT *port* NONE is set, the specified port will be disabled from interpreting any input data. Therefore, the specified port will decode no commands or differential corrections. However, data can still be logged out from the port, and data can be input to the port for formatting into Pass-Through logs. If the GPSCard operator wants to time-tag non-GPS messages as a Pass-Through log, it is recommended that the port accepting the Pass-Through data be set to "NONE". This will prevent the accepting GPSCard COM port from echoing error messages in response to receipt of unrecognized data. If you do not wish to disable the command interpreter, and do want to disable message error reporting, refer to the MESSAGES command, page 39.

The ACCEPT command will not affect a COM port's ability to accept Pass-Through data. Refer to Chapter 6, page 113, for more information on using Pass-Through logs.

The GPSCard user can monitor the differential data link as well as the data decoding process by utilizing the CDSA/B logs. Refer to the CDSA/B log, page 59, for more information on data link monitoring.

NOTE: To accept DCSB, RTCA, RTCM requires the "R" option. To accept RT20 requires the "RT-20" option.

ASSIGN *B*

This command may be used to aid in the initial acquisition of a satellite by allowing you to override the automatic satellite/channel assignment and reacquisition processes with manual instructions. The command specifies that the indicated tracking channel search for a specified satellite at a specified Doppler frequency within a specified Doppler window. The instruction will remain in effect for the specified channel and PRN, even if the assigned satellite subsequently sets. If the satellite Doppler offset of the assigned channel exceeds that specified by the Search-Window parameter of the ASSIGN command, the satellite may never be acquired or re-acquired. To cancel the effects of ASSIGN, you must issue the UNASSIGN or UNASSIGNALL command, or reboot the GPSCard.

When using this command, NovAtel recommends that you monitor the *channel tracking status* (CTSA/B) of the assigned channel and then use the UNASSIGN or UNASSIGNALL commands to cancel the command once the channel has reached channel state 4, the Phase Lock Loop (PLL) state. Refer to Table 5-1, page 65, in the CTSA/B ASCII Log Structure for an explanation of the various channel states.

Syntax:

```
ASSIGN  channel  prn  doppler  search-window
```

Syntax	Range Value	Description	Default	Example
ASSIGN	-	Command	unassignall	assign
channel	0 - 11	Desired channel number from 0 to 11 inclusive (channel 0 represents first channel, channel 11 represents twelfth channel)		0
prn	1 - 32	A satellite PRN integer number from 1 to 32 inclusive		29
doppler	-100,000 to 100,000 Hz	Current Doppler offset of the satellite Note: Satellite motion, receiver antenna motion and receiver clock frequency error must be included in the calculation for Doppler frequency.		0
search-window	0 - 10,000	Error or uncertainty in the Doppler estimate above in Hz Note: Any positive value from 0 to 10000 will be accepted. Example: 500 implies ± 500 Hz.		2000

Example 1:

```
assign 0,29,0,2000
```

In example 1, the first channel will try to acquire satellite PRN 29 in a range from -2000 Hz to 2000 Hz until the satellite signal has been detected.

Example 2:

```
assign 11,28,-250,0
```

The twelfth channel will try to acquire satellite PRN 28 at -250 Hz only.

UNASSIGN *B*

This command cancels a previously issued ASSIGN command and the channel reverts to automatic control. If a channel has reached state 4 (PLL), the satellite being tracked will not be dropped when the UNASSIGN command is issued, unless it is below the elevation cutoff angle, and there are healthy satellites above the ecutoff that are not already assigned to other channels.

Syntax:

```
UNASSIGN  channel
```

Syntax	Range Value	Description	Default
UNASSIGN	-	Command	unassignall
channel	0 - 11	Reset channel to automatic search and acquisition mode	

Example:

```
unassign 11
```

UNASSIGNALL *B*

This command cancels all previously issued ASSIGN commands for all channels. Tracking and control for each channel reverts to automatic mode. If any of the channels have reached state 4 (PLL), the satellites being tracked will not be dropped when the UNASSIGNALL command is issued, unless they are below the elevation cutoff angle, and there are healthy satellites above the ecutoff that are not already assigned to other channels.

Syntax:

```
UNASSIGNALL
```

CLOCKADJUST *Pf*

All oscillators have some inherent drift characterization. This command enables the software to model out these long-term drift characteristics of the clock. The correction is applied to the 1PPS strobe as well. The clock adjustment is performed digitally. As a result, the 1PPS Strobe will have a 49ns jitter on it due to the receiver's attempts to keep it as close as possible to GPS time. If this jitter is unacceptable to the application, the user must disable this option before the clock model is initialized, i.e., in the *first 30 seconds of operation after power-up*.

CLOCKADJUST must also be disabled if the user wishes to measure the drift rate of the oscillator using the CLKA/B data logs.

NOTE: Do not disable clockadjust after 30 seconds from power-up as unpredictable clock drifts may result. Please note that, when disabled, the range measurement bias errors will continue to accumulate with clock drift.

Syntax:

CLOCKADJUST switch

Syntax	Range Value	Description	Default
CLOCKADJUST	-	Command	
switch	enable or disable	Allows or disallows adjustment to the internal clock	enable

Example:

```
clockadjust disable
```

COMn *B*

This command permits you to configure the GPSCard COM port's asynchronous drivers.

Syntax:

```
COMn  bps  parity  databits  stopbits  handshake  echo
```

Syntax	Value	Description	Default	Example
COMn	n = 1 or 2	Specify COM port		com2
BPS	300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600 or 115,200	Specify bit rate	9600	19200
parity	N (none), O (odd) or E (even)	Specify parity	N	E
databits	7 or 8	Specify number of data bits	8	7
stopbits	1 or 2	Specify number of stop bits	1	1
handshake	N (none), XON (Xon/Xoff) or CTS (CTS/RTS)	Specify handshaking	N	N
echo	ON or OFF	Specify echo	OFF	ON

Examples:

```
com2 19200,e,7,1,n,on
com1 1200,e,8,1,n,on
```

COMn_DTR *B*

This command enables versatile control of the DTR handshake line for use with *output data logging* in conjunction with external devices such as a radio transmitter. The default state for the COM1 or COM2 DTR line is always high.

Syntax:

```
COMn_DTR  control  active  lead  tail
```

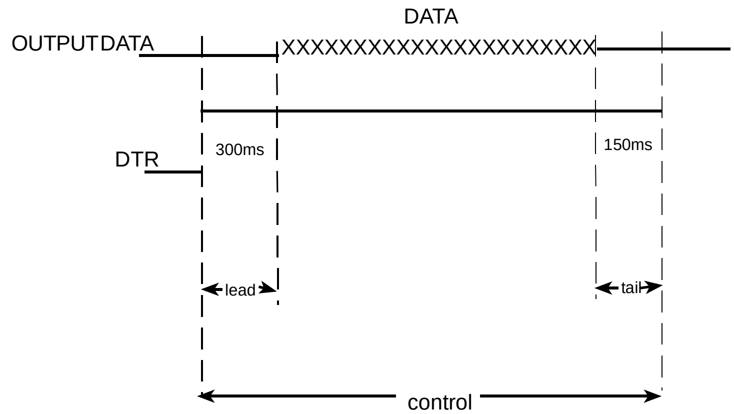
Syntax	Option	Description	Default	Example
COMn_DTR	n = 1 or 2	Selects COM1 or COM2 port		com1_dtr
control	high	control is always high	high	toggle
	low	control is always low		
	toggle	control toggles between high and low		
(active, lead, and tail fields are TOGGLE options only)				
active	high	data available during high	n/a	high
	low	data available during low		
lead	variable	lead time before data transmission (milliseconds)	n/a	300
tail	variable	tail time after data transmission (milliseconds)	n/a	150

COMn_DTR

Control State	Active	Lead	Tail
high	N/A	N/A	N/A
low	N/A	N/A	N/A
toggle	high/low	0 - 999	0 - 999

Example:

```
com1_dtr toggle,high,300,150
```



COMn_RTS

B

This command enables versatile control of the RTS handshake line for use with *output data logging* in conjunction with external devices such as a radio transmitter. The default state for the COM1 or COM2 RTS line is always high. COMn_RTS will not influence the COMn command handshake control of incoming commands.

Syntax:

`COMn_RTS` `control` *`active`* *`lead`* *`tail`*

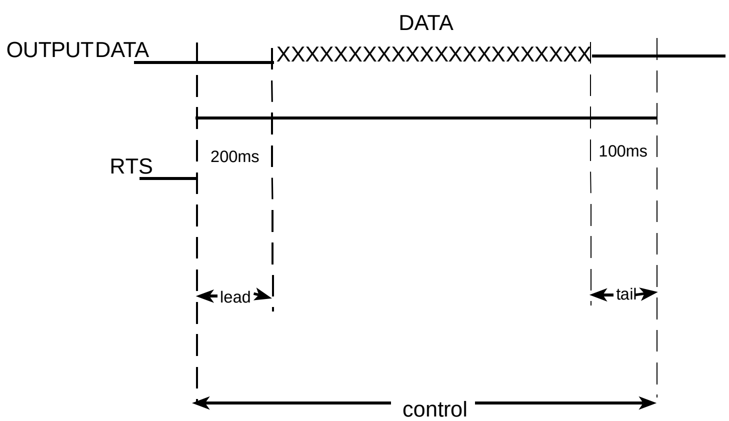
Syntax	Option	Description	Default	Example
COMn_RTS	n = 1 or 2	Selects COM1 or COM2 port		com1_rts
control	high	control is always high	high	toggle
	low	control is always low		
	toggle	control toggles between high and low		
(active, lead, and tail fields are TOGGLE options only)				
active	high	data available during high	n/a	high
	low	data available during low		
lead	variable	lead time before data transmission (milliseconds)	n/a	200
tail	variable	tail time after data transmission (milliseconds)	n/a	100

COMn_RTS

Control State	Active	Lead	Tail
high	N/A	N/A	N/A
low	N/A	N/A	N/A
toggle	high/low	0 - 999	0 - 999

Example:

```
com1_rts toggle,high,200,100
```



CRESET

B

This command completely resets the GPSCard user configurable settings to a factory default state. All data logging is disabled and all the ports are restored to the default power up status. Refer to Command Default Settings, page 19.

Syntax:

```
CRESET
```

CSMOOTH *B*

This command sets the amount of carrier smoothing to be performed on the pseudorange measurements carrier. An input value of 100 corresponds to approximately 100 seconds of smoothing. Upon issuing the command, the locktime for all tracking satellites is reset to zero. From this point each pseudorange smoothing filter is restarted. The user must wait for at least the length of smoothing time for the new smoothing constant to take full effect. 20 seconds is the default smoothing constant used in the GPSCard. The optimum setting for this command is dependent on the user's application and thus cannot be specified.

Syntax:

```
CSMOOTH    value
```

Syntax	Range Value	Description	Default
CSMOOTH	-	Command	
value	20 to 1000	Value in seconds	20

Example:

```
csmooth 500
```

NOTE: The CSMOOTH command should only be used by advanced users of GPS. It may not be suitable for every GPS application. When using CSMOOTH in a differential mode, the same setting should be used at both the reference and remote station.

DATUM *B*

This command permits you to select the geodetic datum for operation of the receiver. If not set, the value is defaulted to WGS-84. See Table A-2, page 166, in *Appendix A*, for a complete listing of all available predefined datums. Refer to the USERDATUM command, page 27, for user definable datums. The datum you select will cause all position solutions to be based on that datum (except PXYA/B, which is always based on WGS-84).

Syntax:

```
DATUM    option
```

Syntax	Datum Option	Description	Default
DATUM	any one of 62 predefined datums	For a complete list of all 62 predefined datums, see Table A-2, page 166, in *Appendix A*.	WGS84
	USER	User defined datum with parameters specified by the USERDATUM command (Default WGS-84)	

Example:

`datum tokyo`   Sets the system datum to Tokyo

Note that the actual datum name must be entered in this command as listed in the NAME column of Table A-2, page 166. Also note that references to datum in the following logs use the GPSCard Datum ID #: MKPA/B, P20A/B, POSA/B and RT20A/B.

USERDATUM *B*

This command permits entry of customized ellipsoidal datum parameters. Use this command in conjunction with the DATUM command. The default setting is WGS-84.

Syntax:

```
USERDATUM  semi-major  flattening  dx  dy  dz  rx  ry  rz  scale
```

Syntax	Range Value	Description	Default	Example
USERDATUM	-	Command		userdatum
semi-major	min. 6300000.0 max. 6400000.0	Datum Semi-major Axis (a) in metres	6378137.000	6378206.4
flattening	min. 290.0 max. 305.0	Reciprocal Flattening, 1/f = a/(a-b)	298.257223563	294.9786982
dx,dy,dz	min. - 2000.0 max. 2000.0	Datum offsets from WGS-84 in metres: These will be the translation values between your datum and WGS-84 (internal reference)	0.000,0.000,0.000	-12,147,192
rx,ry,rz	min. -10 max. 10	Datum Rotation Angle about X, Y and Z axis (sec of arc): These values will be the rotation between your datum and WGS-84	0.000,0.000,0.000	0,0,0
scale	min. -10 max. 10	Scale value is the difference in ppm between your datum and WGS-84	0.000	0

Example:

```
userdatum 6378206.4,294.9786982,-12,147,192,0,0,0,0
```

DGPSTIMEOUT *R*

This command has a two-fold function:

(1) to set the maximum age of differential data that will be accepted when operating as a remote station. Differential data received that is older than the specified time will be ignored. When entering DGPS delay, you can ignore the ephemeris delay field.

(2) to set the ephemeris delay when operating as a reference station. The ephemeris delay sets a time value by which the reference station will continue to use the old ephemeris data. A delay of 120 to 300 seconds will typically ensure that the remote stations have collected updated ephemeris. After the delay period is passed, the reference station will begin using new ephemeris data. To enter an ephemeris delay value, you must first enter a numeric placeholder in the DGPS delay field (e.g., 2). When operating as a reference station, DGPS delay will be ignored.

Syntax:

```
DGPSTIMEOUT    dgps delay  ephem delay
```

Command	Option		Description	Default
DGPSTIMEOUT			Command	
dgps delay	min.	2	Maximum age in seconds	60
	max.	1000		
ephem delay	min.	0	Minimum time delay in seconds	120
	max.	600		

Example 1 (remote):

```
dgpstimeout 15
```

Example 2 (base):

```
dgpstimeout 2,300
```

NOTES: The RTCA Standard for SCAT-I stipulates that the maximum age of differential correction messages cannot be greater than 22 seconds. Therefore, for RTCA logs, the recommended dgps delay setting is 22.

The RTCA Standard also stipulates that a reference station shall wait five minutes after receiving a new ephemeris before transmitting differential corrections. This time interval ensures that the remote stations will have received the new ephemeris, and will compute differential positioning based upon the same ephemeris. Therefore, for RTCA logs, the recommended ephemeris delay is 300 seconds.

DYNAMICS *B*

This command sets the carrier tracking bandwidth of the receiver.

Syntax:

```
DYNAMICS option
```

Command	Option	Description	Default
DYNAMICS	stationary	2.5 Hz bandwidth, where jerk < 0.001 g/s	high
	low	5 Hz bandwidth, where jerk < 0.1 g/s	
	medium	10 Hz bandwidth, where jerk < 1.0 g/s	
	high	15 Hz bandwidth, where jerk < 4.5 g/s	

Example:

```
dynamics medium
```

CAUTION: The user is cautioned against using any setting except high on GPSCard models using the standard tcxo oscillator. If a lower setting is used, frequent loss of phase lock may occur regardless of the user's dynamics. This command is intended to support use of external high-stability reference oscillators.

ECUTOFF *B*

This command sets the elevation cut-off angle for usable satellites. Satellites that are below this angle will be eliminated from the internal position and clock offset solution computations only. It does not affect the satellite tracking system or data logging. All satellites in view will still be tracked, their data logged, and this data may be used in post processing.

If there are more satellites in view than there are channels available, the channels which are tracking satellites below the elevation cut-off will be reassigned to any healthy satellites above the ecutoff which are not already assigned to a channel.

Syntax:

```
ECUTOFF angle
```

Syntax	Range Value	Description	Default
ECUTOFF	-	Command	
angle	0 to 90 degrees	Value in degrees (above the horizon)	0

Example:

```
ecutoff 5.5
```

NOTE: When ecutoff is set to zero (0), the receiver will track all svs in view including some within a few degrees below the horizon.

EXTERNALCLOCK *B*

This command allows the user to set a GPSCard (GPSTN and GPSTNM models only) to operate with an alternate oscillator. An unsteered oscillator can be approximated by a three-state clock model, with two states representing the range bias and range bias rate, and a third state assumed to be a Gauss-Markov process representing the range bias error generated from satellite clock dither. The third state is included because the Kalman filter assumes an (unmodelled) white input error. The significant correlated errors produced by SV clock dither are obviously not white and the Markov process is an attempt to handle this kind of short-term variation.

The user has control over 3 process noise elements of the linear portion of the clock model. These are the h_0, h_{-1}, and h_{-2} elements of the power law spectral density model used to describe the noise characteristics of oscillators:

$$S_y(f) = \frac{h_{-2}}{f^2} + \frac{h_{-1}}{f} + h_0 + h_1 f + h_2 f^2$$

where f is the sampling frequency and $S_y(f)$ is the clock's power spectrum. Typically only h_0, h_{-1}, and h_{-2} affect the clock Allan variance and the clock model process noise elements. Typical values are shown in Table 2-2 Typical Values of Clock Filters.

Syntax:

```
EXTERNALCLOCK  option
```

Command	Option	Description	Default
EXTERNALCLOCK	DISABLE	Revert to TCXO	see Table 2-2, page29
	OCXO	Set defaults for ovenized crystal oscillator	
	RUBIDIUM	Set defaults for rubidium oscillator	
	CESIUM	Set defaults for cesium oscillator	
	USER,h_0,h_{-1},h_{-2}	Define custom values for process noise elements	

Example:

```
externalclock,user,1.0e-20,1.0e-24,1.0e-28
```

Table 2-2 Typical Values of Clock Filters

Timing Standard	h_0	h_{-1}	h_{-2}
Specified TCXO	1.0e-21	1.0e-20	1.0e-20
Crystal	2.0e-19	7.0e-21	2e-20
Ovenized Crystal (OCXO)	2.51e-26	2.51e-24	2.51e-23
Rubidium	1.0e-23	1.0e-22	1.3e-26
Cesium	8.0e-21	2.59e-21	7.0e-32
User minimum	1.0e-31	1.0e-31	1.0e-31
User maximum	1.0e-18	1.0e-18	1.0e-18

FIX HEIGHT *B*

This command configures the GPSCard in 2D mode with its height constrained to a given value. The command would be used mainly in marine applications where height in relation to mean sea level may be considered to be approximately constant. The height entered using this command is always referenced to the geoid (mean sea level) and uses units of metres. The FIX HEIGHT command will override any previous FIX HEIGHT or FIX POSITION command and **disables** the output of differential corrections. The receiver is capable of receiving and applying differential corrections from a reference station while FIX HEIGHT is in effect. Use the UNFIX command to disable the current FIX command. No special solution status is reported in the POSA/B or PRTKA/B logs for a 2 dimensional solution. This mode is detected by the standard deviation of the height being 0.001m.

Syntax:

```
FIX HEIGHT  height
```

Syntax	Range Value	Description	Default
FIX HEIGHT	-	Command	unfix
height	-1,000.0 to 20,000,000.0	Height in metres above mean sea level	

Example:

```
fix height 4.567
```

REMEMBER: Any error in the height estimate will cause an error in the position computed of the same order of magnitude or higher. For example, if the user fixed height to zero and the antenna was installed on a 20 m mast, the position can be expected to be in error by 10 to 60 m, depending on the geometry of the satellites. This command should only be used when absolutely necessary, i.e., when only three satellites are visible.

When FIX HEIGHT has been properly set, the GPSCard will provide position solutions while tracking only three satellites. If FIX HEIGHT is set to UNFIX, the GPSCard must be tracking four good satellites before position solutions will be produced.

FIX POSITION *B (R) (RT20)*

Invoking this command will result in the GPSCard position being held fixed. A computation will be done to solve local clock offset, pseudorange, and pseudorange differential corrections (with R or RT20 option). This mode of operation can be used for time transfer applications where the position is fixed and accurate GPS time output is required (refer to the logs CLKA/B, page 61, and TM1A/B, page 109, for time data).

As well, this command must be properly initialized before the GPSCard can operate as a GPS pseudorange reference station. Once initialized, the receiver will compute pseudorange differential corrections for each satellite being tracked. The computed differential corrections can then be output to remote stations by utilizing any of the following GPSCard differential corrections data log formats: RTCM, RTCMA, RTCMB, RTCA, RTCAA, RTCAB, DCSA, or DCSB. The reference station servicing RT-20 remote receivers must log RTCM3 and RTCM59(N) pseudorange and carrier phase observation data in order for the RT-20 remote receiver to compute double difference carrier phase solutions.

The values entered into the FIX POSITION command should reflect the precise position of the reference station antenna's phase centre. Any errors in the FIX POSITION coordinates will directly bias the pseudorange corrections that are calculated by the reference receiver.

The GPSCard performs all internal computations based on WGS-84 and the datum command is defaulted as such. The datum in which you choose to operate (by changing the DATUM command) will internally be converted to and from WGS-84. Therefore, all differential corrections are based on WGS-84, regardless of your operating datum.

The GPSCard will begin logging differential data while tracking as few as three healthy satellites. Refer to Chapter 10, page 137, for further discussions on differential positioning.

The FIX POSITION command will override any previous FIX HEIGHT or FIX POSITION command settings. Use the UNFIX command to disable the FIX POSITION setting.

Syntax:

```
FIX POSITION  | lat | lon | height | station id | RTCM stn health |
```

Syntax	Range Value	Description	Default	Example
FIX POSITION	-	Command	unfix	fix position
lat	0 to ± 90.0 (up to 7 decimal places allowed, depending on accuracy required)	Latitude (in degrees/decimal degrees) of fixed reference station antenna in current datum. A negative sign implies South latitude.		51.3455323
lon	0 to ± 360.0 (up to 7 decimal places allowed, depending on accuracy required)	Longitude (in degrees) of fixed reference station antenna in current datum. A negative sign implies West longitude.		-114.289534
height	-1,000 to 20,000,000	Height (in metres) above the geoid of reference station in current datum.		1201.123
station id	0 to 1023 (10 bits) for RTCM or DCSA/B output "xxxx" for RTCA output where "xxxx" are four alphanumeric characters, entered between double quotes	Specify a Reference Station identification number *(optional entry)* (See SETDGPSID, page 44		1002
RTCM reference station health	0 – 7 where 0 – 5 Specified by user 6 Reference station transmission not monitored 7 Reference station not working	Specify RTCM reference station health (optional) (This field will only be reported in RTCM message header – word 2.)	6	0

Example:

```
fix position 51.3455323,-114.289534,1201.123,1002,0
```

The above example configures the receiver as a reference station with fixed coordinates of:

Latitude	N 51° 20' 43.9163" (WGS-84 or local datum)
Longitude	W 114° 17' 22.3224"
Height above sea level	1201.123 m
Station ID	1002
RTCM health	0

FIX VELOCITY *B*

This command supports INS (Inertial Navigation System) integration. It accepts ECEF XYZ velocity values in units of m/s. This information is only used by the tracking loops of the receiver to aid in reacquisition of satellites after loss of lock; otherwise it is ignored. It is not used in the position solution and velocity calculations. This command is only useful for very high dynamics where expected velocity changes during the signal blockage of more than 100 m/s can occur. Refer to Figure 5-3, page 108, for ECEF definitions. The UNFIX command is used to clear the effects of the FIX VELOCITY command. The FIX VELOCITY command will override any previous FIX HEIGHT or FIX POSITION command. Use the UNFIX command to disable the current FIX command.

Syntax:

```
FIX VELOCITY  [vx] [vy] [vz]
```

Syntax	Range Value	Description	Default	Example
FIX VELOCITY	-	Command	unfix	fix velocity
vx	± 999.99	X = Antenna Velocity (ECEF) in the X direction [m/s].		315
vy	± 999.99	Y = Antenna Velocity (ECEF) in the Y direction [m/s].		212
vz	± 999.99	Z = Antenna Velocity (ECEF) in the Z direction [m/s].		150

Example:

```
fix velocity 315,212,150
```

UNFIX *B*

This command removes all position constraints invoked with any of the FIX commands (FIX POSITION, FIX HEIGHT, or FIX VELOCITY).

Syntax:

```
UNFIX
```

FREQUENCY_OUT *Pf 51*

This command allows you to specify the frequency of the output pulse at the VARF pin of the I/O strobe connector. The frequency in Hz is calculated according to the formula below. The time between pulses may have up to 49 ns jitter variation from the true frequency pulse.

$$\text{FREQUENCY\_OUT} = \frac{\left[\ 20473000 - \frac{20473000}{(n+1)}\ \right]}{(k+1)}$$

Syntax:

```
frequency_out  [n] [k]
```

OR

```
frequency_out  [disable]
```

Syntax	Range Value	Description	Default	Example
FREQUENCY_OUT	-	Command	disable	frequency_out
n	1 to 65535	Variable integer		1
k	1 to 65535	Variable integer		65535

Example 1:

```
frequency_out 1,65535
n=1, k=65535 results in an output pulse frequency of 156.196594 Hz
```

Example 2:

```
frequency_out 65535,1
n=65535, k=1 results in an output pulse frequency of 10,236,343.8034 Hz
```

As a reference, some n and k selections and their corresponding frequency outputs are listed in the following table:

n	k	Frequency_Out (Hz)	
1	65535	156.1966	(Minimum)
65535	65535	312.3884	
20472	20471	1 000.0000	
1569	2045	9 999.9804	
346	345	59 000.0000	
74	201	100 000.1320	
58	57	347 000.0000	
1	9	1 023 650.0000	
1	1	5 118 250.0000	
65535	1	10 236 343.8034	(Maximum)

If the 49 ns jitter is not suitable for your application, the following formula may be used to eliminate the jitter.

$$\text{FREQUENCY\_OUT} = \frac{20473000}{(k+1)}$$

where: N is constrained to 0, and K = 1 to 65535

NOTE: Frequency resolution of this method is not as fine as original formula but provides jitter-free pulses.

FRESET

O XII

This command clears all data that is stored in non-volatile memory. Such data includes the almanac, satellite channel configuration, and any user-specific configurations. It is only available on 12-channel OEM cards with the SAVECONFIG option. The GPSCard is forced to reset and will start up with factory defaults.

See also the commands CRESET, page 25, and RESET, page 40.

Syntax:

```
FRESET
```

HELP *B*

This command provides you with on-line help. The command, with no options, gives a complete list of the valid system commands. For detailed help on any command, append the optional command name to the HELP command.

Syntax:

```
HELP  option
```

OR:

```
? option
```

Syntax	Range Value	Description
HELP (or ?)	-	Entering HELP without an option will list all valid command options.
option	Refer to Figure 2-2, page 34	Can be any valid system command. Information about the command entered will be displayed.

Example:

```
help dynamics
```

Figure 2-2 shows the screen display of the HELP command and *Figure 2-3* shows a specific example of the RTKMODE command appended to the HELP command.

Figure 2-2 HELP Command Screen Display

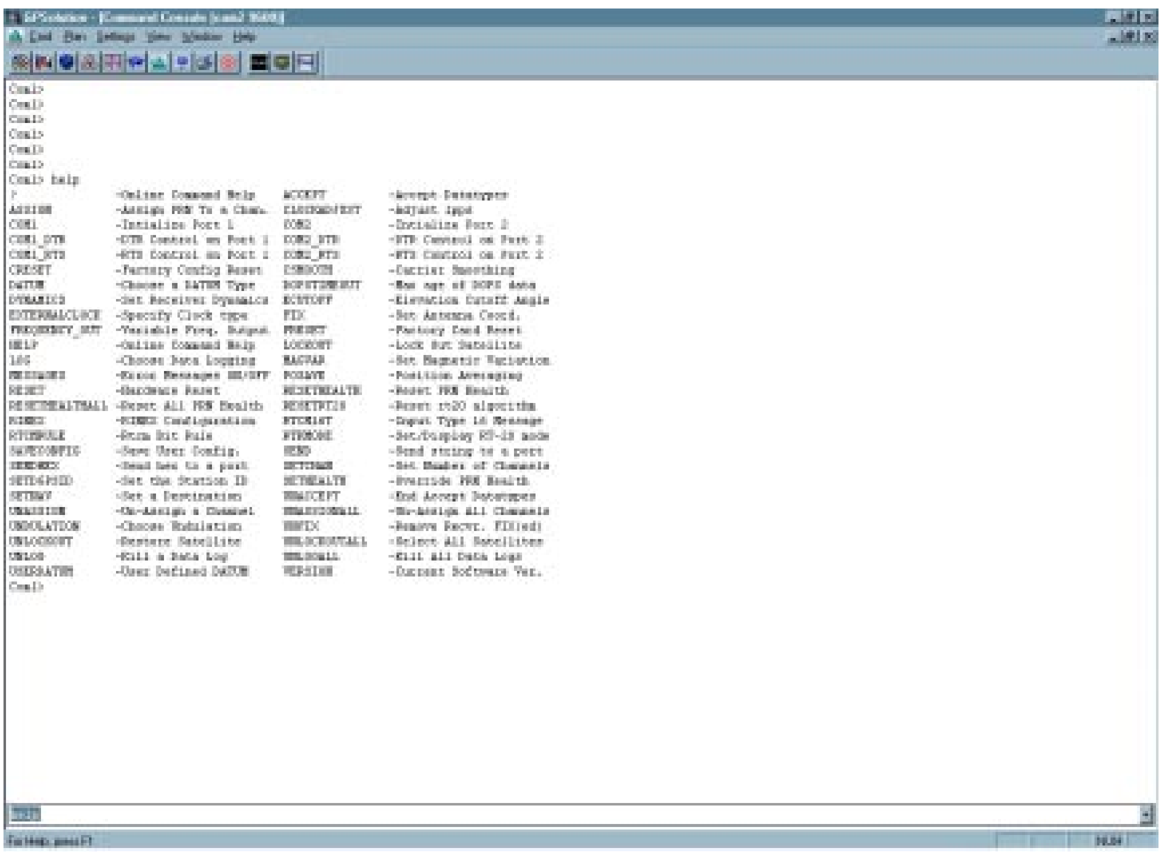
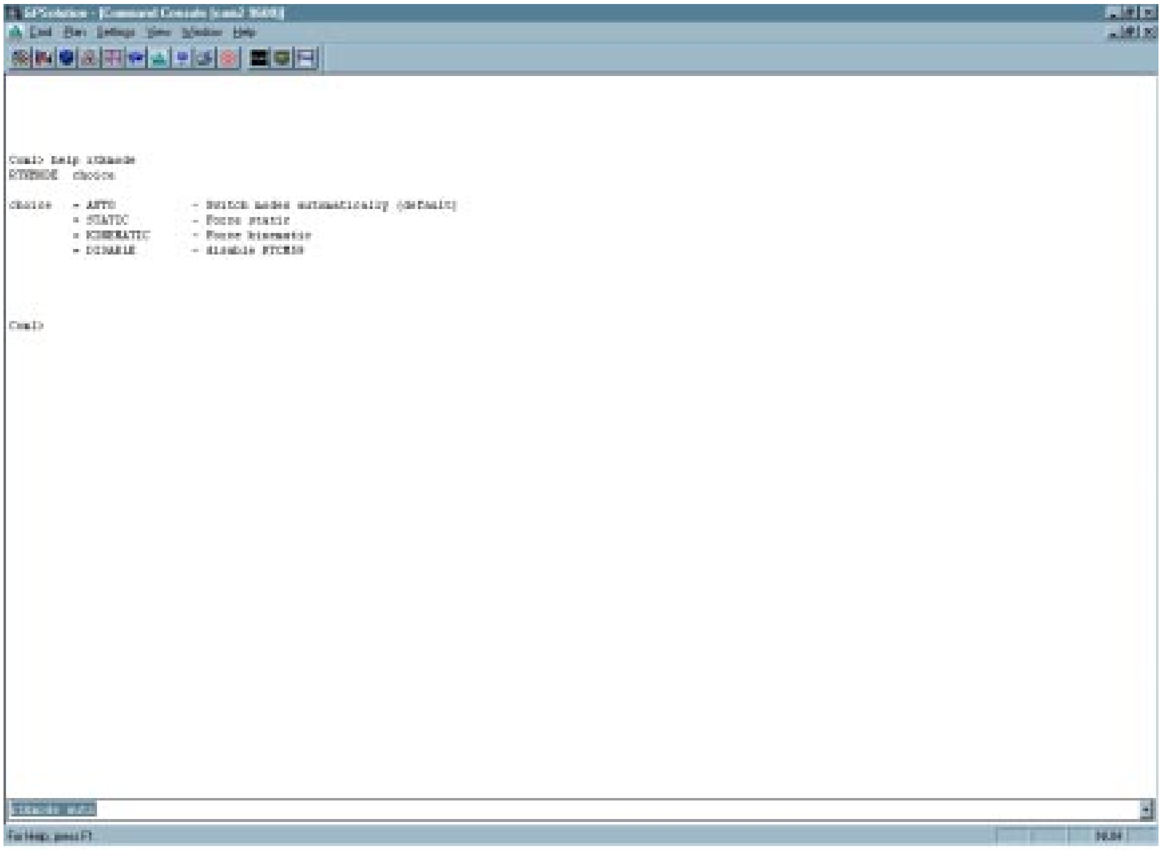


Figure 2-3 Appended Command Screen Display



LOCKOUT

B

This command will prevent the GPSCard from using a satellite by de-weighting its range in the solution computations. Note that the LOCKOUT command does not prevent the GPSCard from tracking an undesirable satellite. This command must be repeated for each satellite to be locked out.

Syntax:

```
LOCKOUT  prn
```

Syntax	Range Value	Description	Default
LOCKOUT	-	Command	unlockoutall
prn	1 - 32	A single satellite PRN integer number to be locked out	

Example:

```
lockout 8
```

UNLOCKOUT *B*

This command allows a satellite that has been previously locked out (LOCKOUT command) to be reinstated in the solution computation. If more than one satellite is to be reinstated, this command must be reissued for each satellite reinstatement.

Syntax:

```
UNLOCKOUT [prn]
```

Syntax	Range Value	Description	Default
UNLOCKOUT	-	Command	unlockoutall
prn	1 - 32	A single satellite PRN to be reinstated	

Example:

```
unlockout 8
```

UNLOCKOUTALL *B*

This command allows all satellites that have been previously locked out (LOCKOUT command) to be reinstated in the solution computation.

Syntax:

```
UNLOCKOUTALL
```

LOG *B*

Many different types of data can be logged using several different methods of triggering the log events. Every log element can be directed to either the console, COM1 or COM2 ports. If a selected log element is to be directed to all the ports, then separate LOG commands are required to control them. The ONTIME trigger option requires the addition of the *period* parameter and optionally allows input of the *offset* parameter. See Chapter 5, page 54, for further information and a complete list of ASCII and Binary data log structures.

Syntax:

```
LOG [port] [datatype] [trigger] [[period]] [[offset]]
```

Example:

```
log com1,posa,ontime,60,1
```

The previous example will cause the POSA log to be logged to COM port 1, recurring every 60 seconds, and offset by 1 second. To send a log only one time, the trigger option can be ignored.

Example:

```
log com1 posa
```

UNLOG *B*

This command permits you to remove a specific log request from the system.

Syntax:

```
UNLOG  port  log name
```

Syntax	Range Value	Description	Default
UNLOG	-	Command	unlogall
port	COM1, COM2 or console	COMn port from which log originated	
log name	any valid log	The name of the log to be disabled	

Example:

```
unlog com1,posa
```

UNLOGALL *B*

If [*port*] is specified (COM1 or COM2) this command disables all logs on the specified port only. All other ports are unaffected. If [*port*] is not specified, this command disables all logs on all ports.

Syntax:

```
UNLOGALL [port]
```

MAGVAR *B*

The GPSCard computes directions referenced to True North. Use this command (magnetic variation correction) if you intend to navigate in agreement with magnetic compass bearings. The correction value entered here will cause the "bearing" field of the NAVA/B and GPVTG logs to report bearing in degrees magnetic. The magnetic variation correction is also reported in the GPRMC log.

Syntax:

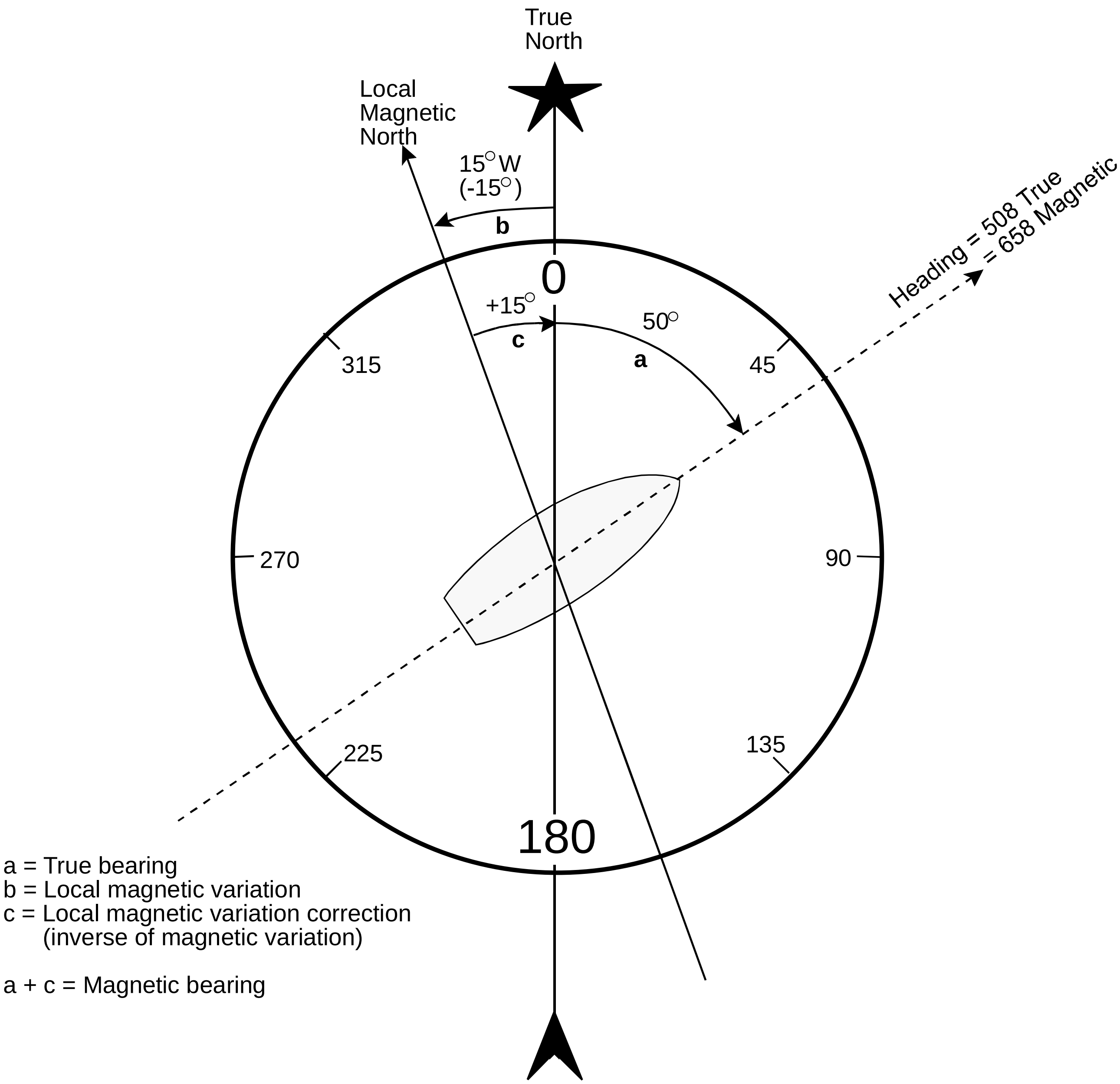
```
MAGVAR  correction
```

Syntax	Range Value	Description	Default
MAGVAR	-	Command	
correction	± 0 - 180	The magnetic variation correction for the area of navigation in units of degrees. Magnetic bearing = true bearing + magnetic variation correction. See Figure 2-4, page 38.	0.000

Example:

```
magvar +15.0
```

Figure 2-4 Illustration of Magnetic Variation & Correction



MESSAGES *B*

The MESSAGES command is used to disable the port prompt and error message reporting from a specified port. This feature can be useful if the port is connected to a modem or other device that responds with data the GPSCard does not recognize. Refer to Chapter 6, page 113, for further information on using this command with Special Pass-Through Logs.

Syntax:

```
MESSAGES port option
```

Syntax	Range Value	Description	Default
MESSAGES	-	Command	MESSAGES
port	COM1, COM2, console, or all	Specifies the port being controlled	-
option	ON or OFF	Enable or disable port prompt and error message reporting	ON

Example:

```
messages com1,off
```

POSAVE *B*

This command implements position averaging for reference stations. Position averaging will continue for a specified number of hours or until the averaged position is within specified accuracy limits. Averaging will stop when the time limit or the horizontal standard deviation limit or the vertical standard deviation limit is achieved. When averaging is complete, the fix position command will automatically be invoked.

If the maximum time is set to 1 hour or larger, positions will be averaged every 10 minutes and the standard deviations reported in the PAVA/B log should be correct. If the maximum time is set to less than 1 hour, positions will be averaged once per minute and the standard deviations reported in the log will likely not be accurate; also, the optional horizontal and vertical standard deviation limits cannot be used.

One could initiate differential logging, then issue the posave command followed by the SAVECONFIG command. This will cause the GPSCard to average positions after every power-on or reset, then invoke the fix position command to enable it to send differential corrections.

Syntax:

```
POSAVE maxtime maxhorstd maxverstd
```

Command	Range Values	Description
POSAVE	-	Command
maxtime	0.025 - 100	Maximum amount of time that positions are to be averaged (hours). 1.5 minutes to 100 hours
mashorstd	0.1 - 100	Option: desired horizontal standard deviation (m)
maxverstd	0.1 - 100	Option: desired vertical standard deviation (m)

Example:

```
posave 2,3,4
```

RESET *O*

This command performs a hardware reset. It is only available on OEM Series GPSCards. Following a RESET command, the GPSCard will initiate a cold-start bootup. Therefore, the receiver configuration will revert to the factory default or last SAVECONFIG settings.

Syntax:

```
RESET
```

RESETRT20 *RT20*

This command performs a manual restart of RT20 mode. Convergence begins at the 1 m level and converges down to the < 20 cm level in three to five minutes.

Syntax:

```
RESETRT20
```

RTCM16T *R*

This is a NovAtel command relating to the RTCM Standard – Type 16 Special Message. It enables the user to enter an ASCII message that can be sent out in RTCM Type 16 format. Once created, the RTCM16T message can be viewed in the RCCA command settings list. The text message can also be logged using the RTCM16 or RTCM16T log option. This command will limit the input message length to a maximum of 90 ASCII characters.

Refer to Chapter 8, page 129, for related topics.

RTCMRULE *R*

This command allows the user flexibility in the usage of the RTCM Standard “bit rule”.

Refer to Chapter 8, page 130, for further information.

RTKMODE *RT20*

This command sets up the RTK (RT-20) mode. Invoking this command allows you to set different parameters and control the operation of the RTK system. The RTKMODE command is actually a family of commands; a description of the various arguments and options is as follows. Some arguments require data input, while others do not.

Certain arguments can be used only at the reference station and others only at the remote station. The structure of the syntax is shown on the next page, followed by a detailed description of each argument.

Syntax - Reference Station

For RTCA-format messaging only:

RTKMODE `sv_entries` `4 to 20`

RTKMODE `elev_mask` `0 to 90`

Command	Argument	Data Range	Default
RTKMODE			
	sv_entries	4 to 20	12
	elev_mask	0 to 90	2

For RTCM-format messaging only:

RTKMODE `rtcmver` `2.1 or 2.2`

Command	Argument	Data Range	Default
RTKMODE			
	rtcmver	2.1 or 2.2	2.2

Syntax - Remote Station (for RTCA, RTCM or CMR-format messaging):

RTKMODE `enable`

RTKMODE `disable`

RTKMODE `auto`

RTKMODE `static`

RTKMODE `kinematic`

Command	Argument	Default Argument	Data Range
RTKMODE			
	enable or disable	enable	
	auto, static or kinematic	auto	

Below is additional information for each argument:

Station	Command	Argument
Remote	rtkmode	enable (default) disable
RTKMODE ENABLE, when issued at the remote station, turns on its ability to receive and process RTCA or RTCM messages. **RTKMODE DISABLE** exits the RTK positioning mode.		

Station	Command	Argument
Remote	rtkmode	auto (default) static kinematic
RTKMODE AUTO configures the RTK system to automatically detect motion. It is the default mode. It will reliably detect motion of 2.5 cm/sec or greater. If you are undergoing motion slower than this that covers more than 2 cm, you should use the manual mode selection commands (static and kinematic).		
RTKMODE STATIC forces the RTK software to treat the remote station as though it were stationary, regardless of the output of the motion detector.		
Note: For reliable performance the antenna should not move more than 1 - 2 cm when in static mode.		
RTKMODE KINEMATIC forces the RTK software to treat the remote station as though it was in motion, regardless of the output of the motion detector. If the remote station is undergoing very slow steady motion (< 2.5 cm/sec for more than 5 seconds), you should declare KINEMATIC mode to prevent inaccurate results and possible resets.		

Example:

```
rtkmode auto
```

SAVECONFIG *O XII*

This command saves the current configuration and up to 10 active logging commands in flash (non-volatile) memory. It is only available on 12-channel OEM cards with the SAVECONFIG option. The last saved configuration becomes the new power-on default overriding the factory default.

Between 9 and 18 SAVECONFIG commands can be issued before a reset is necessary. If a SAVECONFIG is not possible, the error message "Flash full – RESET or use FORCE option" will be given. If at this point the user enters "SAVECONFIG FORCE", the configuration will be saved and the card will be reset. If the flash memory is not full, the FORCE option has no effect. SAVECONFIG FORCE will simply cause a normal save and no reset will occur.

A CRESET command may be entered to restore the factory default settings, which will become the new saved configuration if the user enters another SAVECONFIG command. The RCCA log can be used to monitor the current configuration.

Syntax:

```
SAVECONFIG
```

or

```
SAVECONFIG   FORCE
```

SEND *B*

This command is used to send ASCII printable data from the console, COM1, COM2 or disk file to a specified communications port. For instance, if you were using a PC Series GPSCard and wanted to control a modem connected to COM1, you could issue all the dial and modem control commands from the console port (keyboard or disk file) using this command. This is a one-time command, therefore the data message must be preceded by the SEND command followed by the Enter key (<CR><LF>) each time you wish to send data. (Remember to use the MESSAGES command to disable error reporting whenever two GPSCards are connected together via the COM ports.)

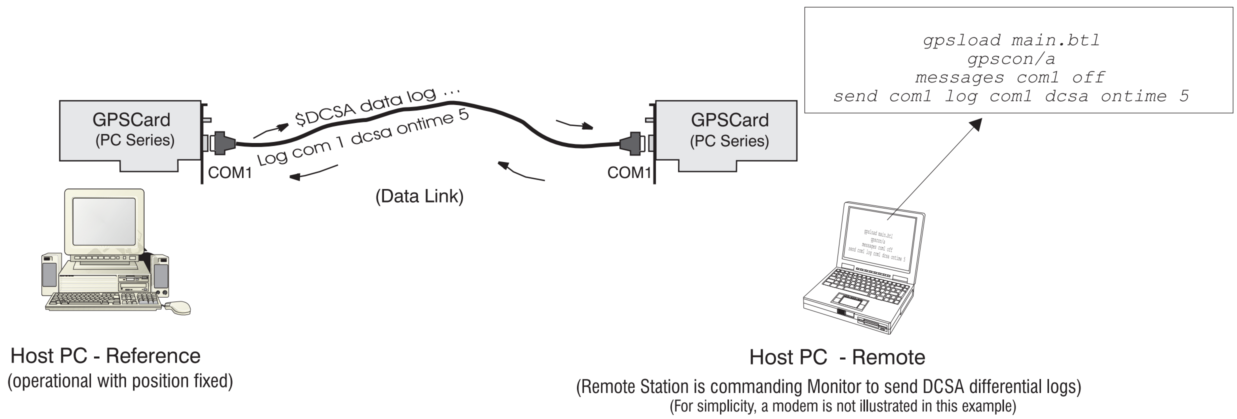
Syntax:

```
SEND   to-port   data
```

Syntax	Range Value	Description
SEND		Command
to-port	COM1, COM2, console	Port option
data	up to 100 characters	ASCII data

Scenario: Assume that you are operating PC Series GPSCards as reference and remote stations. It could also be assumed that the reference station is unattended but operational and you wish to control it from the remote station. From the remote station, you could establish the data link and command the reference station GPSCard to send differential corrections.

Figure 2-5 Using SEND Command



SENDHEX *B*

This command is like the SEND command but is used to send non-printable characters expressed as hexadecimal pairs.

Syntax:

```
SENDHEX  to-port  data
```

Syntax	Range Value	Description
SENDHEX		Command
to-port	COM1, COM 2, console	Port option
data	- even number of ASCII characters from set of 0-9, A-F - spaces allowed between pairs of characters - carriage return & line feed provided by entering 0D0A at end of string - maximum number of characters limited to about 1400 characters by command interpreter buffer (2800 ASCII characters pairs)	ASCII data

SETCHAN *XII*

This command sets the maximum number of channels for tracking. For example, setting the number of tracking channels to 10 on a 12-channel GPSCard will disable the last two channels (11 and 12) and will assign the highest SVs to the first 10 channels. Satellites that are lower to the horizon could be bumped. The value set will change the number of channels reported in the CTSA/B logs.

Use this command if you wish your 12 channel GPSCard range data logs (RGEA/B) to be backwards compatible with earlier versions of GPSCard 10 channel logs (RNGA/B).

Example:

```
SETCHAN 10
```

SETDGPSID *R*

This command is used to enter a station ID. Once set, the receiver will only accept differential corrections from a station whose ID matches the set station ID. It is typically used when a station has data links containing RTCM or RTCA messages from several stations. By entering a specific station ID, the operator can select which station to listen to. Having set a station ID, incoming DCSA, DCSB, RTCM, RTCMA, RTCA, RTCAA, and RTCAB messages will be received from only that station. When a valid station ID is entered, an improved data synchronization algorithm will be used. It is recommended to always set the station ID. This command can also be used to set the station ID for a GPSCard reference station. See FIX POSITION, page 30, 4th parameter (*station ID*).

Syntax:

```
SETDGPSID    station ID #
```

or

```
SETDGPSID    all
```

Syntax	Range Value	Description	Default
SETDGPSID		Command	
station ID #	0 – 1023 or "xxxx" or all	- Reference station ID number for DCSA/B or RTCM - Reference station name for RTCA where "xxxx" are four alphanumeric characters, entered between double quotes - Accepts differential corrections from any station	all

Example 1:

```
SETDGPSID 1023
```

Example 2:

```
SETDGPSID "abcd"
```

SETHEALTH *B*

This command permits you the flexibility to override the broadcast health of a satellite. Under certain conditions and applications, it may be desirable to track and use information from a GPS satellite even though its health has been set bad by the GPS control segment. To SETHEALTH for more than one satellite, the command must be re-issued for each satellite.

IMPORTANT: There is usually a reason when the GPS Control Segment sets a satellite to bad health condition. If you decide to ignore the health warnings and use the satellite information, unpredictable errors may occur.

Syntax:

```
SETHEALTH prn health
```

Syntax	Range Value	Description	Default
SETHEALTH	-	Command	resethealthall
prn	1 - 32	A satellite PRN integer number	
health	good or bad	Desired health	

Example:

```
sethealth 4,good
```

RESETHEALTH *B*

This command cancels the SETHEALTH command and restores the health of a satellite to the broadcast value contained in the almanac and ephemeris data.

Syntax:

```
RESETHEALTH [prn]
```

Syntax	Range Value	Description
RESETHEALTH	-	Command
prn	1 - 32	The PRN integer number of the satellite to be restored.

Example:

```
resethealth 4
```

RESETHEALTHALL *B*

This command resets the health of all satellites to the broadcast values contained in the almanac and ephemeris data.

Syntax:

```
RESETHEALTHALL
```

SETNAV *B*

This command permits entry of one set of navigation waypoints (see Figure 2-6, page 46). The origin (FROM) and destination (TO) waypoint coordinates entered are considered on the ellipsoidal surface of the current datum (default WGS-84). Once SETNAV has been set, you can monitor the navigation calculations and progress by observing the NAVA/B, GPRMB, and GPZTG log messages.

Track offset is the perpendicular distance from the great circle line drawn between the FROM lat-lon and TO lat-lon waypoints. It establishes the desired navigation path, or track, that runs parallel to the great circle line, which now becomes the offset track, and is set by entering the track offset value in metres. A negative track offset value indicates that the offset track is to the left of the great circle line track. A positive track offset value (no sign required) indicates the offset track is to the right of the great circle line track (looking from origin to destination). Refer to Figure 2-6, page 46, for clarification.

Syntax:

```
SETNAV [from-lat] [from-lon] [to-lat] [to-lon] [track offset] [from-port] [to-port]
```

or

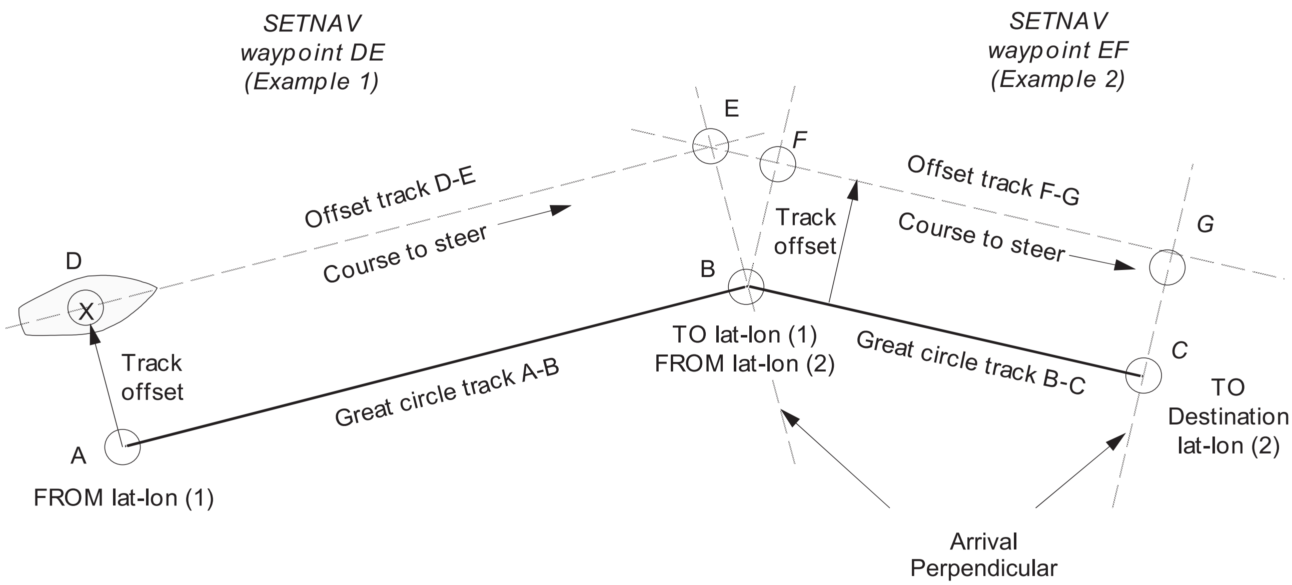
```
SETNAV [disable]
```

Syntax	Range Value	Description	Default	Example
SETNAV	-	Command		setnav
from-lat	0.0 to ± 90.0	Origin latitude in units of degrees/decimal degrees. A negative sign implies South latitude. No sign implies North latitude.	disable	51.1516
from-lon	0.0 to ± 360.0	Origin longitude in units of degrees/decimal degrees. A negative sign implies West longitude. No sign implies East longitude.		-114.16263
to-lat	0.0 to ± 90.0	Destination latitude in units of degrees/decimal degrees		51.16263
to-lon	0.0 to ± 360.0	Destination longitude in units of degrees/decimal degrees		-114.1516
track offset	± 1000	Waypoint great circle line offset (in metres); establishes offset track; positive indicates right of great circle line; negative indicates left of great circle line		-125.23
from-port	1 to 5 characters	Optional ASCII station name		from
to-port	1 to 5 characters	Optional ASCII station name		to

Example:

```
setnav 51.1516,-114.16263,51.16263,-114.1516,-125.23,from,to
```

Figure 2-6 Illustration of SETNAV Parameters



<u>1st Waypoint Track</u>

A = FROM lat-lon (1)
B = TO lat-lon (1)
AD = Track Offset from A to D (perpendicular to AB)
AB = Great circle line drawn between A lat-lon and B lat-lon
DE = Offset track determined by track offset AD and parallel to AB

<u>2nd Waypoint Track</u>

B = FROM lat-lon (2)
C = TO lat-lon (2)
BF = Track Offset from B to F (perpendicular to BC)
BC = Great circle line drawn between B lat-lon and C lat-lon
EF = Course to steer to get on track FG
FG = Offset track determined by track offset BF and parallel to BC

UNDULATION *B*

This command permits you to either enter a specific geoidal undulation value or use the internal table of geoidal undulations. The separation values only refer to the separation between the WGS-84 ellipsoid and the geoid, regardless of the datum chosen.

Syntax:

```
UNDULATION  separation
```

Syntax	Range Value	Description	Default
UNDULATION	-	Command	
separation	table or enter a value	Selects the internal table of undulations and ignores any previously entered value. The internal table utilizes OSU - 89B 1° x ~1.3°. A numeric entry that overrides the internal table with a value in metres.	table

Example 1:

```
undulation table
```

Example 2:

```
undulation -5.6
```

VERSION *B*

Use this command to determine the current software version of the GPSCard. The response to the VERSION command is logged to the port from which the command originated.

Syntax:

```
VERSION
```

Command	Response Syntax				
VERSION	Card type	Model #S/N	HW Rev	SW Rev	Date

Example:

```
version
OEM-2 RT20 SGN98190073 HW 1 SW 3.352D6/1.02 Nov 11/98
console>
```

3 SPECIAL DATA INPUT COMMANDS ($xxxx)

This chapter focuses on the usage of Special NovAtel Data Input Commands ($xxxx). These commands are actually **re-injection of NovAtel ASCII logs** back into the GPSCard. The data structure must follow that defined in *Chapter 4.0, Output Logging*. Therefore, each Special Command leads with the NovAtel ASCII log header "$xxxx" (e.g., $DCSA), followed by valid data fields, and terminates with the "*xx" checksum field.

The injection of special command data can take place via COM1, COM2, or console (PC Series GPSCards). Remember, the source of these special data commands is a valid NovAtel ASCII data log.

The special data commands fall into two categories: **Differential Corrections** and **Almanac Data**.

ALMANAC DATA

The GPSCard's standard features include almanac data collection. Following a cold-start boot-up or system reset, the GPSCard will begin a sky search. Once a valid satellite is acquired, the GPSCard will begin almanac downloading and decoding. This process will take at least 12.5 minutes following the cold-start (assuming there are no problems with satellite visibility or the antenna system). It is noted that Ionospheric Correction Data and UTC data are also collected at the same time as almanac data and will also be available following the 12.5 minutes collection period mentioned above.

12 channel OEM cards with the SAVECONFIG option will automatically save almanacs in their Flash memory. They will also automatically load the last saved almanac following a cold start or a reset. The card will save an almanac and ionospheric and UTC data received from a satellite if there is no current data in flash, or if the GPS week number of the received data is newer than the week number of the data in flash. The save will not occur until between 12.5 and 25 minutes have elapsed since the last reset. To check if almanac data is saved in the flash of the OEM card, check the "almanac data saved" bit in the receiver status word. Refer to the RCSA/B logs, page 88, for details.

The PC Series GPSCard does not have Flash memory, and so the new almanac data that has been collected will reside in the GPSCard RAM as long as system power is maintained or until a system restart is initiated. In the case of a restart, the almanac collection process must be repeated once again.

The GPSCard is capable of logging almanac data utilizing the NovAtel-format ASCII log command option ALMA. Once logged, the data records will precede the header with the $ character (e.g., $ALMA).

There are no specific NovAtel log option commands to independently specify output of ionospheric or UTC parameters. These parameters will always output following the $ALMA log (identifiable by the headers $IONA and $UTCA respectively). Refer to Chapter 4, page 52, for more information on the ALMA output log command option.

The GPSCard has the capability to accept injection of previously logged NovAtel-format ASCII almanac data ($ALMA, $IONA, and $UTCA). The GPSCard will interpret this log data as special data input commands. This provides the user with the advantage of being able to inject recent almanac data following a cold-start or RESET without having to wait the 12.5 minutes described in above paragraphs. As well, this provides you with faster and more accurate first-fix data because of the advantage of a full almanac being resident immediately following the injection of the special data input commands described above. This is especially beneficial when the receiver is cold-starting in an environment with poor reception and frequent satellite visibility obstruction.

There are various ways by which this can be accomplished.

- By connecting the COM1 or COM2 port from one GPSCard (base) directly to the COM1 or COM2 port of another GPSCard (remote). The reference card is assumed to be tracking satellites for some time and can be commanded by the ALMA log command option to output almanac records to the remote card. The remote card can be assumed to be just powered-up or RESET and will recognize the $ALMA, $IONA, and $UTCA data as special input commands and update its almanac tables with this new data.

REMEMBER: When connecting two GPSCard com ports together, the messages command option should be set to "off" to prevent inter-card "chatter".

- If the GPSCard is a PC Series type, it can log current almanac data to its host PC disk utilizing the log console command to direct the almanac data to a file called almanac.dat. At a later time following a system restart, the GPSCard can have this almanac.dat file (containing $ALMA, $IONA, and $UTCA records) downloaded as a special input command for immediate use. This is accomplished utilizing the GPSLOAD MAIN.BTL */aalmanac.dat* boot-up option. Refer to the "*GPSCard PC Series Installation and Operating Manual*" for further information on GPSLOAD, MAIN.BTL, and GPSCON.

- If the GPSCard is an OEM Series type, it can log current almanac data to a PC connected to its COM1 or COM2 port. Assuming the PC is correctly configured using terminal emulator communications software, then the PC can redirect the GPSCard almanac log to its disk storage device. At a later time following a system restart, the GPSCard can have this almanac.dat file (containing $ALMA, $IONA, and $UTCA records) immediately downloaded as a special input command for immediate use. Refer to the "*GPSCard OEM Series Installation and Operating Manual*" for more information about interfacing with the OEM card with a PC. [Note: this procedure will generally not be required with OEM cards as all 12 channel cards now have an almanac save feature built in using flash memory.]

PROTOCOLS:

$ALMA... *B*

Use this special data input command to quickly update the GPSCard almanac tables following a system restart. It is generated from a GPSCard ALMA log and is accepted by any GPSCard as the following format:

```
$ALMA,1,3.55148E-003,552960,744,-7.8174E-009,6.10457691E-002,-1.1820041E+000,
1.90436112E+000,-1.8119E-005,-3.6379E-012,1.45854758E-004,2.65602532E+007,
9.55600E-001,1,0,0*0C
...
(one record for each valid satellite)
...
$ALMA,31,4.90379E-003,552960,744,-7.9660E-009,-3.1044479E+000,6.13853346E-001,
1.92552900E+000,6.67572E-006,3.63797E-012,1.45861764E-004,2.65594027E+007,
9.61670E-001,1,0,0*3F
```

$IONA... *B*

Use this special data input command to quickly update the GPSCard ionospheric correction tables following a system restart (always appended to $ALMA records unless intentionally stripped). This data will ensure that the initial position solutions computed by the GPSCard are as accurate as possible. It is generated from a GPSCard ALMA log and is accepted by any GPSCard as the following format:

```
$IONA,1.0244548320770265E-008,1.4901161193847656E-008,-5.960464477539061E-008,
-1.192092895507812E-007,8.8064000000000017E+004,3.2768000000000010E+004, -
1.966080000000001E+005,-1.966080000000001E+005*02
```

$UTCA... *B*

Use this special data input command to quickly update the GPSCard Universal Time Coordinated (UTC) parameters following a system restart (always appended to $ALMA records unless intentionally stripped). The UTC data is required before the GPSCard can accurately compute UTC time. If not input with $UTCA, it may take up to 12.5 minutes after a reset for the GPSCard to receive current UTCA data. In order to comply with NMEA standards, the GPSCard will null NMEA log data fields until valid UTC parameters are collected or injected by the $UTCA input command. This command is generated from a GPSCard ALMA log and is accepted by any GPSCard as the following format:

```
$UTCA,-1.769512891769409E-008,-1.776356839400250E-015,552960,744,755,9,10,5*03
```

DIFFERENTIAL CORRECTIONS DATA

NovAtel GPSCards with differential capability (xxxxR models) can utilize the special data input commands $DCSA, $RTCA and $RTCM. A GPSCard operating as a remote station to accept NOVATEL ASCII format differential corrections utilizes these special data input commands. The data is generated by a GPSCard operating as a reference station with intent to be received by remote stations. To correctly interpret these commands, the remote GPSCard must have its ACCEPT command option set to “COMMANDS” (default). Refer to Chapter 10, page 137, for further information on differential positioning.

PROTOCOLS:

$DCSA... *R*

Use this special data input command to directly input NovAtel DCSA differential correction data, ASCII format. The data can be accepted using the host PC console (PC Series cards), COM1, or COM2. The differential corrections will be accepted and applied upon receipt of this special data input command.

The data is generated from a GPSCard DCSA log and is accepted by a GPSCard remote station without any special initialization. The DCSA data format is as follows:

```
$DCSA,744,488906.00,1,7,19,165,267.718,-0.195,22,123,-592.682,-0.361,29,223,
-91.016,0.065,4,138,-188.193,-0.025,28,154,64.760,-0.465,18,141,-270.081,
0.020,14,77,730.942,-0.135*13
```

$RTCA... (RTCAA) *R*

Use this special data input command to directly input NovAtel RTCAA differential correction data, ASCII format. The data can be accepted using the host PC console (PC Series cards), COM1, or COM2. The differential corrections will be accepted and applied upon receipt of this special data input command.

The data is generated from a GPSCard RTCAA log and is accepted by a GPSCard remote station as in the following format:

```
$RTCA,990000000447520607BE7C92FA0B82423E9FE507DF5F3FC9FD071AFC7FA0D207D090808C
0E045BACC055E9075271FFB0200413F43FF810049C9DFF8FFD074FCF3C940504052DFB*20
```

$RTCM... (RTCMA) *R*

Use this special data input command to directly input RTCMA differential correction data, ASCII format (RTCM data converted to ASCII hexadecimal, with NovAtel header added). The data can be accepted using the host PC console (PC Series cards), COM1, or COM2. The differential corrections will be accepted and applied upon receipt of this special data input command. Refer to Chapter 8, page 129, for further information on RTCM related topics.

The data is generated from a GPSCard RTCMA log and is accepted by a GPSCard remote station as in the following format:

```
$RTCM,664142404E7257585C6E7F424E757D7A467C47414F6378635552427F7357726162427877
7F5B5A525C7354527C4060777B4843637C7F555F6A784155597D7F6763507B77496E7F7A6A426F
555C4C604F4E7F467F5A787F6B5F69506C6D6A4C*2B
```

NOTE: The $DCSA, $RTCA and $RTCM commands allow the user to intermix differential corrections along with other ASCII commands or logs over a single port. (You must, however, ensure that the ACCEPT command option is set to "COMMANDS".

TIP: The decoding success and status of $DCSA, $RTCA and $RTCM records can be monitored using the CDSA/B data log. These commands will not generate any reply response from the command interpreter. They will simply be processed for valid format and checksum and used internally. If there is any problem with the data, characters missing or checksum fail, the data will be discarded with no warning message.

---

4 OUTPUT LOGGING

GENERAL

The GPSCard provides versatility in your logging requirements. You can direct your logs to the console, COM1, COM2, or all three ports, as well as combine data types. The GPSCard has four major logging formats:

- NovAtel Format Data Logs (ASCII/Binary)
- NMEA Standard Format Data Logs (ASCII)
- RTCM Standard Format Data Logs (Binary)
- RTCA Standard Format Data Logs (Binary)

All data types can be logged using several methods of triggering each log event. Each log is initiated using the LOG command. The LOG command and syntax are listed below.

Syntax:

```
log port,datatype,[trigger,{period},{offset}]
```

Syntax	Description		Example
LOG			LOG
port	Console, COM1 or COM2		COM1
datatype	Enter one of the valid ASCII or Binary Data Logs (see Chapter 5, page 54)		POSA
trigger	Enter one of the following *triggers*.		ONTIME
	ONCE	Immediately logs the selected data to the selected port once. Default if trigger field is left blank.	
	ONMARK	Logs the selected data when a MARKIN electrical event is detected. Outputs internal buffers at time of mark – does not extrapolate to mark time. Use MKPA/B for extrapolated position at time of mark .	
	ONNEW	Logs the selected data each time the data is new even if the data is unchanged.	
	ONCHANGED	Logs the selected data only when the data has changed.	
	ONTIME [period], [offset]	Immediately logs the selected data and then periodically logs the selected data at a frequency determined by the *period* and *offset* parameters. The logging will continue until an UNLOG command pertaining to the selected data item is received (see UNLOG Command, page 37).	
	CONTINUOUSLY	Will log the data all the time. The GPSCard will generate a new log when the output buffer associated with the chosen port becomes empty. **This may cause unpredictable results if more than one log is assigned to the port.** The *continuously* option was designed for use with differential corrections over low bit rate data links. This will provide optimal record generation rates. The next record will not be generated until the last byte of the previous record is loaded into the output buffer of the UART.	
period	Use only with the *ONTIME* trigger. Units for this parameter are seconds. The selected period may be any value from 0.05 second to 3600 seconds. Selected data is logged immediately and then periodic logging of the data will start at the next even multiple of the period. If a period of 0.20 sec is chosen, then data will be logged when the receiver time is at the 0.20, 0.40, 0.60 and the next (0.80) second marks. If the period is 15 seconds, then the logger will log the data when the receiver time is at even 1/4 minute marks. The same rule applies even if the chosen period is not divisible into its next second or minute marks. If a period of 7 seconds is chosen, then the logger will log at the multiples of 7 seconds less than 60, that is, 7, 14, 21, 28, 35, 42, 49, 56 and every 7 seconds thereafter.		60
offset	Use only with the *ONTIME* trigger. Units for this parameter are seconds. It provides the ability to offset the logging events from the above startup rule. If you wished to log data at 1 second after every minute you would set the period to 60 seconds and the offset to 1 second (Default is 0).		1

Example:

```
log com1,posa,ontime,60,1
```

If the LOG syntax does not include a *trigger* type, it will be output only once following execution of the LOG command. If *trigger* type is specified in the LOG syntax, the log will continue to be output based on the *trigger* specification. Specific logs can be disabled using the UNLOG command, whereas all enabled logs will be disabled by using the UNLOGALL command (refer to Chapter 2, page 37). All activated logs will be listed in the receiver configuration status log (RCCA).

Table 4-1 GPSCard Log Summary

Syntax: **log** *port,datatype,trigger,[period,offset]*

NovAtel Format Logs			
Datatype	**Description**	**Datatype**	**Description**
ALMA/B	Decoded Almanac	PRTKA/B	Computed Position
CDSA/B	Communication and Differential Decode Status	PXYA/B	Computed Cartesian Coordinate Position
CLKA/B	Receiver Clock Offset Data	RALA/B	Raw Almanac
COM1A/B	Log data from COM1	RCCA	Receiver Configuration
COM2A/B	Log data from COM2	RCSA/B	Receiver status incl. S/W version, # of working channels, CPU idle time, BISTs status, clock status
CONSOLEA/B	Log data from console	REPA/B	Raw Ephemeris
CTSA/B	Channel Tracking Status	RGEA/B/C/D	Channel Range Measurements
DCSA/B	Differential Corrections - NovAtel format	RT20A/B	Computed Position – Time Matched
DOPA/B	Dilution of Precision	RTCAA/B	RTCA format Differential Corrections with NovAtel headers
FRMA/B	Framed Raw Navigation Data	RTCMA/B	RTCM Type 1 Differential Corrections with NovAtel headers
FRWA/B	Framed Raw Navigation Words	RTCM16T	Special Message – NovAtel ASCII Format
GGAB	Global Position System Fix Data - Binary Format	RTKA/B	Computed Position – Time Matched
MKPA/B	Mark Position	SATA/B	Satellite Specific Data
MKTA/B	Time of Mark Input	SPHA/B	Speed and Direction Over Ground
NAVA/B	Navigation Data	SVDA/B	SV Position in ECEF XYZ Coordinates with Corrections
P20A/B	Computed Position – Best Available	TM1A/B	Time of 1PPS
PAVA/B	Positioning Averaging Status	VERA/B	GPSCard current hardware type and software version number
POSA/B	Computed Position	VLHA/B	Velocity, Latency, and Direction over Ground
NMEA Format Logs			
GPALM	Almanac Data	GPGSV	GPS Satellites in View
GPGGA	Global Position System Fix Data	GPGSV	GPS Satellites in View
GPGLL	Geographic Position - lat/lon	GPRMB	Generic Navigation Information
GPGRS	GPS Range Residuals for Each Satellite	GPRMC	GPS Specific Information
GPGSA	GPS DOP and Active Satellites	GPVTG	Track Made Good and Ground Speed
GPGST	Pseudorange Measurement Noise Statistics	GPZDA	UTC Time and Date
		GPZTG	UTC & Time to Destination Waypoint
RTCA Format			
RTCA	RTCA Differential Corrections		
RTCM Format			
RTCM	Type 1 – Differential Corrections		
RTCM3	Type 3 – Reference Station Precise Position Data		
RTCM16	Type 16 – Special Message		
RTCM59	Type 59 Proprietary Message “N” – Pseudorange and Carrier Phase Observation Data		

N.B. A/B/C/D
- A refers to GPSCard output logs in ASCII format.
- B refers to GPSCard output logs in Binary format.
- C refers to GPSCard output logs in Compressed binary format.
- D refers to GPSCard output logs in Compressed binary format.

5 NOVATEL FORMAT DATA LOGS

GENERAL

The GPSCard is capable of executing more than 30 NovAtel format log commands. Each log is selectable in ASCII and Binary formats. The one exception to this rule is the RGE log, which can be logged as RGEC/D. The "C" or “D” indicates a compressed binary format to allow higher speed logging. Any format can be selected individually or simultaneously over the same COMn ports.

All of the following log descriptions are listed in alphabetical order. Each log first lists the ASCII format, followed by the Binary format description.

ASCII LOG STRUCTURE

Log types ending with the letter A (or a) will be output in ASCII format (e.g., POSA). The structures of all ASCII logs follow the general conventions as noted here:

1. The lead code identifier for each record is '$'.
2. Each log is of variable length depending on amount of data and formats.
3. All data fields are delimited by a comma ',' with the exception of the last data field, which is followed by a * to indicate end of message data.
4. Each log ends with a hexadecimal number preceded by an asterisk and followed by a line termination using the carriage return and line feed characters, e.g., *xx[CR][LF]. This 8-bit value is an exclusive OR (XOR) of all bytes in the log, excluding the '$' identifier and the asterisk preceding the two checksum digits.

Structure:

`$xxxx,`	`data field...,`	`data field...,`	`data field...`	`*xx`	`[CR][LF]`

BINARY LOG STRUCTURE

Log types ending with the letter B (or b) will be output in Binary format (e.g., POSB). The structures of all Binary logs follow the general conventions as noted here:

1. Basic format of:

Sync	3 bytes
Checksum	1 byte
Message ID	4 bytes unsigned integer
Message byte count	4 bytes unsigned integer
Data	x bytes

2. The Sync bytes will always be:

Byte	Hex	Decimal
First	AA	170
Second	44	68
Third	11	17

3. The Checksum is an XOR of all the bytes (including the 12 header bytes) and is initially set to 00.

4. The Message ID identifies the type of log to follow.

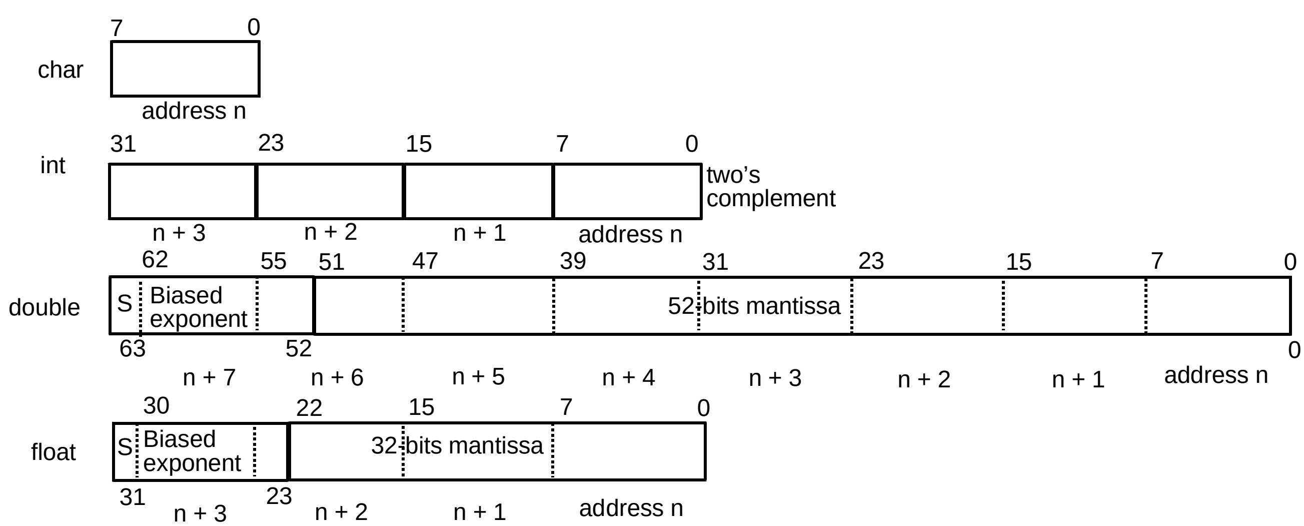
5. The Message byte count equals the total length of the data block including the header.

NOTE: Maximum flexibility for logging data is provided to the user by these logs. The user is cautioned, however, to recognize that each log requested requires additional CPU time and memory buffer space. Too many logs may result in lost data and degraded CPU performance. CPU overload can be monitored using the idle-time and buffer overload bits from the RCSA/B log. Refer to Table 5-5, page 90.

The following table describes the format types used in the description of binary logs.

Type	Size (bytes)	Size (bits)	Description
char	1	8	The **char** type is used to store the integer value of a member of the representable character set. That integer value is the ASCII code corresponding to the specified character.
int	4	32	The size of a signed or unsigned **int** item is the standard size of an integer on a particular machine. On a 32-bit processor (such as the NovAtel GPSCard), the **int** type is 32 bits, or 4 bytes. The **int** types all represent signed values unless specified otherwise. Signed integers are represented in two's-complement form. The most-significant bit holds the sign: 1 for negative, 0 for positive and zero.
double	8	64	The **double** type contains 64 bits: 1 for sign, 11 for the exponent, and 52 for the mantissa. Its range is ±1.7E308 with at least 15 digits of precision.
float	4	32	The **float** type contains 32 bits: 1 for the sign, 8 for the exponent, and 23 for the mantissa. Its range is ±3.4E38 with at least 7 digits of precision.

Each byte within an **int** has its own address, and the smallest of the addresses is the address of the int. The byte at this lowest address contains the eight least significant bits of the doubleword, while the byte at the highest address contains the eight most significant bits. The following illustration shows the arrangement of bytes within words and doublewords. Similarly the bits of a "double" type are stored least significant byte first. This is the same data format used by IBM PC computers.



GPS TIME vs LOCAL RECEIVER TIME

All logs report GPS time expressed in GPS weeks and seconds into the week. The time reported is not corrected for local receiver clock error. To derive the closest GPS time, one must subtract the clock offset shown in the CLKA log (field 4) from GPS time reported.

GPS time is based on an atomic time scale. Universal Time Coordinated (UTC) time (reported in NMEA logs) is also based on an atomic time scale, with an offset of seconds applied to coordinate Universal Time to GPS time. GPS time is designated as being coincident with UTC at the start date of January 6, 1980 (00 hours). GPS time does not count leap seconds, and therefore an offset exists between UTC and GPS time (at this date: 12 seconds). The GPS week consists of 604800 seconds, where 000000 seconds is at Saturday midnight. Each week at this time, the week number increments by one, and the seconds into the week resets to 0.

LOG DESCRIPTIONS

ALMA/B Decoded Almanac B

This log contains the decoded almanac parameters from subframes four and five as received from the satellite with the parity information removed and appropriate scaling applied. Multiple messages are transmitted, one for each SV almanac collected. The Ionospheric Model parameters (IONA) and the UTC Time parameters (UTCA) are also provided, following the last almanac records. For more information on Almanac data, refer to the GPS SPS Signal Specification. (See Appendix D, page 178, of this manual for *References*.)

You can use the ALMA log to create a PC Series GPSCard almanac boot-up file. The boot file can then be used to inject recent almanac data back into the GPSCard when performing a cold start. See the "*PC Series GPSCard Installation and Operating Manual*" for more information on creating almanac boot files. 12 channel OEM cards with the SAVECONFIG option will automatically save almanacs in their Flash memory, therefore creating an almanac boot file would not be necessary.

ALMA

Structure:

$ALMA	prn	ecc	seconds	week	rate-ra	ra	w	M_o	af0	af1	cor-mean-motion
A	incl-angle	health-4	health-5	health-alm	*xx	[CR][LF]					

ALMA Format

Field #	Field type	Data Description	Example
1	$ALMA	Log header	$ALMA
2	prn	Satellite PRN number for current message	1
3	ecc	Eccentricity	3.55577E-003
4	seconds	Almanac reference time, seconds into the week	32768
5	week	Almanac reference week (GPS week number)	745
6	rate-ra	Rate of right ascension, radians	-7.8860E-009
7	ra	Right ascension, radians	-6.0052951E-002

Field #	Field type	Data Description	Example
8	w	Argument of perigee, radians	-1.1824254E+000
9	M_0	Mean anomaly, radians	1.67892137E+000
10	a_{f0}	Clock aging parameter, seconds	-1.8119E-005
11	a_{f1}	Clock aging parameter, seconds/second	-3.6379E-012
12	cor-mean-motion	Corrected mean motion, radians/second	1.45854965E-004
13	A	Semi-major axis, metres	2.65602281E+007
14	incl-angle	Angle of inclination, radians	9.55576E-001
15	health-4	Anti-spoofing and SV config from subframe 4, page 25	1
16	health-5	SV health, 6 bits/SV (subframe 4 or 5, page 25)	0
17	health-alm	SV health, 8 bits (almanac)	0
18	*xx	Checksum	*20
19	[CR][LF]	Sentence terminator	[CR][LF]
1 – 19	$ALMA	Next satellite PRN almanac message	
1 – 19	$ALMA	Last satellite PRN almanac message	
1 – 11	$IONA	Ionospheric Model Parameters	
1 – 11	$UTCA	UTC Time Parameters	

Example:

```
$ALMA,1,3.55577E-003,32768,745,-7.8860E-009,-6.0052951E-002,-1.1824254E+000,
1.67892137E+000,-1.8119E-005,-3.6379E-012,1.45854965E-004,2.65602281E+007,
9.55576E-001,1,0,0*20[CR][LF]
...
$ALMA,31,4.90665E-003,32768,745,-8.0460E-009,3.05762855E+000,6.14527459E-001,
1.69958217E+000,6.67572E-006,3.63797E-012,1.45861888E-004,2.65593876E+007,
9.61664E-001,1,0,0*13[CR][LF]
```

IONA Format

Structure:

$IONA	act	a1ot	a2ot	a3ot	bct	b1ot	b2ot	b3ot	*xx	[CR][LF]

Field #	Field type	Data Description	Example
1	$IONA	Log header	$IONA
2	act	Alpha constant term, seconds	1.0244548320770265E-008
3	a1ot	Alpha 1st order term, sec/semicircle	1.4901161193847656E-008
4	a2ot	Alpha 2nd order term, sec/(semic.)^2	-5.960464477539061E-008
5	a3ot	Alpha 3rd order term, sec/(semic.)^3	-1.192092895507812E-007
6	bct	Beta constant term, seconds	8.8064000000000017E+004
7	b1ot	Beta 1st order term, sec/semicircle	3.2768000000000010E+004
8	b2ot	Beta 2nd order term, sec/(semic.)^2	-1.966080000000001E+005
9	b3ot	Beta 3rd order term, sec/(semic.)^3	-1.966080000000001E+005
10	*xx	Checksum	*02
11	[CR][LF]	Sentence terminator	[CR][LF]

Example:

```
$IONA,1.0244548320770265E-008,1.4901161193847656E-008,-5.960464477539061E-008,
-1.192092895507812E-007,8.8064000000000017E+004,3.2768000000000010E+004,
-1.966080000000001E+005,-1.966080000000001E+005*02[CR][LF]
```

UTCA Format

Structure:

`$UTCA` `pct` `p1ot` `data-ref` `wk#-utc` `wk#-lset` `delta-time` `lsop` `day #-lset` `*xx` `[CR][LF]`

Field #	Field type	Data Description	Example
1	$UTCA	Log header	$UTCA
2	pct	Polynomial constant term, seconds	-2.235174179077148E-008
3	p1ot	Polynomial 1st order term, seconds/second	-1.243449787580175E-014
4	data-ref	UTC data reference time, seconds	32768
5	wk #-utc	Week number of UTC reference, weeks	745
6	wk #-lset	Week number for leap sec effect time, weeks	755
7	delta-time	Delta time due to leap sec, seconds	9
8	lsop	For use when leap sec on past, seconds	10
9	day #-lset	Day number for leap sec effect time, days	5
10	*xx	Checksum	*37
11	[CR][LF]	Sentence terminator	[CR][LF]

Example:

```
$UTCA,-2.235174179077148E-008,-1.243449787580175E-014,32768,745,755,9,10,5*37
[CR][LF]
```

ALMB

ALMB Format: Message ID = 18 Message byte count = 120

Field #	Field Type		Bytes	Format	Units	Offset
1	Sync		3			0
(header)	Checksum		1			3
	Message ID		4			4
	Message byte count		4			8
2	Satellite PRN number		4	integer	dimensionless	12
3	Eccentricity		8	double	dimensionless	16
4	Almanac ref. time		8	double	seconds	24
5	Almanac ref. week		4	integer	weeks	32
6	Omegadot - rate of right ascension		8	double	radians/second	36
7	Right ascension		8	double	radians	44
8	Argument of perigee	w	8	double	radians	52
9	Mean anomaly	Mo	8	double	radians	60
10	Clock aging parameter	a_{f0}	8	double	seconds	68
11	Clock aging parameter	a_{f1}	8	double	seconds/second	76
12	Corrected mean motion		8	double	radians/second	84
13	Semi-major axis	A	8	double	metres	92
14	Angle of inclination		8	double	radians	100
15	Sv health from subframe 4		4	integer	discretes	108
16	Sv health from subframe 5		4	integer	discretes	112
17	Sv health from almanac		4	integer	discretes	116

IONB Format: Message ID = 16 Message byte count = 76

Field #	Field Type	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer	bytes	8
2	Alpha constant term	8	double	seconds	12
3	Alpha 1st order term	8	double	sec/semicircle	20
4	Alpha 2nd order term	8	double	$sec/(semic.)^2$	28
5	Alpha 3rd order term	8	double	$sec/(semic.)^3$	36
6	Beta constant term	8	double	seconds	44
7	Beta 1st order term	8	double	sec/semic	52
8	Beta 2nd order term	8	double	$sec/(semic.)^2$	60
9	Beta 3rd order term	8	double	$sec/(semic.)^3$	68

UTCB Format: Message ID = 17 Message byte count = 52

Field #	Field Type	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer	bytes	8
2	Polynomial constant term	8	double	seconds	12
3	Polynomial 1st order term	8	double	seconds/second	20
4	UTC data reference time	4	integer	seconds	28
5	Week number UTC reference	4	integer	weeks	32
6	Week number for leap sec effect time	4	integer	weeks	36
7	Delta time due to leap sec	4	integer	seconds	40
8	For use when leap sec on past	4	integer	seconds	44
9	Day number for leap sec effect time	4	integer	days	48

CDSA/B Communication and Differential Decode Status *B (R)*

The GPSCard maintains a running count of a variety of status indicators of the data link. This log outputs a report of those indicators.

Parity and framing errors will occur if poor transmission lines are encountered or if there is an incompatibility in the data protocol. If errors occur, you may need to confirm the bit rate, number of data bits, number of stop bits, and parity of both the transmit and receiving ends. Overrun errors will occur if more characters are sent to the UART than can be removed by the on-board microprocessor.

CDSA

Structure:

$CDSA	week	seconds	xon1	cts1	parity1	overrun1	framing1	rx1	tx1
xon2	cts2	parity2	overrun2	framing2	rx2	tx2			
rtca crc	rtcaa chk	rtca good	rtcm par	rtcma chk	rtcm good	dcsa chk	dcsa good	dcsb chk	dcsb good
res'd	*res'd*	*res'd*	*xx	[CR][LF]					

Field #	Field type	Data Description	Example
1	$CDSA	Log header	$CDSA
2	week	GPS week number	787
3	seconds	GPS seconds into the week	500227
4	xon1	Flag to indicate that the com1 is using XON/XOFF handshaking protocol and port has received an xoff and will wait for an xon before sending any more data.	0
5	cts1	Flag to indicate that com1 is using CTS/RTS handshake protocol and cts line port has been asserted. The port will wait for the line to de-assert before sending any more data.	0
6	parity1	A running count of character parity errors from the UART of COM1	0
7	overrun1	A running count of UART buffer overrun errors of COM1	0
8	framing1	A running count of character framing error from the UART of COM1	0
9	rx1	A running count of the characters received from COM1	0
10	tx1	A running count of the characters sent out COM1	9
11	xon2	Flag to indicate that the COM2 is using XON/XOFF handshaking protocol and port has received an xoff and will wait for an xon before sending any more data.	0
12	cts2	Flag to indicate that COM2 is using CTS/RTS handshake protocol and cts line port has been asserted. The Port will wait for the line to de-assert before sending any more data.	0
13	parity2	A running count of character parity errors from the UART of COM2	0
14	overrun2	A running count of UART buffer overrun errors of COM2	0
15	framing2	A running count of character framing error from the UART of COM2	0
16	rx2	A running count of the characters received from COM2	0
17	tx2	A running count of the characters sent out COM2	9
18	rtcacrc †	A running count of RTCA CRC failures	0
19	rtcaachk †	A running count of invalid ASCII $RTCA,....,*xx records indicating that the ASCII checksum "xx" failed.	0
20	rtcagood †	A running count of RTCA records that pass error checking	0
21	rtcmpar †	A running count of 30 bit RTCM parity failures	0
22	rtcmachk †	A running count of invalid ASCII $RTCM,....,*xx records indicating that the ASCII checksum "xx" failed.	0
23	rtcmgood †	A running count of RTCM records that pass error checking	0
24	dcsachk †	A running count of invalid ASCII $DCSA,....,*xx records	0
25	dcsagood †	A running count of DCSA records that pass error checking	0
26	dcsbchk †	A running count of invalid binary DCSB records	0
27	dcsbgood †	A running count of DCSB records that pass error checking	0
28		Reserved for future use	0
29		Reserved for future use	0
30		Reserved for future use	0
31	*xx	Checksum	*33
32	[CR][LF]	Sentence terminator	[CR][LF]

† Fields 18-27 will be 0 except on GPSCards with (R) options.

Example:

```
$CDSA,787,500227,0,0,0,0,0,0,9,0,0,0,0,0,0,9,0,0,0,0,0,0,0,0,0,0,0,0,0
*33[CR][LF]
```

CDSB

Format: Message ID = 39 Message byte count = 128

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer		8
2	Week number	4	integer	weeks	12
3	Time of week	4	integer	seconds	16
4	Xon COM1	4	integer	1 or 0	20
5	CTS COM1	4	integer	1 or 0	24
6	Parity errors COM1	4	integer	Total count	28
7	Overrun errors COM1	4	integer	Total count	32
8	Framing error COM1	4	integer	Total count	36
9	Bytes received in COM1	4	integer	Total count	40
10	Bytes sent out COM1	4	integer	Total count	44
11	Xon COM2	4	integer	1 or 0	48
12	CTS COM2	4	integer	1 or 0	52
13	Parity errors COM2	4	integer	Total count	56
14	Overrun errors COM2	4	integer	Total count	60
15	Framing error COM2	4	integer	Total count	64
16	Bytes received in COM2	4	integer	Total count	68
17	Bytes sent out COM2	4	integer	Total count	72
18	RTCA CRC fails †	4	integer	Total count	76
19	RTCAA checksum fails †	4	integer	Total count	80
20	RTCA records passed †	4	integer	Total count	84
21	RTCM parity fails †	4	integer	Total count	88
22	RTCMA checksum fails †	4	integer	Total count	92
23	RTCM records passed †	4	integer	Total count	96
24	DCSA checksum fails †	4	integer	Total count	100
25	DCSA records passed †	4	integer	Total count	104
26	DCSB checksum fails †	4	integer	Total count	108
27	DCSB records passed †	4	integer	Total count	112
28	Reserved	4	integer	Total count	116
29	Reserved	4	integer	Total count	120
30	Reserved	4	integer	Total count	124

CLKA/B Receiver Clock Offset Data *B*

This record is used to monitor the state of the receiver time. Its value will depend on the CLOCKADJUST command. If CLOCKADJUST is enabled, then the offset and drift times will approach zero. If not enabled, then the offset will grow at the oscillator drift rate. Disabling CLOCKADJUST and monitoring the CLKA/B log will allow you to determine the error in your GPSCard receiver reference oscillator as compared to the GPS satellite reference.

All logs report GPS time not corrected for local receiver clock error. To derive the closest GPS time one must subtract the clock offset shown in the CLKA log (field 4) from GPS time reported.

The interpretation of Field #6 will depend on whether an external oscillator is used (for further information, please refer to the EXTERNALCLOCK command, page 29).

CLKA

Structure:

`$CLKA` `week` `seconds` `offset` `drift` `drift rate` `offset std` `drift std` `cm status`
`*xx` `[CR][LF]`

Field #	Field type	Data Description	Example
1	$CLKA	Log header	$CLKA
2	week	GPS week number	637
3	seconds	GPS seconds into the week	511323.00
4	offset	Receiver clock offset, in seconds. A positive offset implies that the receiver clock is ahead of GPS Time. To derive GPS time, use the following formula: GPS time = receiver time – (offset)	-4.628358547E-003
5	drift	Receiver clock drift, in seconds per second. A positive drift implies that the receiver clock is running faster than GPS Time.	-2.239751396E-007
6 (case 1)	drift rate	In normal (TCXO) mode, this field contains the value of the receiver's internal clock's drift rate, in units of seconds per second per second.	8.292986898E-013
6 (case 2)	SA Gauss-Markov state	In the presence of an external reference clock (after the EXTERNALCLOCK command has been issued) this field contains the output value of the Gauss-Markov Selective Availability clock dither estimator, in units of seconds. The value reflects both the collective SA-induced short-term drift of the satellite clocks as well as any range bias discontinuities that would normally affect the clock model's offset and drift states.	2.061788299E-006
7	offset std	Standard deviation of receiver clock offset, in seconds	5.369997167E-008
8	drift std	Standard deviation of receiver drift, in seconds per second	4.449097711E-009
9	cm status	Receiver Clock Model Status where 0 is valid and values from -21 to -1 imply that the model is in the process of stabilization	0
10	*xx	Checksum	*7F
11	[CR][LF]	Sentence terminator	[CR][LF]

Example (case 1):

```
$CLKA,637,511323.00,-4.628358547E-003,-2.239751396E-007,8.292986898E-013,
5.369997167E-008,4.449097711E-009,0*7F[CR][LF]
```

Example (case 2):

```
$CLKA,841,499296.00,9.521895494E-008,-2.69065747E-008,2.061788299E-006,
9.642598169E-008,8.685638908E-010,0*4F
```

CLKB

Format: Message ID = 02 Message byte count = 68

Field #	Field Type	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer	bytes	8
2	Week number	4	integer	weeks	12
3	Seconds of week	8	double	seconds	16
4	Clock offset	8	double	seconds	24
5	Clock drift	8	double	seconds per second	32
6 (case 1)	Clock drift rate	8	double	seconds per second squared	40
6 (case 2)	SA Gauss-Markov state	8	double	seconds	
7	StdDev clock offset	8	double	seconds	48
8	StdDev clock drift	8	double	seconds per second	56
9	Clock model status	4	integer	0 = good, -1 to –21 = bad	64

COM1A/B Data Pass-Through COM1 port *B*

See Chapter 6, page 113, for details concerning Pass-Through logs.

COM2A/B Data Pass-Through COM2 port *B*

See Chapter 6, page 113, for details concerning Pass-Through logs.

CONSOLEA/B Data Pass-Through Console port *B*

See Chapter 6, page 113, for details concerning Pass-Through logs.

CTSA/B Channel Tracking Status *B*

This log provides channel tracking status information for each of the GPSCard parallel channels. The channel information is sequential from channel 1 to channel n, where n is the highest tracking channel available in the GPSCard you are currently using. This log is intended for status display only. Because some of the data elements are not synchronized together, do not use this information for measurement data. Refer to the logs RGEA/B/C/D, page 93, SATA/B, page *102*, and SVDA/B, page 105, to obtain synchronized data for post processing analysis.

CTSA

Structure:

```
$CTSA | week | seconds | sol status | # chans
prn | chan st | dopp | c/no | residual | locktime | psr | reject code
:
prn | chan st | dopp | c/no | residual | locktime | psr | reject code | *xx | [CR][LF]
```

Field #	Field type	Data Description	Example
1	$CTSA	Log header	$CTSA
2	week	GPS week number	791
3	seconds	GPS seconds into the week (receiver time, not corrected for clock error, CLOCKADJUST enabled)	242805.0 0
4	sol status	Solution status (see Table 5-2, page 65)	0
5	# chans †	Number of receiver channels with information to follow	12
6	prn	Satellite PRN number (1-32) (channel 1)	28
7	chan st	Channel tracking state (See Table 5-1, page 65)	4
8	dopp	Instantaneous carrier Doppler frequency, in Hz	-72.4
9	c/no	Carrier to noise density ratio in dB/Hz	0.000
10	residual	Residual from position filter (cf $SATA) (metres)	0.000
11	locktime	Number of seconds of continuous tracking (no cycle slips)	0.0
12	psr	Pseudorange measurement, in metres	0.00
13	reject code	Indicates that the range is being used in the solution (code 0) or that it was rejected (code 1-11), as shown in Table 5-7 GPSCard Range Reject Codes	1
14-21 - 94-101	- - -	Next PRN (channel 2) - .. (channel n)	
102	*xx	Checksum	*2C
103	[CR][LF]	Sentence terminator	[CR][LF]

Example:

```
$CTSA,791,242805.00,0,12,28,4,-72.4,0.000,0.000,0.0,0.00,1,29,4,-3457.7,
42.684,4.451,2271.3,23182218.85,0,22,4,-3644.9,34.142,0.782,2278.5,
25139342.49,0,18,4,-2364.9,47.428,-10.199,2232.9,21086400.04,0,31,4,
2294.5,44.457,-8.949,2192.1,22192637.97,0,2,4,3389.9,36.117,10.247,
680.1,24886405.46,0,17,1,474.9,0.000,0.000,0.0,0.00,1,26,0,-1833.9,
0.000,0.000,0.0,0.00,1,19,4,475.7,47.985,24.028,2232.4,20162343.19,0,16,4,
867.9,42.432,2.895,2245.5,23437731.14,0,27,4,2712.0,46.145,-23.226,2278.5,
21867641.20,0,2,0,4756.9,0.000,0.000,0.0,0.00,1*2C[CR][LF]
```

† **REMEMBER:** The maximum number of tracking channels depends on your GPSCard specific model type. If you are using a 12 channel GPSCard with the setchan command set to "10", then this log will only report on the first 10 channels.

CTSB

Format: Message ID = 19
Message byte count = 32 + (n*52) where n is number of channels in receiver

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer		8
2	Week number	4	integer	weeks	12
3	Time of week	8	double	seconds	16
4	Solution status	4	integer	(See Table 5-2, page 65)	24
5	No. of channels †	4	integer	number of channels in receiver	28
6	PRN number (chan 0)	4	integer		32
7	Channel tracking state	4	integer	(See Table 5-1, page 65)	36
8	Doppler	8	double	Hz	40
9	C/NO (db-Hz)	8	double	db/Hz	48
10	Residual	8	double	metres	56
11	Locktime	8	double	seconds	64
12	Pseudorange	8	double	metres	72
13	Rejection code	4	integer	(See *SATA*, Table 5-7, page 103)	80
14 ...	Offset = 32 + (chan * 52) where chan varies from 0 – 11				

Table 5-1 GPSCard Channel Tracking States

State	Description
0	Idle
1	Sky searching
2	Wide band frequency pull-in
3	Narrow band frequency pull-in
4	Phase lock loop achieved
5	Reacquisition

Higher numbers are reserved for future use

Table 5-2 GPSCard Solution Status

Value	Description
0	Solution computed
1	Insufficient observations
2	No convergence
3	Singular AtPA Matrix
4	Covariance trace exceeds maximum (trace > 1000 m)
5	Test distance exceeded (maximum of 3 rej if distance > 10 km)
6	Not yet converged from cold start
7	Height or velocity limit exceeded. (In accordance with COCOM export licensing restrictions)

Higher numbers are reserved for future use

Table 5-3 Position Type

Type	Definition
0	No position
1	Single point position
2	Differential pseudorange position
3	RT-20 position
4	RT-2 position
5	WAAS position solution

Higher numbers are reserved for future use

Table 5-4 RTK Status for Position Type 3 (RT-20)

Status	Definition
0	Floating ambiguity solution (converged)
1	Floating ambiguity solution (not yet converged)
2	Modeling reference phase
3	Insufficient observations
4	Variance exceeds limit
5	Residuals too big
6	Delta position too big
7	Negative variance
8	RTK position not computed

Higher numbers are reserved for future use

DCSA/B Pseudorange Differential Corrections *R*

This log can be transmitted or received by any GPSCard with the “R” option. The log contains pseudorange and range-rate corrections as computed by the GPSCard operating in reference mode.

Before the GPSCard reference station can correctly log this data, it must be operating in “reference mode” by utilizing the FIX POSITION command. As well, the reference GPSCard must be tracking at least three healthy SVs before the log will be correctly transmitted.

The log will contain a variable number of fields, depending on the number of healthy SVs being tracked. However, any SVs locked out by the LOCKOUT command, or any SVs designated with bad health with the SETHEALTH command, will not be reported in this log.

NOTES: The DCSA/B log is specific to NovAtel cards and cannot be interpreted by GPS receivers supplied by other manufacturers.

As the checksum of the DCSB log is 1 byte, there is a 1 in 255 possibility that a complete DCSB log will contain an error.

In previous software releases, this log was recommended as the most efficient differential format because the DCSB format most closely matches the internal data structure of the GPSCard receiver, and requires minimal CPU power to process. However with the introduction of the RTCA Standard, the RTCA log is now the recommended format for greatest efficiency combined with data integrity.

DCSA

This log is transmitted, in NovAtel ASCII format, by the GPSCard reference station. The data can be directly interpreted by a GPSCard remote station as a special data input command $DCSA. The remote receiver must have the ACCEPT command set to ACCEPT *port* COMMANDS (default setting).

Structure:

```
$DCSA | week | seconds | station ID | # obs
prn | iode | diff cor | cor rate
:
prn | iode | diff cor | cor rate | *xx | [CR][LF]
```

Field #	Field type	Data Description	Example
1	$DCSA	Log header	$DCSA
2	week	GPS week number	653
3	seconds	GPS seconds into the week	338608.50
4	station id	Reference station ID	0
5	# obs	Number of valid satellite observations with information to follow:	8
6	prn	Satellite PRN number (1-32)	**18**
7	iode	Issue of data for the current ephemeris being used	224
8	diff cor	Differential range correction, in metres	-43.054
9	cor rate	Differential correction rate of change, in m/s	0.203
10 – 13	...	Next PRN (4 fields) ...	
variable	...	Last PRN	
variable	*xx	Checksum	*36
variable	[CR][LF]	Sentence terminator	[CR][LF]

Example:

```
$DCSA,653,338608.50,0,8,18,224,-43.054,0.203,3,109,8.014,-0.262,13,193,
-28.666,-0.240,25,135,-0.389,-0.128,16,63,7.748,0.248,24,98,-32.389,
0.165,12,72,-23.717,-0.251,20,176,59.575,-0.786*36[CR][LF]
```

DCSB

The DCSB differential correction log data can be interpreted by other NovAtel GPSCard receivers operating as a remote station. The remote station must be initialized by using the ACCEPT *port* DCSB command before it will interpret the DCSB data.

Format: Message ID = 09 Message byte count = 32 + (#obs*24)

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer	bytes	8
2	Week number	4	integer	weeks	12
3	Seconds of week	8	double	seconds	16
4	Station ID	4	integer		24
5	Number of correction sets to follow (obs)	4	integer		28
6	PRN, 1-32 (obs 0)	4	integer		32
7	IODE	4	integer		36
8	Correction	8	double	metres	40
9	Correction rate of change	8	double	m/s	48
10...	Next PRN offset = 32 + (obs * 24) where obs varies from 0 to (obs-1)				

CAUTION: The DCSB message only has an 8-bit error-check value. Because of this, it is not recommended for use over broadcast transmissions where the bit error rate could be high (i.e., > 10-3). The most reliable data integrity format for differential correction broadcast is RTCA.

REMEMBER: When the accept port DCSB command is issued, the port specified will be dedicated to interpret only DCSB differential corrections input data; all other commands and differential data types to the port will be ignored. However pass-through data will still be accepted but not interpreted by the GPSCard port command interpreter.

For further information about the DCSA/B logs, refer to Chapter 10, page 139.

DOPA/B Dilution of Precision *B*

The dilution of precision data is calculated using the geometry of only those satellites that are currently being tracked and used in the position solution by the GPSCard and updated once every 60 seconds or whenever a change in the constellation occurs. Therefore, the total number of data fields output by the log is variable, depending on the number of SVs tracking. Twelve is the maximum number of SV PRNs contained in the list.

NOTE: If a satellite is locked out using the LOCKOUT command, it will still be shown in the prn list, but is significantly deweighted in the DOP calculation.

DOPA

Structure:

```
$DOPA  week  seconds  gdop  pdop  htdop  hdop  tdop  # sats  prn list
*xx  [CR][LF]
```

Field #	Field type	Data Description	Example
1	$DOPA	Log header	$DOPA
2	week	GPS week number	637
3	seconds	GPS seconds into the week	512473.00
4	gdop	Geometric dilution of precision - assumes 3-D position and receiver clock offset (all 4 parameters) are unknown	2.9644
5	pdop	Position dilution of precision - assumes 3-D position is unknown and receiver clock offset is known	2.5639
6	htdop	Horizontal position and time dilution of precision - assumes height is known if the FIX HEIGHT command has been invoked. If not, it will give the normalized precision of the horizontal and time parameters given that nothing has been constrained.	2.0200
7	hdop	Horizontal dilution of precision - makes no constraint assumptions about time, and about height only if the FIX HEIGHT command has been invoked.	1.3662
8	tdop	Time dilution of precision - assumes 3-D position is known and only receiver clock offset is unknown	1.4880
9	# sats	Number of satellites used in position solution (0-12)	6
10...	prn list	PRN list of SV PRNs tracking (1-32), null field until first position solution available	18,6,11,2,16,19
variable	*xx	Checksum	*29
variable	[CR][LF]	Sentence terminator	[CR][LF]

Example:

```
$DOPA,637,512473.00,2.9644,2.5639,2.0200,1.3662,1.4880,6,18,6,11,2,16,19
*29[CR][LF]
```

DOPB

Format: Message ID = 07 Message byte count = 68+(sats*4)

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer	bytes	8
2	Week number	4	integer	weeks	12
3	Seconds of week	8	double	seconds	16
4	gdop	8	double		24
5	pdop	8	double		32
6	htdop	8	double		40
7	hdop	8	double		48
8	tdop	8	double		56
9	Number of satellites used	4	integer		64
10	1st PRN	4	integer		68
11...	Next satellite PRN Offset = 68 + (sats*4) where sats = 0 to (number of sats-1)				

FRMA/B Framed Raw Navigation Data *B*

This message contains the raw framed navigation data. An individual message is sent for each PRN being tracked. The message is updated with each new frame, therefore it is best to log the data with the 'onnew' trigger activated.

FRMA

Structure:

```
$FRMA | week | seconds | prn | cstatus | # of bits | framed raw data
*xx | [CR][LF]
```

Field #	Field type	Data Description	Example
1	$FRMA	Log header	$FRMA
2	week	GPS week number	845
3	seconds	GPS seconds into the week	238623.412
4	prn	PRN of satellite from which data originated	120
5	cstatus	Channel Tracking Status (see Table 5-6, page 95)	80811F14
6	# of bits	Number of bits transmitted in the message. 250 for WAAS, 300 for GPS and 85 for GLONASS.	250
7	framed raw data	One field of raw framed navigation data.	9AFE5354656C2053796E6368726F6E6963 69747920202020202020202020B0029E40*3F
8	*xx	Checksum	*42
9	[CR][LF]	Sentence terminator	[CR][LF]

FRMB

Format: Message ID = 54 Message byte count = variable

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer	bytes	8
2	Week number	4	integer	weeks	12
3	Seconds of week	8	double	seconds	16
4	PRN number	4	integer	1-999	24
5	Channel Tracking Status (see Table 5-1, page 65)	4	integer	n/a	28
6	Number of Bits	4	integer	250 for WAAS 300 for GPS 85 for GLONASS	32
7	Data Sub-frame	variable	char	N/A	36

FRWA/B Framed Raw Navigation Words *B*

This message contains the raw framed navigation words. An individual message is sent for each PRN being tracked. The message is updated with each new word, therefore it is best to log the data with the 'onnew' trigger activated.

FRWA

Structure:

$FRWA	week	seconds	prn	cstatus	# of bits	framed raw data
*xx	[CR][LF]					

Field	Data	Example	Data Description
1	header	$FRWA	ASCII log header
2	week	845	GPS week number
3	seconds	238626.672	GPS Seconds into the week first bit of word received
4	PRN	16	PRN number of satellite data is from
5	channel status	80811F14	Channel tracking status of channel tracking this satellite
6	nav word	FEEFF00F	2 bits of previous word + 30 bits of new nav word

FRWB

Field	Data	Bytes	Format	Offset
1	header	12	bytes	0
2	week	4	integer	12
3	seconds	8	double	16
4	PRN	4	integer	24
5	channel status	4	integer	28
6	2+30 bit word	4	integer	32

Example:

```
$FRWA,0,28.982,19,EB4,C016FBBE*45
```

NOTES:

- Each log will contain a new 30 bit nav word (in the least significant 30 bits), plus the last 2 bits of the previous word (in the most significant 2 bits). The 30 bit nav word contains 24 bits of data plus 6 bits of parity.
- The time stamp is the GPS time that the first bit of the 30 bit nav word was received. Only navigation data that passes parity checking will appear in this log.
- One log will appear for each PRN tracking every 0.6 seconds if logged ONNEW or ONCHANGED.
- Both ASCII and binary versions will be provided ($FRWA, $FRWB), but they will not be supported by NovAtel's convert utility.

GGAB Global Position System Fix Data (Binary Format) *B (R)*

Time, position and fix-related data of the GPS receiver. This binary log is a replica of the NMEA GPGGA ASCII log expressed in binary format with NovAtel header added.

Format: Message ID = 27 Message byte count = 80

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer	bytes	8
2	UTC time of position	8	double	hhmmss.ss	12
3	Latitude (DDmm.mm) (+ is North, - is South)	8	double	degrees	20
4	Longitude (DDDmm.mm) (+ is East, - is West)	8	double	degrees	28
5	Fix status 0 = fix not available or invalid 1 = GPS fix 2 = DifferentialGPS fix †	4	integer		36
6	Number of satellites in use. May be different to the number in view	4	integer		40
7	Horizontal dilution of precision	8	double		44
8	Antenna altitude above/below mean-sea-level (geoid)	8	double	metres	52
9	Geoidal separation	8	double	metres	60
10	Age of Differential GPS data † ††	8	double	seconds	68
11	Differential reference station ID, 0000-1023 †	4	integer		76

† Fields 5, 10, and 11 will not report this data unless the GPSCard has the (R) option.

†† The maximum age reported here is limited to 99 seconds.

MKPA/B Mark Position *B*

This log contains the estimated position of the antenna at detected mark impulse. It uses the last valid position and velocities to extrapolate the position at time of mark. Refer to the *"GPSCard Installation and Operating Manual Appendix"* for Mark Input pulse specifications. The latched time of mark impulse is in GPS weeks and seconds into the week. The resolution of the latched time is 49 nsec.

MKPA

Structure:

```
$MKPA | week | seconds | lat | lon | hgt | undulation | datum ID | lat std | lon std | hgt std
sol status | *xx | [CR][LF]
```

Field #	Field type	Data Description	Example
1	$MKPA	Log header	$MKPA
2	week	GPS week number	653
3	seconds	GPS seconds into the week measured from the receiver clock, coincident with the time of electrical closure on the Mark Input port.	338214.773382376
4	lat	Latitude of position in current datum, in degrees/decimal degrees (DD.dddddddd), where a negative sign implies South latitude	51.11227014
5	lon	Longitude of position in current datum, in degrees/decimal degrees (DDD.dddddddd), where a negative sign implies West longitude	-114.03907552
6	hgt	Height of position in current datum, in metres above MSL	1003.799
7	undulation	Geoid undulation, in metres	-16.199
8	datum ID	Current datum (see Table A-2, page 166) I.D. #	61
9	lat std	Standard deviation of latitude solution element, in metres	7.793
10	lon std	Standard deviation of longitude solution element, in metres	3.223
11	hgt std	Standard deviation of height solution element, in metres	34.509
12	sol status	Solution status as listed in Table 5-2, page 65	0
13	*xx	Checksum	*3C
14	[CR][LF]	Sentence terminator	[CR][LF]

Example:

```
$MKPA,653,338214.773382376,51.11227014,-114.03907552,1003.799,-16.199,61,
7.793,3.223,34.509,0*3C[CR][LF]
```

MKPB

Format: Message ID = 05 Message byte count = 88

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer	bytes	8
2	Week number	4	integer	weeks	12
3	Seconds of week	8	double	seconds	16
4	Latitude	8	double	degrees (+ is North, - is South)	24
5	Longitude	8	double	degrees (+ is East, - is West)	32
6	Height	8	double	metres above MSL	40
7	Undulation	8	double	metres	48
8	Datum ID	4	integer	see Table A-2, page 166	56
9	StdDev of latitude	8	double	metres	60
10	StdDev of longitude	8	double	metres	68
11	StdDev of height	8	double	metres	76
12	Solution status	4	integer	see Table 5-2, page 65	84

MKTA/B Time of Mark Input *B*

This log contains the time of the detected Mark Input pulse leading edge as detected at the Mark Input I/O port. The resolution of this measurement is 49 ns. Refer to the "*GPSCard Installation and Operating Manual Appendix*" for the Mark Input pulse specifications.

MKTA

Structure:

```
$MKTA | week | seconds | offset | offset std | utc offset | cm status | *xx | [CR][LF]
```

Field #	Field type	Data Description	Example
1	$MKTA	Log header	$MKTA
2	week	GPS week number	653
3	seconds	Seconds into the week as measured from the receiver clock, coincident with the time of electrical closure on the Mark Input port.	338214.773382376
4	offset	Receiver clock offset, in seconds. A positive offset implies that the receiver clock is ahead of GPS Time. To derive GPS time, use the following formula: GPS time = receiver time – (offset)	0.000504070
5	offset std	Standard deviation of receiver clock offset, in seconds	0.000000013
6	utc offset	This field represents the offset of GPS time from UTC time, computed using almanac parameters. To reconstruct UTC time, algebraically subtract this correction from field 3 above (GPS seconds). UTC time = GPS time – (utc offset)	-8.000000000
7	cm status	Receiver Clock Model Status where 0 is valid and values from -20 to -1 imply that the model is in the process of stabilization	0
8	*xx	Checksum	*05
9	[CR][LF]	Sentence terminator	[CR][LF]

Example:

```
$MKTA,653,338214.773382376,0.000504070,0.000000013,-8.000000000,0 *05[CR][LF]
```

MKTB

Format: Message ID = 04 Message byte count = 52

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer	bytes	8
2	Week number	4	integer	weeks	12
3	Seconds of week	8	double	seconds	16
4	Clock offset	8	double	seconds	24
5	StdDev clock offset	8	double	seconds	32
6	UTC offset	8	double	seconds	40
7	Clock model status	4	integer	0 = good, -1 to -20 = bad	48

NAVA/B Waypoint Navigation Data *B*

This log reports the status of your waypoint navigation progress. It is used in conjunction with the SETNAV command.

REMEMBER: The setnav command must be enabled before valid data will be reported from this log.

NAVA

Structure:

```
$NAVA  week  seconds  distance  bearing  distance  xtrack  etaw  etas
nav status  sol status  *xx  [CR][LF]
```

Field #	Field type	Data Description	Example
1	$NAVA	Log header	$NAVA
2	week	GPS week number	640
3	seconds	GPS seconds into the week	333115.00
4	distance	Straight line horizontal distance from current position to the destination waypoint, in metres (see SETNAV command, Chapter *2*; Figure 2-6, page 46*)*	6399.6305
5	bearing	Direction from the current position to the destination waypoint in degrees with respect to True North (or Magnetic if corrected for magnetic variation by MAGVAR command)	88.017
6	distance	Horizontal track distance from the current position to the closest point on the waypoint arrival perpendicular; expressed in metres	6396.9734
7	xtrack	The horizontal distance (perpendicular track-error) from the vessel's present position to the closest point on the great circle line that joins the FROM and TO waypoints. If a "track offset" has been entered in the SETNAV command, xtrack will be the perpendicular error from the "offset track". Xtrack is expressed in metres. Positive values indicate the current position is right of the Track, while negative offset values indicate left.	184.3929
8	etaw	Estimated GPS week number at time of arrival at the "TO" waypoint along-track arrival perpendicular based on current position and speed, in units of GPS weeks. If the receiving antenna is moving at a speed of less than 0.1 m/sec in the direction of the destination, the value in this field will be "9999".	657
9	etas	Estimated GPS seconds into week at time of arrival at destination waypoint along-track arrival perpendicular, based on current position and speed, in units of GPS seconds into the week. If the receiving antenna is moving at a speed of less than 0.1 m/sec in the direction of the destination, the value in this field will be "0.000".	51514.000
10	nav status	Navigation data status, where 0 = good, 1 = no velocity, and 2 = bad navigation calculation	0
11	sol status	Solution status as listed in Table 5-2, page 65	1
12	*xx	Checksum	*11
13	[CR][LF]	Sentence terminator	[CR][LF]

Example:

```
$NAVA,640,333115.00,6399.6305,88.017,6396.9734,184.3929,657,51514.000,0,1
*11[CR][LF]
```

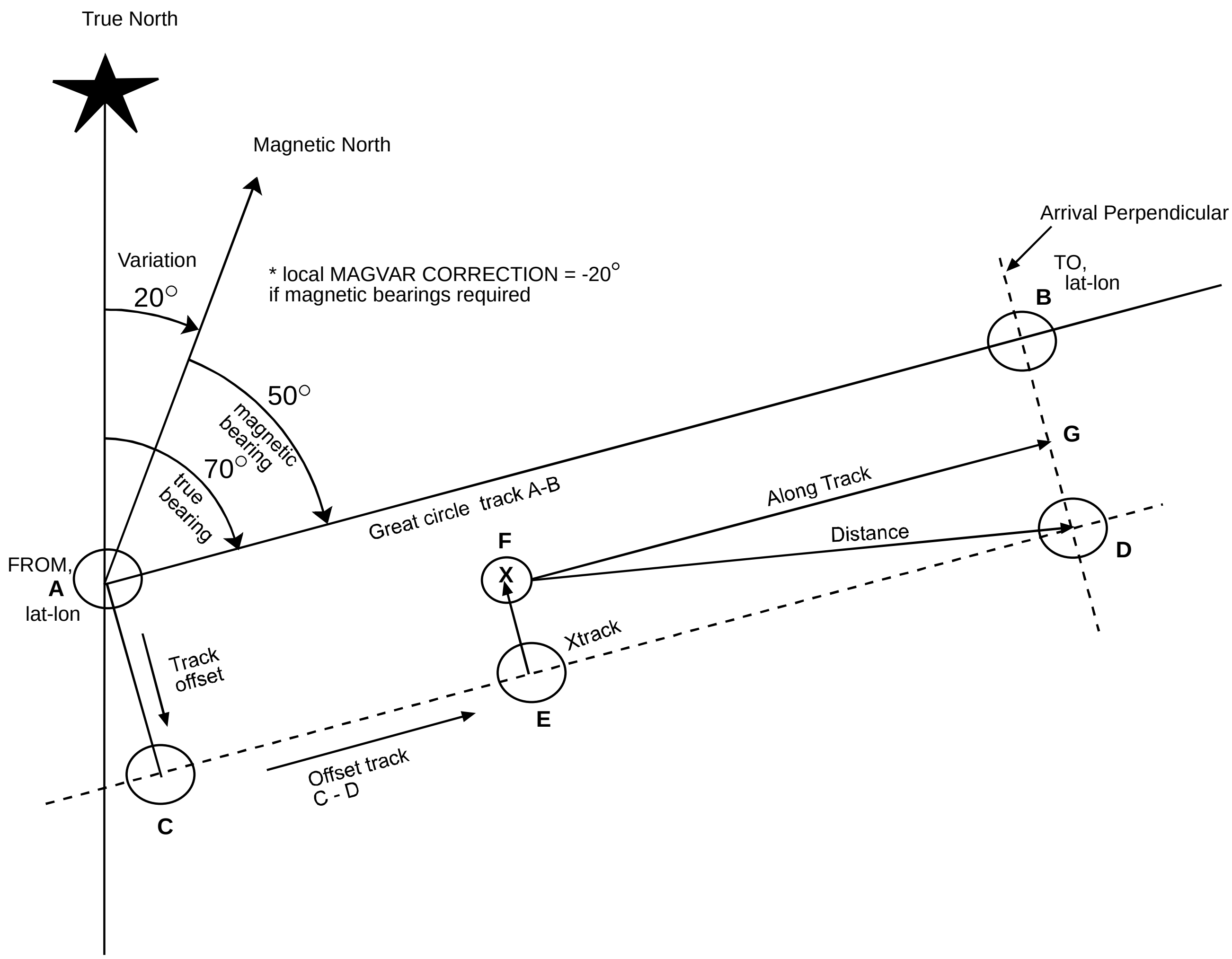
NOTE: All distances and angles are calculated using Vincenty's long line geodetic equations that operate on the currently selected user datum.

NAVB

Format: Message ID = 08 Message byte count = 76

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer	bytes	8
2	Week number	4	integer	weeks	12
3	Seconds of week	8	double	seconds	16
4	Distance	8	double	metres	24
5	Bearing	8	double	degrees	32
6	Along track	8	double	metres	40
7	Xtrack	8	double	metres	48
8	ETA week	4	integer	weeks	56
9	ETA seconds	8	double	seconds	60
10	NAV status where 0 = good, 1 = no velocity, 2 = bad navigation	4	integer		68
11	Solution status	4	integer	see Table 5-2, page 65	72

Figure 5-1 Example of Navigation Parameters



A	=	FROM lat-lon
B	=	TO lat-lon
AB	=	Great circle line drawn between FROM A lat-lon and TO B lat-lon
AC	=	Track offset from A to C
BD	=	Track offset from B to D
CD	=	Offset track to steer (parallel to AB)
F	=	Current GPS position
FD	=	Current distance and bearing from F to D
E	=	Xtrack perpendicular reference point
EF	=	Xtrack error from E to F (perpendicular to CD)
FG	=	Along track from F to G (perpendicular to BD)

AB	–	True bearing	=	70°
AB	–	Magnetic bearing	=	True + (MAGVAR correction)
			=	70° + (-20)
			=	50°

P20A/B Computed Position – Best Available

B (R) (RT20)

This log contains the best available position computed by the receiver, along with three status flags. In addition, it reports other status indicators, including differential lag, which is useful in predicting anomalous behavior brought about by outages in differential corrections. GPSCards with the RT-20 option are limited to a maximum logging rate of 5 Hz.

P20A

Structure:

```
$P20A | week | seconds | diff lag | # sats | lat | lon | hgt | undulation | datum ID | lat std
lon std | hgt std | sol status | rt20 status | fix stat | % idle | stn ID | *xx | [CR][LF]
```

Field #	Field type	Data Description	Example
1	$P20A	Log header	$P20A
2	week	GPS week number	779
3	seconds	GPS seconds into the week	237330.00
4	diff lag †	Age of differential correction (seconds) (= 0 if fix status - 2)	2.000
5	# sats	Number of satellites in use (00-12). May be different to the number in view.	9
6	lat	Latitude of position in current datum, in degrees (DD.dddddddd). A negative sign implies South latitude.	51.11411139
7	lon	Longitude of position in current datum, in degrees (DDD.dddddddd). A negative sign implies West longitude	-114.04302698
8	hgt	Height of position in current datum, in metres above mean sea level (MSL) (see Figure 5-2, page 79)	1058.566
9	undulation	Geoidal separation, in metres, where positive is above spheroid and negative is below spheroid	-16.263
10	datum ID	Current datum ID # (see Table A-2, page 166)	61
11	lat std	Standard deviation of latitude solution element, in metres	0.016
12	lon std	Standard deviation of longitude solution element, in metres	0.016
13	hgt std	Standard deviation of height solution element, in metres	0.016
14	sol status	Solution status as listed in Table 5-2, page 65	0
15	rt20 status††	RT20 status as listed in Table 5-4 RTK Status for Position Type 3 (RT-20)	0
16	fix stat	Fix status indicator 0 =fix not available or invalid 1 =single point 2 =differential fix †	2
17	% idle	An integer number representing percent idle time for the CPU, with a valid range of 0 to 99. (System performance degrades when idle time is < 10%.)	7
18	stn ID †	Differential reference station ID, 0000-1023	200
19	*xx	Checksum	*16
20	[CR][LF]	Sentence terminator	[CR][LF]

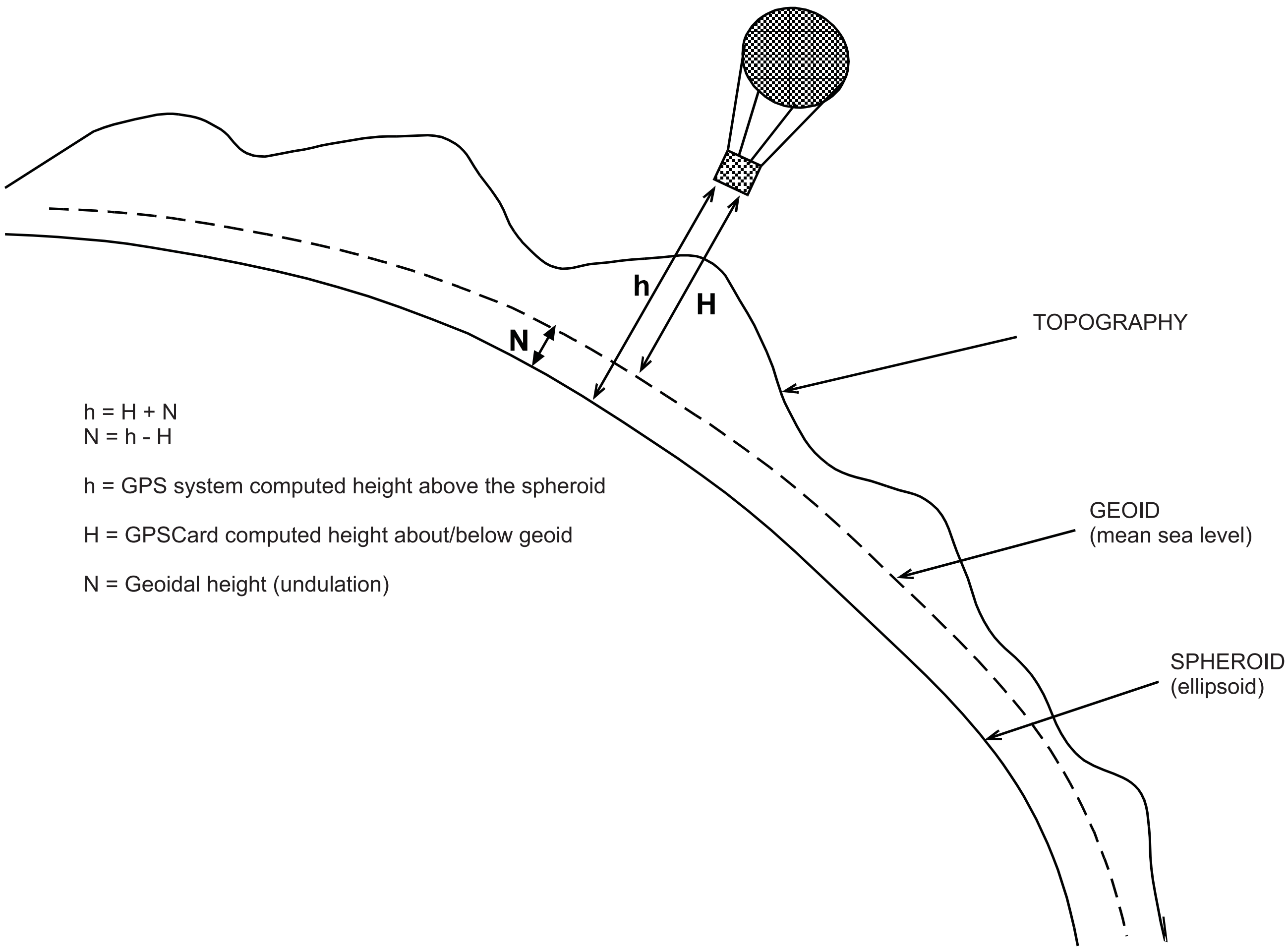
† Fields 4, 16 and 18 will not report differential data unless the GPSCard has the “R” option.

†† Field 15 will always report an “8” unless the GPSCard has the “RT-20” option.

Example:

```
$P20A,779,237330.00,2.000,9,51.11411139,-114.04302698,1058.566,-16.263,61,
0.016,0.016,0.016,0,0,2,7,200*16[CR][LF]
```

Figure 5-2 Illustration of GPSCard Height Measurements



P20B

Format: Message ID = 37 Message byte count = 116

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer	bytes	8
2	Week number	4	integer	weeks	12
3	Seconds of week	8	double	seconds	16
4	Differential lag †	8	double	seconds	24
5	Number of sats in solution	4	integer		32
6	Latitude	8	double	degrees (+ is North, - is South)	36
7	Longitude	8	double	degrees (+ is East, - is West)	44
8	Height	8	double	metres with respect to MSL	52
9	Undulation	8	double	metres	60
10	Datum ID	4	integer	see Table A-2, page 166	68
11	StdDev of latitude	8	double	metres	72
12	StdDev of longitude	8	double	metres	80
13	StdDev of height	8	double	metres	88
14	Solution status	4	integer	see Table 5-2, page 65	96
15	RT20 status ††	4	integer	see Table 5-4, page 66	100
16	Fix status indicator 0 = fix not available or invalid 1 = single point 2 = differential fix †	4	integer		104
17	CPU idle time	4	integer	percent	108
18	Reference station ID †	4	integer		112

PAVA/B Position Averaging Status *B*

These logs are meant to be used in conjunction with the posave command. If the posave command has not been issued, all fields in the PAVA/B logs except week and seconds will be zero. However, when position averaging is underway, the various fields contain the parameters being used in the position averaging process. The log trigger onchanged is recommended, but ontime can also be used.

See the description of the POSAVE command, page 39.

NOTE: All quantities are referenced to the WGS84 ellipsoid, regardless of the use of the datum or userdatum commands, except for the height parameter (field 6). The relation between the geoid and the WGS84 ellipsoid is the geoidal undulation, and can be obtained from the POSA/B logs.

PAVA

Structure :

$PAVA	week	seconds	lat	lng	hgt	sdlat	sdlng
sdhgt	time	samples	*xx	[CR][LF]			

Field #	Field type	Data Description	Example
1	$PAVA	Log header	$PAVA
2	week	GPS week number	846
3	seconds	GPS seconds into the week	145872.00
4	lat	Average WGS84 latitude (degrees)	51.11381167
5	lng	Average WGS84 longitude (degrees)	-114.04356455
6	hgt	Average height above sea level, or geoid (m)	1068.100
7	sdlat	Estimated standard deviation of the average latitude (m)	26.2
8	sdlng	Estimated standard deviation of the average longitude (m)	12.1
9	sdhgt	Estimated standard deviation of the average height (m)	54.9
10	time	Elapsed time of averaging (s)	7
11	samples	Number of samples in the average	1
12	*xx	Checksum	*0C
13	[CR][LF]	Sentence terminator	[CR][LF]

Example:

```
$PAVA,846,145872.00,51.11381167,-
114.04356455,1068.100,26.2,12.1,54.9,7,1*0C [CR][LF]
```

PAVB

Format: Message ID = 50 Message byte count = 80

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer		8
2	GPS week number	4	integer	weeks	12
3	GPS seconds into the week	8	double	seconds	16
4	Average WGS84 latitude	8	double	degrees	24
5	Average WGS84 longitude	8	double	degrees	32
6	Average height above sea level	8	double	meters	40
7	Estimated standard deviation of the average latitude	8	double	meters	48
8	Estimated standard deviation of the average longitude	8	double	meters	56
9	Estimated standard deviation of the average height	8	double	meters	64
10	Elapsed time of averaging	4	integer	seconds	72
11	Number of samples in the average	4	integer		76

POSA/B Computed Position *B*

This log will contain the last valid position and time calculated referenced to the GPSAntenna phase center. The position is in geographic coordinates in degrees based on your specified datum (default is WGS-84). The height is referenced to mean sea level. The receiver time is in GPS weeks and seconds into the week. The estimated standard deviations of the solution and current filter status are also included.

POSA

Structure:

```
$POSA | week | seconds | lat | lon | hgt | undulation | datum ID | lat std | lon std
hgt std | sol status | *xx | [CR][LF]
```

Field #	Field type	Data Description	Example
1	$POSA	Log header	$POSA
2	week	GPS week number	637
3	seconds	GPS seconds into the week	511251.00
4	lat	Latitude of position in current datum, in degrees (DD.dddddddd). A negative sign implies South latitude	51.11161847
5	lon	Longitude of position in current datum, in degrees (DDD.dddddddd). A negative sign implies West longitude	-114.03922149
6	hgt	Height of position in current datum, in metres above mean sea level (MSL) (see Figure 5-2, page 79)	1072.436
7	undulation	Geoidal separation, in metres, where positive is above spheroid and negative is below spheroid	-16.198
8	datum ID	Current datum ID # (see Table A-2, page 166)	61
9	lat std	Standard deviation of latitude solution element, in metres	26.636
10	lon std	Standard deviation of longitude solution element, in metres	6.758
11	hgt std	Standard deviation of height solution element, in metres	78.459
12	sol status	Solution status as listed in Table 5-2, page 65	0
13	*xx	Checksum	*12
14	[CR][LF]	Sentence terminator	[CR][LF]

Example:

```
$POSA,637,511251.00,51.11161847,-114.03922149,1072.436,-16.198,61,26.636,
6.758,78.459,0*12[CR][LF]
```

POSB

Format: Message ID = 01 Message byte count = 88

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer	bytes	8
2	Week number	4	integer	weeks	12
3	Seconds of week	8	double	seconds	16
4	Latitude	8	double	degrees (+ is North, - is South)	24
5	Longitude	8	double	degrees (+ is East, - is West)	32
6	Height	8	double	metres with respect to MSL	40
7	Undulation	8	double	metres	48
8	Datum ID	4	integer	see Table A-2, page 166	56
9	StdDev of latitude	8	double	metres	60
10	StdDev of longitude	8	double	metres	68
11	StdDev of height	8	double	metres	76
12	Solution status	4	integer	see Table 5-2, page 65	84

PRTKA/B Computed Position *(RTK)*

This log contains the best available position computed by the receiver, along with three status flags. In addition, it reports other status indicators, including differential lag, which is useful in predicting anomalous behavior brought about by outages in differential corrections.

This log replaces the P20A log; it is similar, but adds extended status information. With the system operating in an RTK mode, this log will reflect the latest low-latency solution for up to 30 seconds after reception of the last reference station observations. After this 30 second period, the position reverts to the best solution available; the degradation in accuracy is reflected in the standard deviation fields, and is summarized in Table 10-3, page **Error! Bookmark not defined.**. If the system is not operating in an RTK mode, pseudorange differential solutions continue for 60 seconds after loss of the data link, though a different value can be set using the dgpstimeout command.

PRTKA

Structure:

$PRTKA	week	sec	lag	#sv	#high	L1L2 #high	lat
lon	hgt	undulation	datum ID	lat s	lon s	hgt s	soln status
rtk status	posn type	idle	stn ID	*xx	[CR][LF]		

Field #	Field type	Data Description	Example
1	$PRTKA	Log header	$PRTKA
2	week	GPS week number	872
3	sec	GPS time into the week (in seconds)	174963.00
4	lag	Differential lag in seconds	1.000
5	#sv	Number of matched satellites; may differ from the number in view.	8
6	#high	Number of matched satellites above RTK mask angle; observations from satellites below mask are heavily de-weighted	7
7	L1L2 #high	Unused, will report 0	0
8	lat	Latitude of position in current datum, in decimal fraction format. A negative sign implies South latitude	51.11358042429
9	lon	Longitude of position in current datum, in decimal fraction format. A negative sign implies West longitude	-114.04358006710
10	hgt	Height of position in current datum, in meters above mean sea level	1059.4105
11	undulation	Geoidal separation, in meters, where(+ve) is above ellipsoid and (-ve) is below ellipsoid	-16.2617
12	datum ID	Current datum (See Appendix A, page 166)	61
13	lat s	Standard deviation of latitude solution element, in meters	0.0096
14	lon s	Standard deviation of longitude solution element, in meters	0.0100
15	hgt s	Standard deviation of height solution element, in meters	0.0112
16	soln status	Solution status (see Table 5-2, page 65)	0
17	rtk status	RTK status (see Table 5-3, page 66)	0
18	posn type	Position type (see Table 5-3, page 66)	4
19	idle	Percent idle time, percentage	42
20	stn ID	Reference station identification (RTCM: 0 - 1023, or RTCA: 266305 - 15179385)	119
21	*xx	Checksum	*51
22	[CR][LF]	Sentence terminator	[CR][LF]

Example:

```
$PRTKA,872,174963.00,1.000,8,7,0,51.11358042429,
-114.04358006710,1059.4105,
-16.2617,61,0.0096,0.0100,0.0112,0,0,4,42,119*51[CR][LF]
```

PRTKB

Format:

```
Message ID = 63  Message byte count = 124
```

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer		8
2	Week number	4	integer	weeks	12
3	GPS time into the week	8	double	seconds	16
4	Differential lag	8		seconds	24
5	Number of matched satellites (00-12)	4	integer		32
6	Number of matched satellites above RTK mask angle	4	integer		36
7	Unused, will report 0	4	integer		40
8	Latitude	8	double	degrees	44
9	Longitude	8	double	degrees	52
10	Height above mean sea level	8	double	meters	60
11	Undulation	8	double	meters	68
12	Datum ID	4	integer		76
13	Standard deviation of latitude	8	double	meters	80
14	Standard deviation of longitude	8	double	meters	88
15	Standard deviation of height	8	double	meters	96
16	Solution status (see Table 5-2, page 65)	4	integer		104
17	RTK status (see Table 5-4, page 66)	4	integer		108
18	Position type (see Table 5-3, page 66)	4	integer		112
19	Idle	4	integer		116
20	Reference station identification (RTCM: 0 - 1023, or RTCA: 266305 - 15179385)	4	integer		120

PXYA/B Computed Cartesian Coordinate Position *B (R)*

This log contains the last valid position, expressed in Cartesian x-y-z space coordinates, relative to the center of the Earth. The positions expressed in this log are always relative to WGS-84 regardless of the setting of the DATUM or USERDATUM command. Refer to Figure 5-3, page 108, for a definition of the coordinates.

PXYA

Structure:

```
$PXYA week seconds x y z x std y std z std sol status fix status
diff lag *xx [CR][LF]
```

Field #	Field type	Data Description	Example
1	$PXYA	Log header	$PXYA
2	week	GPS week number	713
3	seconds	GPS seconds into the week	488150.00
4	x	Position x coordinate, in metres	-1634756.995
5	y	Position y coordinate, in metres	-3664965.028
6	z	Position z coordinate, in metres	4942151.391
7	x std	Standard deviation of x, in metres	2.335
8	y std	Standard deviation of y, in metres	3.464
9	z std	Standard deviation of z, in metres	4.156
10	sol status	Solution status as listed in *Table 5-2*	0
11	fix status	0 = fix not available or invalid 1 = Single point standalone fix 2 = Differential fix † (only available with the "R" option)	2
12	diff lag †	Age of differential correction (seconds) (= 0 if fix status - 2)	0.4
13	*xx	Checksum	*08
14	[CR][LF]	Sentence terminator	[CR][LF]

† This log provides differential fix and lag status. The GPSCard must have the "R" option before fields 11 and 12 will report differential status.

Example:

```
$PXYA,713,488150.00,-1634756.995,-3664965.028,4942151.391,2.335,3.464,
4.156,0,2,0.4*08[CR][LF]
```

PXYB

Format: Message ID = 26 Message byte count = 88

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer	bytes	8
2	Week number	4	integer	weeks	12
3	Seconds of week	8	double	seconds	16
4	x	8	double	metres	24
5	y	8	double	metres	32
6	z	8	double	metres	40
7	StdDev of x	8	double	metres	48
8	StdDev of y	8	double	metres	56
9	StdDev of z	8	double	metres	64
10	Solution status	4	integer	see Table 5-2, page 65	72
11	Fix status †	4	integer		76
12	Differential lag, age of differential corrections †	8	double	seconds	80

RALA/B Raw Almanac *B*

Almanac and health data are contained in subframes four and five of the satellite broadcast message. Subframe four contains information for SVs 25-32, as well as ionospheric, UTC and SV configuration data. Subframe five contains information for SVS 1-24.

Subframes four and five each contain 25 pages of data, and each page contains ten 30-bit words of information as transmitted from the satellite. The RALA/B log outputs this information with parity bits checked and removed (ten words - 24 bits each). The log will not be generated unless all ten words pass parity.

This log will alternately report each page from subframes four and five as they are collected. Logging this log onnew would be the optimal logging rate to capture data from pages in subframes four and five as they are received.

RALA logs contain a hex representation of the raw almanac data (one of the possible 25 pages of either subframe 4 or 5). RALB contains the raw binary information.

RALA

Structure:

$RALA	chan #	prn	subframe	*xx	[CR][LF]

Field #	Field type	Data Description	Example
1	$RALA	Log header	$RALA
2	chan #	Channel number collecting almanac data (0-11)	7
3	prn	PRN of satellite from which data originated	16
4	subframe	Subframe 4 or 5 of almanac data (60 hex characters)	8B0A54852C964C661F086366FDBE00A 10D53DA6565F2503DD7C2AACBFED3
5	*xx	Checksum	*05
6	[CR][LF]	Sentence terminator	[CR][LF]

Example:

```
$RALA,7,16,8B0A54852C964C661F086366FDBE00A10D53DA6565F2503DD7C2AACBFED3
*05[CR][LF]
```

RALB

Format: Message ID = 15 Message byte count = 52

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer	bytes	8
2	Channel number	4	integer	0-11	12
3	PRN number	4	integer	1-32	16
4	Almanac data	30	char	data [30]	20
5	Filler bytes	2	char		50

RCCA Receiver Configuration *B*

This log outputs a list of all current GPSCard command settings. Observing this log is a good way to monitor the GPSCard configuration settings. See Chapter 2, page 17, for the RCCA default list.

RCCA

Example:

```
$RCCA,COM1,9600,N,8,1,XON,OFF*11
$RCCA,COM2,9600,N,8,1,N,OFF*05
$RCCA,COM1_DTR,HIGH*70
$RCCA,COM2_DTR,HIGH*73
$RCCA,COM1_RTS,HIGH*67
$RCCA,COM2_RTS,HIGH*64
$RCCA,UNDULATION,TABLE*56
$RCCA,DATUM,WGS84*15
$RCCA,USERDATUM,6378137.000,298.257223563,0.000,0.000,0.000,0.000,0.000,0.000,
      0.000*6A
$RCCA,SETNAV,DISABLE*5C
$RCCA,MAGVAR,0.000*33
$RCCA,DYNAMICS,HIGH*1B
$RCCA,UNASSIGNALL*64
$RCCA,ACCEPT,COM1,COMMANDS*5B
$RCCA,ACCEPT,COM2,COMMANDS*58
$RCCA,UNLOCKOUTALL*20
$RCCA,RESETHEALTHALL*37
$RCCA,UNFIX*73
$RCCA,RTCMRULE,6CR*32
$RCCA,RTCM16T,*48
$RCCA,CSMOOTH,20.00*7E
$RCCA,ECUTOFF,0.00*45
$RCCA,FREQUENCY_OUT,DISABLE*12
$RCCA,CLOCKADJUST,ENABLE*47
$RCCA,MESSAGES,ALL,ON*67
$RCCA,SETCHAN,12*56
$RCCA,DGPSTIMEOUT,60,120*51
$RCCA,SETDGPSID,ALL*1D
$RCCA,LOG,COM2,POSA,ONTIME,5.00,0.00*3D
```

RCSA/B Receiver Status *B*

The RCSA log will always output four records: one for VERSION, one for receiver CHANNELS, one for receiver CPU IDLE time, and one indicating receiver self-test STATUS. However, RCSB will embed the same information in a single record.

RCSA

Structure:

$RCSA	VERSION	sw ver	*xx	[CR][LF]
$RCSA	CHANNELS	# chans	*xx	[CR][LF]
$RCSA	IDLE	idle time	*xx	[CR][LF]
$RCSA	STATUS	rec status	*xx	[CR][LF]

Log	Data Identifier	Data Description		Checksum	String End
$RCSA	VERSION	sw ver:	.Software information indicating model, S/N, S/W version and S/W version date	*xx	[CR][LF]
$RCSA	CHANNELS	# chans:	Indicates number of parallel channels on GPSCard	*xx	[CR][LF]
$RCSA	IDLE	idle time:	An integer number representing percent idle time for the CPU, with a valid range of 0 to 99	*xx	[CR][LF]
$RCSA	STATUS	rec status:	Indicates result of hardware self-test and software status as shown in *Table 5-4*	*xx	[CR][LF]

Example:

```
$RCSA,VERSION,GPSCard-2 3951R LGR94160001 HW 16 SW 3.15 Mar 31/94*16
$RCSA,CHANNELS,10*12
$RCSA,IDLE,40*03
$RCSA,STATUS,000007F6*60
```

The status code is a hexadecimal number representing the results of the GPSCard BIST test and software status. As an example, the status code '000000F6' indicates that the GPSAntenna is not working properly or is disconnected and the GPSCard is good, while '000000F7' indicates that the GPSAntenna and the GPSCard are both functioning properly.

Refer to Table 5-4, page 66, for a detailed description of the status code. Bit 0 is the least significant bit of the status code and Bit 16 is the most significant bit.

RCSB

Format: Message ID = 13 Message byte count = 100

Data	Bytes	Format	Units	Offset
Sync	3	char		0
Checksum	1	char		3
Message ID	4	integer		4
Message byte count	4	integer	bytes	8
Software version #	80	char	ASCII	12
Number of receiver channels	1	char		92
CPU idle time	1	char	percent	93
Filler	2	bytes		94
Self-test status	4	integer	See Table 5-5, page 90	96

Table 5-5 GPSCard Receiver Self-test Status Codes

Nibble Number	Bit	Description	Range Values	Hex Value
N 0	lsb = 0	ANTENNA	1 = good, 0 = bad	00000001
N 0	1	PRIMARY PLL	1 = good, 0 = bad	00000002
N 0	2	RAM	1 = good, 0 = bad	00000004
N 0	3	ROM	1 = good, 0 = bad	00000008
N 1	4	DSP	1 = good, 0 = bad	00000010
N 1	5	PRIMARY AGC	1 = good, 0 = bad	00000020
N 1	6	COM 1	1 = good, 0 = bad	00000040
N 1	7	COM 2	1 = good, 0 = bad	00000080
N 2	8	WEEK	1 = not set, 0 = set	00000100
N 2	9	NO COARSETIME	1 = not set, 0 = set	00000200
N 2	10	NO FINETIME	1 = not set, 0 = set	00000400
N 2	11	PRIMARY JAMMER	1 = present, 0 = normal	00000800
N 3	12	BUFFER COM 1	1 = overrun, 0 = normal	00001000
N 3	13	BUFFER COM 2	1 = overrun, 0 = normal	00002000
N 3	14	BUFFER CONSOLE	1 = overrun, 0 = normal	00004000
N 3	15	CPU OVERLOAD	1 = overload, 0 = normal	00008000
N 4	16	ALMANAC SAVED IN NVM	1 = yes, 0 = no	00010000
N 4	17	RESERVED		
N 4	18	RESERVED		
N 4	19	RESERVED		
N 5	20	RESERVED		
N 5	21	RESERVED		
N 5	22	RESERVED		
N 5	23	RESERVED		
N 6	24	RESERVED		
N 6	25	RESERVED		
N 6	26	RESERVED		
N 6	27	RESERVED		
N 7	28	RESERVED		
N 7	29	RESERVED		
N 7	30	RESERVED		
N 7	31	RESERVED		

NOTE: Self-test bits 2, 3, 4, 6, 7 are set only once when the GPSCard is first powered up. All other bits are set by internal test processes each time the RCSA/B log is output .

Receiver Status - Detailed Bit Descriptions of Self-Test

Bit 0 Antenna

1 This bit will be set good if the antenna is drawing the appropriate amount of current from the GPSCard antenna jack.

0 If the antenna connections are shorted together, open, not drawing appropriate current, or not connected to the antenna, then this bit will be clear (0) indicating a possible antenna port problem.

NOTE: If the user decides to use an alternate antenna not meeting the GPSCard power requirements or alternate power to the antenna using a DC block, then this bit will set to 0 because the GPSCard detects an abnormal condition at the antenna port. Providing that GPS signals are presented to the receiver, the GPSCard will operate normally. If you are using an OEM card, and have set the external LNA jumper plug (P3) to the external position, then self-test bit 0 will always be set to 1.

Bit 1 PLL

1 When the RF downconverter passes self-test, the bit will be set to 1.

0 If a fault is detected in the RF downconverter, this bit is set to 0.

Bit 2 RAM

1 When this bit is set to 1, the GPSCard RAM has passed the self-test requirements.

0 If the bit has been set to 0, then RAM test has failed and the GPSCard should be returned for service.

Bit 3 ROM

1 When this bit is set to 1, the GPSCard ROM test has passed the self-test requirements.

0 A zero bit indicates the GPSCard has failed the ROM test. (The GPSCard PC Series do not have built in ROM and therefore a clear bit for this test is **normal**.)

Bit 4 DSP

1 This bit will be set to 1 when the digital signal processors (DSP) have passed the self-test requirements.

0 If this bit is set to 0, one or both of the DSP chips has failed self-test and the GPSCard should be returned for service.

Bit 5 AGC

1 When set to 1, the AGC circuits are operating within normal range of control.

0 This bit will be set clear if the AGC is operating out of normal range. Intermittent setting of the AGC bit indicates that the card is experiencing some electro-magnetic interference of a very short duration. Continuous setting of the AGC bit may indicate that the card is receiving too much signal power from the antenna or that a more serious problem with the card may exist. Failure of this test could be the result of various possibilities, such as: bad antenna LNA, excessive loss in the antenna cable, faulty RF downconverter, or a pulsating or high power jamming signal causing interference. If this bit is continuously set clear, and you cannot identify an external cause for the failed test, please contact NovAtel Customer Service.

Bit 6 COM1

1 When set to 1, the COM1 UART has passed the self-test requirements.

0 If set to 0, the COM1 UART has failed self-test and cannot be used for reliable communications.

Bit 7 COM2

1 When set to 1, the COM2 UART has passed the self-test requirements.

0 If set to 0, the COM2 UART has failed self-test and cannot be used for reliable communications.

Bits 8, 9, 10 Time

0 These bits indicate the state of the receiver time and are set only once, generally in the first few minutes of operation, in the presence of adequate numbers of satellite signals to compute position and time.

1 If these bits are not all set to zero, then the observation data, pseudorange, carrier phase, and Doppler measurements may jump as the clock adjusts itself.

Bit 11 Jammer Detection

0 Normal operation is indicated when this bit is 0.

1 If set to 1, the receiver has detected a high power signal causing interference. When this happens, the receiver goes into a special anti-jamming mode where it re-maps the A/D decode values as well as special AGC feedback control. These adjustments help to minimize the loss that will occur in the presence of a jamming signal. You should monitor this bit, and if set to 1, do your best to remedy the cause of the jamming signal. Nearby transmitters or other electronic equipment could be the cause of interference; you may find it necessary to relocate your antenna position if the problem persists.

Bits 12, 13, 14 COM Buffers

0 Normal operation is indicated by a 0 value.

1 These bits are set to 1 to inform the user when any of the 8-Kbyte output buffers have reached an over-run condition (COM1, COM2, or the PC console if applicable). Over-run is caused by requesting more log data than can be taken off the GPSCard because of bit rate limitations or slow communications equipment. If this happens, the new data attempting to be loaded into the buffer will be discarded. The GPSCard will not load a partial data record into an output buffer.

Bit 15 CPU Overload

0 Normal operation is indicated by a 0 value.

1 A value of 1 indicates that the CPU is being over-taxed. Requesting an excessive amount of information from the GPSCard may cause this. If this condition is occurring, limit redundant data logging or change to using binary data output formats, or both.

You can attempt to tune the logging requirements to keep the idle time above 20% for best operation. If the average idle % drops below 10% for prolonged periods of time (2-5 seconds), critical errors may result in internal data loss and the over-load bit will be set to 1. You can monitor the CPU % idle time by using the RCSA log message.

As the amount of CPU power becomes limited, the software will begin to slow down the position calculation rate. If the CPU becomes further limited, the software will begin to skip range measurement processing. Priority processing goes to the tracking loops.

Bit 16 Almanac Saved

0 Almanac not saved in flash memory.

1 Almanac saved in flash memory (12 channel OEM cards only).

REPA/B Raw Ephemeris *B*

REPA

This log contains the raw Binary information for subframes one, two and three from the satellite with the parity information removed. Each subframe is 240 bits long (10 words – 24 bits each) and the log contains a total 720 bits (90 bytes) of information (240 bits x 3 subframes). The PRN number of the satellite from which it originated precedes this information. This message will not be generated unless all 10 words from all 3 frames have passed parity.

Ephemeris data whose toe (time of ephemeris) is older than six hours will not be shown.

Structure:

$REPA	prn	subframe1	subframe2	subframe3	*xx	[CR][LF]

Field #	Field type	Data Description	Example
1	$REPA	Log header	$REPA
2	prn	PRN of satellite from which data originated	14
3	subframe1	Subframe 1 of ephemeris data (60 hex characters)	8B09DC17B9079DD7007D5DE404A9B2D 04CF671C6036612560000021804FD
4	subframe2	Subframe 2 of ephemeris data (60 hex characters)	8B09DC17B98A66FF713092F12B359D FF7A0254088E1656A10BE2FF125655
5	subframe3	Subframe 3 of ephemeris data (60 hex characters)	8B09DC17B78F0027192056EAFFDF2724C 9FE159675A8B468FFA8D066F743
6	*xx	Checksum	*57
7	[CR][LF]	Sentence terminator	[CR][LF]

Example:

```
$REPA,14,8B09DC17B9079DD7007D5DE404A9B2D04CF671C6036612560000021804FD,
8B09DC17B98A66FF713092F12B359DFF7A0254088E1656A10BE2FF125655,
8B09DC17B78F0027192056EAFFDF2724C9FE159675A8B468FFA8D066F743*57[CR][LF]
```

REPB

Format: Message ID = 14 Message byte count = 108

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer	bytes	8
2	PRN number	4	integer	1-32	12
3-4-5	Ephemeris data	90	char	data [90]	16
	Filler bytes	2	char		106

RGEA/B/C/D Channel Range Measurements *51*

The RGEA/B message replaces the obsolete RNGA/B and RQGA/B logs. It is smaller than the RNGA/B message and outputs an improved channel status number that contains more information for the user. The RGEC/D messages are a compressed form of the RGEB message.When using these logs, please keep in mind the constraints noted along with the description.

It is important to ensure that the receiver clock has been set and can be monitored by the bits in the rec-status word. Large jumps in range as well as ADR will occur as the clock is being adjusted. If the ADR measurement is being used in precise phase processing it is important not to use the ADR if the "parity known" flag in the tr-status word is not set as there may exist a half (1/2) cycle ambiguity on the measurement. The tracking error estimate of the pseudorange and carrier phase (ADR) is the thermal noise of the receiver tracking loops only. It does not account for possible multipath errors or atmospheric delays.

RGEA

Structure:

```
$RGEA | week | seconds | # obs | rec status
prn | psr | psr std | adr | adr std | dopp | C/No | locktime | tr-status
:
prn | psr | psr std | adr | adr std | dopp | C/No | locktime | tr-status
*xx | [CR][LF]
```

Field #	Field type	Data Description	Example
1	$RGEA	Log header	$RGEA
2	week	GPS week number	663
3	seconds	GPS seconds into the week (receiver time, not corrected for clock error, CLOCKADJUST enabled)	247893.30
4	# obs	Number of satellite observations with information to follow	7
5	rec status	Receiver self-test status (cf. *Table 5-4*)	000040F6
6	prn	Satellite PRN number (1-32) of range measurement	26
7	psr	† Pseudorange measurement, in metres	23704623.130
8	psr std	† Pseudorange measurement standard deviation, in metres	0.148
9	adr	† Carrier phase, in cycles (accumulated Doppler range)	-124567967.330
10	adr std	† Estimated carrier phase standard deviation, in cycles	0.010
11	dopp	Instantaneous carrier Doppler frequency, in Hz	2659.351
12	C/N_0	Signal to noise density ratio, where $C/No = 10[\log_{10}(S/N_0)]$, in dBHz	43.0
13	locktime	Number of seconds of continuous tracking (no cycle slipping)	2693.370
14	tr-status	Hexadecimal number indicating phase lock, channel number and channel state as shown in Table 5-6, page **Error! Bookmark not defined.**	E04
15-23		Next PRN range measurement	
...		Next PRN range measurement	
variable	*xx	Checksum	*73
variable	[CR][LF]	Sentence terminator	[CR][LF]

† These fields are only valid with X51(R) and XX51(R) models.

This output will always be a hexadecimal representation that must be converted to a binary format.

Example:

```
$RGEA,747,238091.45,7,000000F6,
26,23704623.130,0.148,-124567967.330,0.010,2659.351,43.0,2693.370,E04,
16,24492422.112,0.234,-128707643.246,0.015,-2473.786,39.0,6803.360,E14,
27,19929152.742,0.076,-104727535.338,0.006,15.233,48.7,6790.780,E34,
2,21729907.530,0.084,-114191131.178,0.006,2219.321,47.9,5899.770,E54,
19,21063013.716,0.088,-110686797.802,0.007,-1989.666,47.5,6801.570,E74,
28,24457949.736,0.202,-128525991.915,0.013,-3214.007,40.2,6556.760,E84,
31,22049154.556,0.108,-115869177.391,0.008,-1877.032,45.7,6788.370,EA4*6E
```

RGEB

Format: Message ID = 32 Message byte count = 32 + (obs*44)

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer	bytes	8
2	Week number	4	integer	weeks	12
3	Seconds of week	8	double	seconds	16
4	Number of observations (obs)	4	integer		24
5	Receiver self-test status	4	integer	cf. *Table 5-4*	28
6	PRN	4	integer		32
7	† Pseudorange	8	double	metres	36
8	† StdDev pseudorange	4	float	metres	44
9	† Carrier phase (adr)	8	double	cycles	48
10	† StdDev accumulated Doppler	4	float	cycles	56
11	Doppler frequency	4	float	Hz	60
12	C/N_0	4	float	C/N_0=10*log(S/N_0)dBHz	64
13	Locktime	4	float	seconds	68
14	Tracking status	4	integer	see Table 5-6, page 95 ††	72
15...	Next PRN offset = 32 + (obs*44)				

† These fields are only valid with X51(R) and XX51(R) models.

†† The maximum channel, reported in the channel number field, is dependent on the GPSCard model type.

Table 5-6 GPSCard Tracking Status

Nibble Number: N 7 (bits 31–28), N 6 (27–24), N 5 (23–20), N 4 (19–16), N 3 (15–12), N 2 (11–8), N 1 (7–4), N 0 (3–0)

Bit	Description	Range Values	Hex.
lsb = 0	Tracking state	0 - 7 See below	1
1			2
2			4
3			8
4	Channel number	0 - n (0 = first, n = last) (n depends on GPSCard)	10
5			20
6			40
7			80
8			100
9	Phase lock flag	1 = Lock, 0 = Not locked	200
10	Parity known flag	1 = Known, 0 = Not known	400
11	Code locked flag	1 = Lock, 0 = Not locked	800
12	Reserved		1000
13			2000
14			4000
15	Reserved		8000
16			10000
17			20000
18	Reserved		40000
19	Grouping	1 = Grouped, 0 = Not grouped	80000
20	Frequency	1 = L2, 0 = L1	100000
21	Code type	0 = C/A 2 = P-codeless	200000
22		1 = P 3 = Reserved	400000
23	Reserved		800000
24 : 29	Reserved		
30	Reserved		
31	Reserved		

Table 5-6, Bits 0 -7: Channel Tracking State and Channel Number

State	Description	State	Description
0	Idle	4	Phase-lock loop
1	Sky search	5	Re-acquisition
2	Wide frequency band pull-in	6	Steering
3	Narrow frequency band pull-in	7	Frequency-lock loop

Higher numbers are reserved for future use

Example:

Offset (bytes)	Data (Hex) *															
00000000:	AA	44	11	43	20	00	00	00	AC	01	00	00	1A	03	00	00
00000016:	00	00	00	00	70	F5	0C	41	09	00	00	00	F6	00	00	00
00000032:	02	00	00	00	14	9B	C1	62	84	FD	77	41	BD	81	1B	3E
00000048:	46	AA	64	65	6D	84	9F	C1	3A	C5	24	3C	34	B7	55	45
00000064:	19	E4	2A	42	C3	95	D3	43	04	0E	00	00	... start of next record			

* Refer to Binary Log Structure, page 54, for details on binary log formats.

where :

Data Location (bytes offset)	Data	Description	Decoded Value
0 .. 2	AA 44 11	Sync	
3	43	Checksum	
4 .. 7	20000000	Message ID	32
8 .. 11	AC010000	Message byte count	428
12 ..15	1A030000	Week number	794
16 ..23	00000000 70F50C41	Seconds of week	237230.00
24 .. 27	09000000	Number of observations	9
28 ..31	F6000000	Receiver self-test status	000000F6
32 .. 35	02000000	PRN	2
36 .. 43	149BC162 84FD7741	Pseudorange	25155654.172
44 .. 47	ED811B3E	Std deviation pseudorange	0.152
48 .. 55	46AA6465 6D849FC1	Carrier phase (adr)	-132193113.348
56 .. 59	3AC5243C	Std deviation accumulated Doppler	0.010
60 .. 63	34B75545	Doppler frequency	3419.450
64 .. 67	19E42A42	C/N_0	42.7
68 .. 71	C395D343	Locktime	423.170
72 .. 75	040E0000	Tracking status	E04

RGEC/D

Format: Message ID = 33 (RGEC) or Message ID = 65 (RGED) Message byte count = 24 + (20*number of obs)

Data	Bytes	Format	Scale	Offset
Sync	3	char		0
Checksum	1	char		3
Message ID	4	integer		4
Message byte count	4	integer		8
Number of obs	2		1	12
Week number	2		1	14
Seconds of week	4	integer	1/100	16
Receiver status	4	integer	1	20
First PRN range record	20	See tables below: Range Record Format and Range Record Format (RGED only)		24

Next PRN offset = 24 + (20*number of obs)

Range Record Format

Data	Bit(s) from first to last	Length (bits)	Units	Scale
PRN	0..5	6	integer	1
C/No [1]	6..10	5	integer	(20+n) dBHz
Lock time [2]	11..31	21	integer	1/32 seconds
Accumulated Doppler range * [3]	32..63	32	integer 2's comp.	1/256 cycles
Doppler frequency	68..95	28	integer 2's comp.	1/256 Hz
Pseudorange	64..67 msn 96..127 lsw	36	integer 2's comp.	1/128 m
StdDev Accumulated Doppler	128..131	4	integer	[(n+1)*1/512] cyc
StdDev Pseudorange	132..135	4	integer	RGEC = [(n+1)*1/16] m RGED = see [4]
Channel Tracking Status	136..159	24	integer	see Table 5-6, page 95

* Accumulated Doppler range will roll over every ± 8388608 carrier cycles.

Notes on Range Record Format (RGED only)

1 C/No is constrained to a value between 20-51dB-Hz, Thus, if it is reported that C/No = 20 dB-Hz, the actual value could be less. Likewise, if it is reported that C/No = 51 dB-Hz, the true value could be greater.

2 Lock time rolls over after 2,097,151 seconds.

3 ADR (Accumulated Doppler Range) is calculated as follows:

ADR_ROLLS = (-RGED_PSR / WAVELENGTH - RGED_ADR) / MAX_VALUE

Round to the closest integer
IF (ADR_ROLLS ≤ -0.5)

ADR_ROLLS = ADR_ROLLS - 0.5

ELSE

ADR_ROLLS = ADR_ROLLS + 0.5

At this point change ADR_ROLLS to an integer
CORRECTED_ADR = RGED_ADR + (MAX_VALUE * ADR_ROLLS)

where:
ADR has units of cycles

WAVELENGTH = 0.1902936727984 for L1

WAVELENGTH = 0.2442102134246 for L2

MAX_VALUE = 838860

4

StdDev Pseudorange Scale

Code	RGED	Code	RGED
0	0.000 to 0.050	8	0.855 to 1.281
1	0.051 to 0.075	9	1.282 to 2.375
2	0.076 to 0.113	10	2.376 to 4.750
3	0.114 to 0.169	11	4.751 to 9.500
4	0.170 to 0.253	12	9.501 to 19.000
5	0.254 to 0.380	13	19.001 to 38.000
6	0.381 to 0.570	14	38.001 to 76.000
7	0.571 to 0.854	15	76.001to 52.000

5 Only bits 0 - 23 are represented in the RGED log

RT20A/B Computed Position – Time Matched *RT20*

This log represents positions that have been computed from time-matched reference and remote observations. There is no extrapolation error on these positions but because they are based on buffered measurements, they lag real time by some amount depending on the latency of the data link. With the recommended reference station logs active (RTCM3 ontime 10, RTCM59 ontime 2, RTCM ontime 5), the lag varies from 1-2 seconds at 1200 bps to about 0.4 seconds at 9600 bps.

The data in the RT-20 logs will change only when a reference observation (RTCM59) changes. If the log is being output at a fixed rate and the reference corrections are interrupted, then the RT20A/B log will continue to be output at the same rate but the position and time will not change.

A better trigger for this log is “ONCHANGED”. Then, only positions related to unique reference messages will be produced, and the existence of this log will indicate a successful link to the base.

RT20A

Structure:

```
$RT20A | week | seconds | # sats | lat | lon | hgt | undulation | datum ID | lat std | lon std
hgt std | sol status | rt20 status | stn ID | *xx | [CR][LF]
```

Field #	Field type	Data Description	Example
1	$RT20A	Log header	$RT20A
2	week	GPS week number	779
3	seconds	GPS seconds into the week	237328.00
4	# sats	Number of satellites in use (00-12). May be different to the number in view	9
5	lat	Latitude of position in current datum, in degrees (DD.dddddddd). A negative sign implies South latitude	51.11411137
6	lon	Longitude of position in current datum, in degrees (DDD.dddddddd). A negative sign implies West longitude	-114.04302707
7	hgt	Height of position in current datum, in metres above mean sea level (MSL) (see Figure 5-2, page 79)	1058.601
8	undulation	Geoidal separation, in metres, where positive is above spheroid and negative is below spheroid	-16.263
9	datum ID	Current datum (see Table A-2, page 166)	61
10	lat std	Standard deviation of latitude solution element, in metres	0.015
11	lon std	Standard deviation of longitude solution element, in metres	0.016
12	hgt std	Standard deviation of height solution element, in metres	0.015
13	sol status	Solution status as listed in Table 5-2, page 65	0
14	rt20 status	RT20 status as listed in Table 5-4, page 66	0
15	stn ID	Differential reference station ID, 0000-1023	200
16	*xx	Checksum	*47
17	[CR][LF]	Sentence terminator	[CR][LF]

Example:

```
$RT20A,779,237328.00,9,51.11411137,-114.04302707,1058.601,-16.263,61,0.015,
0.016,0.015,0,0,200*47[CR][LF]
```

RT20B

Format: Message ID = 35 Message byte count = 100

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer	bytes	8
2	Week number	4	integer	weeks	12
3	Seconds of week	8	double	seconds	16
4	Number of sats in solution	4	integer		24
5	Latitude	8	double	degrees (+ is North, - is South)	28
6	Longitude	8	double	degrees (+ is East, - is West)	36
7	Height	8	double	metres above MSL	44
8	Undulation	8	double	metres	52
9	Datum ID	4	integer	see Table A-2, page 166	60
10	StdDev of latitude	8	double	metres	64
11	StdDev of longitude	8	double	metres	72
12	StdDev of height	8	double	metres	80
13	Solution status	4	integer	see Table 5-2, page 65	88
14	RT20 status	4	integer	see Table 5-4, page 66	92
15	Reference station ID	4	integer		96

RTCAA/B Real Time Differential Corrections (Aviation) *R*

The RTCAA/B logs contain RTCA standard differential corrections. The RTCAA log contains RTCA data in ASCII hexadecimal with a NovAtel header and terminating with a checksum. The RTCAB log contains RTCA data in binary format with a NovAtel header. See Chapter 9, page 135, for more detailed information on RTCA.

RTCMA/B Real Time Differential Corrections (Maritime) *R*

The RTCMA/B logs contain RTCM standard differential corrections. The RTCMA log contains RTCM data in ASCII hexadecimal with a NovAtel header and terminating with a checksum. The RTCMB log contains RTCM data in binary format with a NovAtel header. See Chapter 8, page 129, for more detailed information on RTCM.

RTKA/B Computed Position - Time Matched *RTK*

This log represents positions that have been computed from time-matched reference and remote observations. There is no reference station extrapolation error on these positions but because they are based on buffered measurements, they lag real time by some amount depending on the latency of the data link. If the remote receiver has not been enabled to accept RTK differential data, or is not actually receiving data leading to a valid solution, this will be reflected by the code shown in field #16 (RTK status) and #17 (position type).

The data in the logs will change only when a reference observation (RTCM Type 59 or the corresponding RTCA Type 7) changes. If the log is being output at a fixed rate and the differential data is interrupted, then the RTKA/B logs will continue to be output at the same rate but the position and time will not change.

A good message trigger for this log is "onchanged". Then, only positions related to unique reference station messages will be produced, and the existence of this log will indicate a successful link to the reference station.

RTKA

Structure:

$RTKA	week	seconds	# sv	# high	L1L2 #high
lat	lon	hgt	undulation		datum ID
lat s	lon s	hgt s	soln status		rtk status
posn type		dyn mode	stn ID	*xx	[CR][LF]

Field #	Field type	Data Description	Example
1	$RTKA	Log header	$RTKA
2	week	GPS week number	872
3	seconds	GPS time into the week (in seconds)	174962.00
4	#sv	Number of matched satellites; may differ from the number in view.	8
5	#high	Number of matched satellites above RTK mask angle; observations from satellites below mask are heavily de-weighted	7
6	L1L2 #high	Unused, will report 0	0
7	lat	Latitude of position in current datum, in decimal fraction format. A negative sign implies South latitude	51.11358039754
8	lon	Longitude of position in current datum, in decimal fraction format. A negative sign implies West longitude	-114.04358003164
9	hgt	Height of position in current datum, in meters above mean sea level	1059.4105
10	undulation	Geoidal separation, in meters, where positive is above ellipsoid and negative is below ellipsoid	-16.2617
11	datum ID	Current datum (see Appendix A, page 166)	61
12	lat s	Standard deviation of latitude solution element, in meters	0.0036
13	lon s	Standard deviation of longitude solution element, in meters	0.0039
14	hgt s	Standard deviation of height solution element, in meters	0.0066
15	soln status	Solution status (see Table 5-2, page 65)	0
16	rtk status	RTK status (see Table 5-4, page 66)	0
17	posn type	Position type (seeTable 5-3, page 66)	4
18	dyn mode	Dynamics mode (0= static, 1= kinematic)	0
19	stn ID	Reference station identification (RTCM: 0 - 1023, or RTCA: 266305 - 15179385)	119
20	*xx	Checksum	*33
21	[CR][LF]	Sentence terminator	[CR][LF]

Example:

```
$RTKA,872,174962.00,8,7,0,51.11358039754,-114.04358003164,1059.4105,
-16.2617,61,0.0036,0.0039,0.0066,0,0,4,0,119*33[CR][LF]
```

RTKB

Format:

```
Message ID = 61  Message byte count = 116
```

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer		8
2	Week number	4	integer	weeks	12
3	GPS time into the week	8	double	seconds	16
4	Number of matched satellites (00-12)	4	integer		24
5	Number of matched satellites above RTK mask angle	4	integer		28
6	Unused, will report 0	4	integer		32
7	Latitude	8	double	degrees	36
8	Longitude	8	double	degrees	44
9	Height above mean sea level	8	double	meters	52
10	Undulation	8	double	meters	60
11	Datum ID	4	integer		68
12	Standard deviation of latitude	8	double	meters	72
13	Standard deviation of longitude	8	double	meters	80
14	Standard deviation of height	8	double	meters	88
15	Solution status	4	integer		96
16	RTK status	4	integer		100
17	Position type	4	integer		104
18	Dynamics mode	4	integer		108
19	Reference station identification (RTCM: 0 - 1023, or RTCA: 266305 - 15179385)	4	integer		112

SATA/B Satellite Specific Data *B (R)*

This log provides satellite specific data for satellites actually being tracked. The record length is variable and depends on the number of satellites.

Each satellite being tracked has a reject code indicating whether it is used in the solution, or the reason for its rejection from the solution. The reject value of 0 indicates the observation is being used in the position solution. Values of 1 through 11 indicate the observation has been rejected for the reasons specified in Table 5-5. A range reject code of 8 only occurs when operating in differential mode and an interruption of corrections has occurred or the DGPSTIMEOUT has been exceeded.

SATA

Structure:

```
$SATA week seconds sol status # obs
prn azimuth elevation residual reject code
:
prn azimuth elevation residual reject code *xx [CR][LF]
```

Field #	Field type	Data Description	Example
1	$SATA	Log header	$SATA
2	week	GPS week number	637
3	seconds	GPS seconds into the week	513902.00
4	sol status	Solution status as listed in *Table 5-2, page 65*	0
5	# obs	Number of satellite observations with information to follow:	7
6	prn	Satellite PRN number (1-32)	**18**
7	azimuth	Satellite azimuth from user position with respect to True North, in degrees	168.92
8	elevation	Satellite elevation from user position with respect to the horizon, in degrees	5.52
9	residual	Satellite range residual from position solution for each satellite, in metres	9.582
10	reject code	Indicates that the range is being used in the solution (code 0) or that it was rejected (code 1-11), as shown in *Table 5-7, page 103*	0
11...	..	Next PRN	
variable	*xx	Checksum	*1F
variable	[CR][LF]	Sentence terminator	[CR][LF]

Example:

```
$SATA,637,513902.00,0,7,18,168.92,5.52,9.582,0,6,308.12,55.48,0.737,0,
15,110.36,5.87,16.010,0,11,49.63,40.29,-0.391,0,
2,250.05,58.89,-12.153,0,16,258.55,8.19,-20.237,0,
19,118.10,49.46,-14.803,0*1F[CR][LF]
```

Table 5-7 GPSCard Range Reject Codes

Value	Description
0	Observations good
1	Bad health
2	Old ephemeris
3	Eccentric anomaly error
4	True anomaly error
5	Satellite coordinate error
6	Elevation error
7	Misclosure too large
8 †	No Differential Correction
9	No Ephemeris
10	Invalid IODE
11	Locked Out

Higher values reserved for future use.

† This code only available with "R" option.

SATB

Format: Message ID = 12 Message byte count = 32 + (obs*32)

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer	bytes	8
2	Week number	4	integer	weeks	12
3	Seconds of week	8	double	seconds	16
4	Solution status	4	integer	see Table 5-2, page 65	24
5	Number of observations (obs)	4	integer		28
6	PRN	4	integer		32
7	Azimuth	8	double	degrees	36
8	Elevation	8	double	degrees	44
9	Residual	8	double	metres	52
10	Reject code	4	integer	see Table 5-7, page 103	60
11...	Next PRN offset = 32 + (obs * 32) where obs varies from 0 to (obs-1)				

SPHA/B Speed and Direction Over Ground *B*

This log provides the actual speed and direction of motion of the GPSCard antenna over ground, at the time of measurement, and is updated up to 10 times per second. It should be noted that the GPSCard does not determine the direction a vessel, craft, or vehicle is pointed (heading), but rather the direction of motion of the GPS antenna relative to ground.

Structure:

```
$SPHA | week | seconds | hor spd | trk gnd | vert spd | sol status | *xx | [CR][LF]
```

Field #	Field type	Data Description	Example
1	$SPHA	Log header	$SPHA
2	week	GPS week number	640
3	seconds	GPS seconds into the week	333111.00
4	hor spd	Horizontal speed over ground, in m/s	0.438
5	trk gnd	Actual direction of motion over ground (track over ground) with respect to True North, in degrees	325.034
6	vert spd	Vertical speed, in m/s, where positive values indicate increasing altitude (up) and negative values indicate decreasing altitude (down)	2.141
7	sol status	Solution status as listed in *Table 5-2*	0
8	*xx	Checksum	*02
9	[CR][LF]	Sentence terminator	[CR][LF]

Example:

```
$SPHA,640,333111.00,0.438,325.034,2.141,0*02[CR][LF]
```

SPHB

Format: Message ID = 06 Message byte count = 52

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer	bytes	8
2	Week number	4	integer	weeks	12
3	Seconds of week	8	double	seconds	16
4	Horizontal speed	8	double	m/s	24
5	Track over ground (TOG)	8	double	degrees	32
6	Vertical speed	8	double	m/s	40
7	Solution status	4	integer	see Table 5-2, page 65	48

SVDA/B SV Position in ECEF XYZ Coordinates with Corrections *B (R)*

When combined with a RGEA/B/C/D log, this data set contains all of the decoded satellite information necessary to compute the solution: satellite coordinates (ECEF WGS-84), satellite clock correction, ionospheric corrections (from broadcast model), tropospheric correction (Hopfield model), decoded differential correction used and range weight standard deviation. The corrections are to be added to the pseudoranges. Only those satellites that are healthy are reported here. Also see Figure 5-3, page 108.

SVDA

Structure:

```
$SVDA  week  seconds  rec clk err  # obs
prn  x  y  z  clk corr  ion corr  trop corr  diff corr  rng std
..
prn  x  y  z  clk corr  ion corr  trop corr  diff corr  rng std  *xx  [CR][LF]
```

Field #	Field type	Data Description	Example
1	$SVDA	Log header	$SVDA
2	week	GPS week number	766
3	seconds	GPS seconds into the week (receiver time, not corrected for clock error, CLOCKADJUST enabled)	143860.00
4	rec clk err	Solved receiver clock error (metres)	-4.062
5	# obs	Number of satellite observations to follow	7
6	prn	Satellite PRN number (1-32)	20
7	x	Satellite x coordinate (metres)	-15044774.225
8	y	Satellite y coordinate (metres)	-9666598.520
9	z	Satellite z coordinate (metres)	19499537.398
10	clk corr	Satellite clock correction (metres)	6676.013
11	ion corr	Ionospheric correction (metres)	-1.657
12	trop corr	Tropospheric correction (metres)	-2.662
13	diff corr †	Decoded differential correction used (metres)	16.975
14	rng std	Range weight standard deviation (metres)	0.674
15..	..	Next PRN	
variable	*xx	Checksum	*23
variable	[CR][LF]	Sentence terminator	[CR][LF]

† This field only valid in GPSCards with "R" options.

Example:

```
$SVDA,766,143860.00,-4.062,7,
20,-15044774.225,-9666598.520,19499537.398,6676.013,-1.657,-2.662,16.975,0.674
5,-10683387.874,-21566845.644,11221810.349,18322.228,-1.747,-2.819,-8.864,0.790,
6,-20659074.698,-28381.667,16897664619,57962.693,-2.543,4.401,-37.490,1.203,
16,142876.148,-26411452.927,2795075.561,-22644.136,-2.733,-4.904,7.701,1.259,
24,-852160.876,-16138149.057,21257323.813,229594.682,-1.545,-2.451,32.178,0.420,
25,-12349609.643,11102877.199,20644151.935,-4313.339,-3.584,-8.579,-42.813,1.370,
..,
4,14209626.440,-9259502.647,20544348.215,12811.399,-2.675,-4.741,-10.778,1.239
*23[CR][LF]
```

SVDB

Format: Message ID = 36 Message byte count = 36 +(obs*68)

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer		8
2	Week number	4	integer	weeks	12
3	Time in seconds	8	double	seconds	16
4	Receiver clock error	8	double	metres	24
5	Number of observations to follow (obs)	4	integer		32
6	Satellite PRN number	4	integer		36
7	x coordinate of satellite	8	double	metres	40
8	y coordinate of satellite	8	double	metres	48
9	z coordinate of satellite	8	double	metres	56
10	Satellite clock correction	8	double	metres	64
11	Ionospheric correction	8	double	metres	72
12	Tropospheric correction	8	double	metres	80
13	Decoded differential correction used †	8	double	metres	88
14	Range weight standard deviation	8	double	metres	96
15...	Next PRN offset = 36 + (obs*68) where obs varies from 0 to (obs-1)				

Figure 5-3 The WGS-84 ECEF Coordinate System

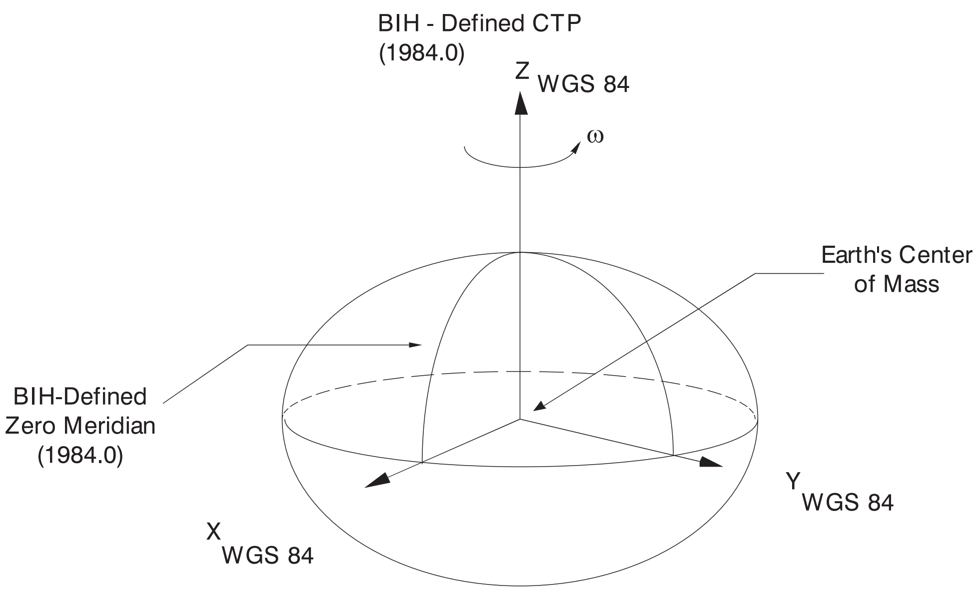
- Definitions - *

Origin = Earth's center of mass

Z-Axis = Parallel to the direction of the Conventional Terrestrial Pole (CTP) for polar motion, as defined by the Bureau International de l'Heure (BIH) on the basis of the coordinates adopted for the BIH stations.

X-Axis = Intersection of the WGS 84 Reference Meridian Plane and the plane of the CTP's Equator, the Reference Meridian being parallel to the Zero Meridian defined by the BIH on the basis of the coordinates adopted for the BIH stations.

Y-Axis = Completes a right-handed, earth-centered, earth-fixed (ECEF) orthogonal coordinate system, measured in the plane of the CTP Equator, 90i East of the X-Axis.



* Analogous to the BIH Defined Conventional Terrestrial System (CTS), or BTS, 1984.0.

TM1A/B Time of 1PPS *B*

This log provides the time of the GPSCard 1PPS in GPS week number and seconds into the week. It also includes the receiver clock offset, the standard deviation of the receiver clock offset and clock model status. This log will output at a maximum rate of 1 Hz.

TM1A

Structure:

$TM1A	week	seconds	offset	offset std	utc offset	cm status	*xx	[CR][LF]

Field #	Field type	Data Description	Example
1	$TM1A	Log header	$TM1A
2	week	GPS week number	794
3	seconds	GPS seconds into the week at the epoch coincident with the 1PPS output strobe (receiver time)	414634.999999966
4	offset	Receiver clock offset, in seconds. A positive offset implies that the receiver clock is ahead of GPS Time. To derive GPS time, use the following formula: GPS time = receiver time – (offset)	-0.000000078
5	offset std	Standard deviation of receiver clock offset, in seconds	0.000000021
6	utc offset	This field represents the offset of GPS time from UTC time, computed using almanac parameters. To reconstruct UTC time, algebraically subtract this correction from field 3 above (GPS seconds). UTC time = GPS time – (utc offset)	-9.999999998
7	cm status	Receiver Clock Model Status where 0 is valid and values from -20 to -1 imply that the model is in the process of stabilization	0
8	*xx	Checksum	*57
9	[CR][LF]	Sentence terminator	[CR][LF]

Example:

```
$TM1A,794,414634.999999966,-0.000000078,0.000000021,-9.999999998,0*57[CR][LF]
```

TM1B

Format: Message ID = 03 Message byte count = 52

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer	bytes	8
2	Week number	4	integer	weeks	12
3	Seconds of week	8	double	seconds	16
4	Clock offset	8	double	seconds	24
5	StdDev clock offset	8	double	seconds	32
6	UTC offset	8	double	seconds	40
7	Clock model status	4	integer	0 = good, -1 to -20 = bad	48

VERA/B Receiver Hardware and Software Version Numbers *B*

This log contains the current hardware type and software version number for the GPSCard. Together with the RVSA/B log, it supersedes the RCSA/B log.

VERA

Structure:

`$VERA | week | seconds | version | *xx | [CR][LF]`

Field #	Field type	Data Description	Example
1	$VERA	Log header	$VERA
2	week	GPS week number	853
3	seconds	GPS seconds into the week.	401364.50
4	version	GPSCard hardware type and software version number	OEM-3 MILLENSTD CGL96170069 HW 3-1 SW 4.42/2.03 May 14/96
5	*xx	Checksum	*2B
6	[CR][LF]	Sentence terminator	[CR][LF]

Example:

```
$VERA,853,401364.50,OEM-3 MILLENSTD CGL96170069 HW 3-1 SW 4.42/2.03 May
14/96*2B[CR][LF]
```

VERB

`Format:        Message ID = 58        Message byte count = 104`

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer		8
2	Week number	4	integer	weeks	12
3	Time into week	8	double	s	16
4	Version numbers	80	char		24

VLHA/B Velocity, Latency, and Direction over Ground *B (R)*

This log is similar to the SPHA/B message. As in the SPHA/B messages the actual speed and direction of the GPSCard antenna over ground is provided. The VLHA/B differs in that it provides a measure of the latency in the velocity time tag and a new velocity status word that gives the user more velocity quality information. The velocity status indicates varying degrees of velocity quality. To ensure healthy velocity, the position sol-status must also be checked. If the sol-status is non-zero, the velocity will likely be invalid. Also, it includes the age of the differential corrections used in the velocity computation. It should be noted that the GPSCard does not determine the direction a vessel, craft, or vehicle is pointed (heading), but rather the direction of motion of the GPS antenna relative to ground.

VLHA

Structure:

`$VLHA` `week` `seconds` `latency` `age` `hor spd` `trk gnd` `vert spd` `sol status` `vel status` `*xx` `[CR][LF]`

Field #	Field type	Data Description	Example
1	$VLHA	Log header	$VLHA
2	week	GPS week number	640
3	seconds	GPS seconds into the week	333111.00
4	latency †	A measure of the latency in the velocity time tag in seconds. It should be subtracted from the time to give improved results.	0.250
5	age ††	Age of Differential GPS data in seconds	3.500
6	hor spd	Horizontal speed over ground, in m/s	0.438
7	trk gnd	Actual direction of motion over ground (track over ground) with respect to True North, in degrees	325.034
8	vert spd	Vertical speed, in m/s, where positive values indicate increasing altitude (up) and negative values indicate decreasing altitude (down)	2.141
9	sol status	Solution status as listed in *Table 5-2*	0
10	vel status †††	Velocity status as listed in *Table 5-6*	0
11	*xx	Checksum	*02
12	[CR][LF]	Sentence terminator	[CR][LF]

† Velocity Latency

The velocity is computed using Doppler values derived from differences in consecutive carrier phase measurements. As such, it is an average velocity based on the time difference between successive position computations and not an instantaneous velocity at the SPHA/B time tag. Under normal operation the position's coordinates are updated at a rate of two times per second. The velocity latency compared to this time tag will normally be 1/2 the time between position fixes. The default filter rate is 2 Hz, so this latency is typically 0.25 second, but if, for example, the POSA records were to be logged ontime 0.2, then the velocity latency would be one half of 0.2, or 0.1 second. The latency can be reduced further by the user requesting the POSA/B, the SPHA/B, or the VLHA/B message at rates higher than 2 Hz. For example, a rate of 10 Hz will reduce the velocity latency to 1/20 of a second. For integration purposes, the velocity latency should be applied to the record time tag.

†† Differential age is only available from receivers with the "R" or "RT-20" option.

††† Only receivers with the "R" option can report a value of 0, 1, or 2.

Example:

```
$VLHA,640,333111.00,0.250,3.500,0.438,325.034,2.141,0,0*02[CR][LF]
```

NOTE: Logging rates greater than once per second require x51 or xx51 models.

VLHB

Format: Message ID = 34 Message byte count = 72

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer	bytes	8
2	Week number	4	integer	weeks	12
3	Seconds of week	8	double	seconds	16
4	Latency	8	double	m/s	24
5	Age ††	8	double	seconds	32
6	Horizontal speed	8	double	m/s	40
7	Track over ground (TOG)	8	double	degrees	48
8	Vertical speed	8	double	m/s	56
9	Solution status	4	integer	see Table 5-2, page 65	64
10	Velocity status †††	4	integer	see Table 5-8, page 112	68

Table 5-8 GPSCard Velocity Status

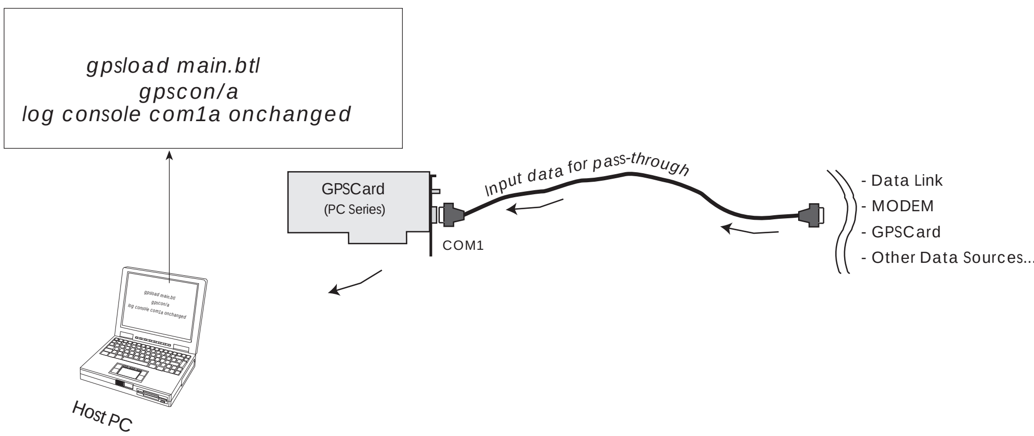
Value	Description
0 †††	Velocity computed from differentially corrected carrier phase data
1 †††	Velocity computed from differentially corrected Doppler data
2 †††	Old velocity from differentially corrected phase or Doppler (higher latency)
3	Velocity from single point computations
4	Old velocity from single point computations (higher latency)
5	Invalid velocity

††† Higher values reserved for future use

6 SPECIAL PASS-THROUGH LOGS

The pass-through logging feature enables the GPSCard to redirect any ASCII or binary data that is input at a specified port (COM1, COM2, or Console) to any specified GPSCard port (COM1, COM2, or Console). This capability, in conjunction with the SEND command, can allow the GPSCard to perform bi-directional communications with other devices such as a modem, terminal, or another GPSCard.

Figure 6-1 Illustration of Pass-Through



There are three pass-through logs – **COM1A/B**, **COM2A/B**, and **CONSOLEA/B** (console is available only with PC Series GPSCards).

Pass-through is initiated the same as any other log, i.e., LOG [to-port] [data-type-A/B] [trigger]. However, pass-through can be more clearly specified as: LOG [to-port] [from-port-A/B] [onchanged]. Now, the [from-port-A/B] field designates the port which accepts data (i.e., COM1, COM2, or Console) as well as the format in which the data will be logged by the [to-port] — (A for ASCII or B for Binary).

When the [from-port-A/B] field is designated with an [**A**], all data received by that port will be redirected to the [to-port] in **ASCII** format and will log according to standard NovAtel ASCII format. Therefore, all incoming ASCII data will be redirected and output as ASCII data. However, any binary data received will be converted to a form of ASCII hexadecimal before it is logged.

When the [from-port-A/B] field is designated with a [**B**], all data received by that port will be redirected to the [to-port] exactly as it is received. The log header and time-tag adhere to standard NovAtel Binary Format followed by the pass-through data as it was received (ASCII or binary).

Pass-through logs are best utilized by setting the [**trigger**] field as **onchanged** or **onnew**. Either of these two triggers will cause the incoming data to log when any one of the following conditions is met:

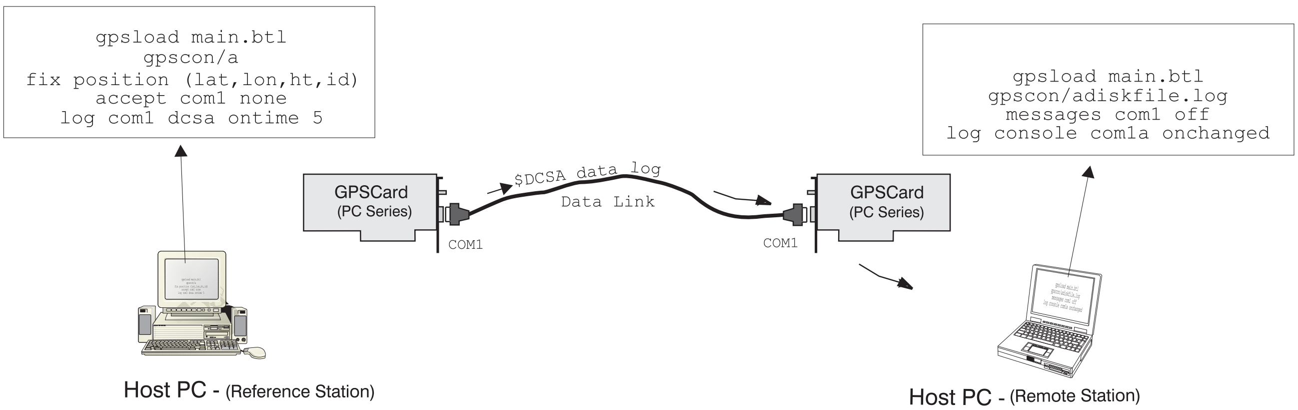
- Upon receipt of a <CR> character
- Upon receipt of a <LF> character
- Upon receipt of 80 characters

- 1/2 second timeout following receipt of last character

Each pass-through record transmitted by the GPSCard is time tagged by the GPSCard clock in GPS weeks and seconds.

For illustration purposes, you could connect two PC Series GPSCards together via their COM1 ports such as in a reference station – remote station scenario. If the reference station were logging DCSA data to the remote station, it would be possible to use the pass-through logs to pass through the received DCSA differential correction data to a disk file (let's call it DISKFILE.log) at the remote station host PC hard disk. (See Figure 6-2, page 114.)

Figure 6-2 Pass-Through Log Data



When pass-through logs are being used, the GPSCard's command interpreter continues to monitor the port for valid input commands and replies with error messages when the data is not recognized as such. If you do not want the pass-through input port to respond with error messages during unrecognized data input, refer to the MESSAGES command, page 39, for details on how to inhibit the port's error message responses. As well, if you do not want the reference station to accept any input from the remote device, use the ACCEPT NONE command to disable the port's command interpreter.

COMMAND SYNTAX

Syntax:

log	to-port	from-port-A/B	trigger

Syntax	Range Value	Description	Default
log	—	Log command	unlogall
to-port	COM1, COM2, or console	Port that will output the pass-through log data	—
from-port-[A/B]	COM1A/B, COM2A/B, ConsoleA/B	Port that will accept input data; [A] option logs data as ASCII, [B] option logs data with binary header	—
trigger	onchanged or onnew	log will output upon receipt of : <CR>, <LF>, 80 characters, or 1/2 sec. timeout	—

Example 1:

```
log com2 com1a onchanged
```

Example 2:

```
log console com1a onnew
```

ASCII LOG STRUCTURE

$port ID	week	seconds	pass-through data	*xx	[CR][LF]

Field #	Field type	Data Description	Example
1	$port ID	Log header: Identifies port accepting input data	$COM1
2	week	GPS week number	747
3	seconds	GPS seconds into the week at time of log	347131.23
4	pass-through data	Data accepted into COM1(up to 80 characters)	$TM1A,747,347131.000000000, 0.000000058,0.000000024, -9.000000009,0*78<CR>
5	*xx	Checksum	*2E
6	[CR][LF]	Sentence terminator	[CR][LF]

Example 1:

```
$COM1,747,347131.23,$TM1A,747,347131.000000000,0.000000058,0.000000024,
-9.000000009,0*78<CR>*2E[CR][LF]
$COM1,747,347131.31,<LF>*4F[CR][LF]
$COM1,747,347131.40,Invalid Command Option<LF>*7C[CR][LF]
$COM1,747,347131.42,Com1>Invalid Command Option<LF>*30[CR][LF]
$COM1,747,347131.45,Com1>*0A[CR][LF]
```

Example 1 above shows what would result if a GPSCard logged TM1A data into the COM1 port of another GPSCard, where the accepting card is redirecting this input data as a pass-through log to its COM2 port (log com2 com1a onchanged). Under default conditions the two cards will *"chatter"* back and forth with the ***Invalid Command Option*** message (due to the command interpreter in each card not recognizing the command prompts of the other card). This *chattering* will in turn cause the accepting card to transmit new pass-through logs with the response data from the other card. To avoid this chattering problem, use the GPSCard MESSAGES command on the accepting port to disable error reporting from the receiving port command interpreter or if the incoming data is of no use to the GPSCard, then disable the command interpreter with the ACCEPT NONE command.

If the accepting port's error reporting is disabled by MESSAGES OFF, the $TM1A data record would pass through creating two records as follows:

Example 1a:

```
$COM1,747,347204.80,$TM1A,747,347203.999999957,-0.000000015,0.000000024,
-9.000000009,0*55<CR>*00[CR][LF]
$COM1,747,347204.88,<LF>*48[CR][LF]
```

The reason that two records are logged from the accepting card is because the first record was initiated by receipt of the $TM1A log's first terminator <CR>. Then the second record followed in response to the $TM1A log's second terminator <LF>.

Note that the time interval between the first character received ($) and the terminating <LF> can be calculated by differencing the two GPS time tags (0.08 seconds). This pass-through feature is useful for time tagging the arrival of external messages. These messages could be any user-related data. If the user is using this feature for tagging external events then it is recommended that the command interpreter be disabled so that the GPSCard does not respond to the messages. See the ACCEPT command, page 20.

Example 1b illustrates what would result if $TM1B binary log data were input to the accepting port (i.e., log com2 com1a onchanged).

Example 1b:

```
$COM1,747,349005.18,<AA>D<DC1>k<ETX><NUL><NUL><NUL>4<NUL><NUL><NUL>
<EB><STX><NUL><NUL><FE>3M<NAK>A<VT><83><D6>o<82><C3>Z<BE><FC><97>I
<91><C5>iV><7F><8F>O<NUL><NUL><NUL>"<C0><NUL><NUL><NUL><NUL>*6A
```

As can be seen, the $TM1B binary data at the accepting port was converted to a variation of ASCII hexadecimal before it was passed through to COM2 port for logging (MESSAGES command set to OFF).

Example 2 below illustrates what would result if $DCSA data is accepted into the GPSCard COM1 port and logged to the host PC console (MESSAGES command set to OFF) (i.e., log console com1a onchanged).

Example 2:

```
$COM1,747,328116.97,$DCSA,747,327962.50,123,6,19,161,46.125,0.044,2,17,
47.844,-0.151,15,164,-7.166,*55[CR][LF]
$COM1,747,328117.05,0.095,27,237,61.697,-0.125,7,64,-13.049,0.048,26,0,
36.795,0.106*16<CR>*53[CR][LF]
$COM1,747,328117.12,<LF>*40[CR][LF]
```

Here, it can be seen that the single $DCSA message accepted into the GPSCard COM1 port resulted in three records being logged to the console. This is because the first record resulted from receipt of the 80 character input data limit, the second record resulted from receipt of the $DCSA record terminator character <CR>, and a third record followed receipt of the $DCSA record terminator character <LF>.

Example 3 shown below is the result of data being manually transmitted from a dumb terminal into an accepting GPSCard COM1 port which may then be saved to a PC disk file. The [Return] key was not pressed at the terminal. Pass-through was set up as: log console com1a onnew. The PC Series GPSCard has been booted using GPSCON/adiskfile.log as the console disk logging destination.

The command interpreter was disabled via ACCEPT COM1 NONE so that if valid commands were in the data, e.g., "creset" or "unlogall", the GPSCard would not be erroneously reconfigured. Use the MESSAGES OFF command if the incoming data is to be processed by the GPS receiver. Use ACCEPT COM1 NONE for pass-through data that has nothing to do with the receiver.

Multiple messages resulted from the pass-through log 1/2 second default time-out.

Example 3:

```
$COM1,747,328850.28,This is a test us*06
$COM1,747,328855.08,ing the passthru log*1B
$COM1,747,328860.79,s.*3F
$COM1,747,328866.89,If *4A
$COM1,747,328868.64,I pause too long the recor*3D
$COM1,747,328876.07,d will send automatically*61
$COM1,747,328898.43,As you can see *0C
$COM1,747,328903.72,I*0A
$COM1,747,328904.47, am not a very fast*62
$COM1,747,328910.79, typist.*79
$COM1,747,328922.14,End of *06
$COM1,747,328924.42,test*53
```

BINARY LOG STRUCTURE

Format: Message ID = 29 for CONSOLEB
30 for COM1B
31 for COM2B
Message byte count = 24 + (length of pass-through data string received (80 maximum)

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer	bytes	8
2	Week number	4	integer	weeks	12
3	Seconds of week	8	double	seconds	16
4	Pass-through data	variable	char	data as received	24 + (variable data)

RTK

After setting up your system and initialising the positioning algorithms you can use the logs listed in this chapter to record the data collected. The low-latency-solution logs (e.g. PRTKA/B) are recommended for kinematic users, while the matched-solution logs (e.g. RTKA/B) are recommended for stationary users.

A matched solution is *always* a carrier-phase differential solution, and consequently offers the greatest possible accuracy. A low-latency solution, on the other hand, is the best one that is currently available; the possibilities are categorised as follows, starting with the one offering the greatest accuracy and precision:

1.Carrier-phase differential solution

2.Pseudorange differential solution

3.Single-point solution

Therefore, if an RTK solution is not available, then a low-latency-solution log will contain a pseudorange differential solution if it exists. If neither an RTK nor a pseudorange differential solution is available, then a low-latency-solution log will contain a single-point solution.

7 NMEA FORMAT DATA LOGS

GENERAL

The NMEA log structures follow format standards as adopted by the National Marine Electronics Association. The reference document used is "Standard For Interfacing Marine Electronic Devices NMEA 0183 Version 2.00". For further information, refer to Appendix D, page 178.

The following table contains excerpts from Table 6 of the NMEA Standard that defines the variables for the NMEA logs. The actual format for each parameter is indicated after its description.

Field Type	Symbol	Definition
Special Format Fields		
Status	A	Single character field: A = Yes, Data Valid, Warning Flag ClearV = No, Data Invalid, Warning Flag Set
Latitude	llll.ll	Fixed/Variable length field: degrees|minutes.decimal - 2 fixed digits of degrees, 2 fixed digits of minutes and a variable number of digits for decimal-fraction of minutes. Leading zeros always included for degrees and minutes to maintain fixed length. The decimal point and associated decimal-fraction are optional if full resolution is not required.
Longitude	yyyyy.yy	Fixed/Variable length field: degrees|minutes.decimal - 3 fixed digits of degrees, 2 fixed digits of minutes and a variable number of digits for decimal-fraction of minutes. Leading zeros always included for degrees and minutes to maintain fixed length. The decimal point and associated decimal-fraction are optional if full resolution is not required
Time	hhmmss.ss	Fixed/Variable length field: hours|minutes|seconds.decimal - 2 fixed digits of hours, 2 fixed digits of minutes, 2 fixed digits of seconds and variable number of digits for decimal-fraction of seconds. Leading zeros always included for hours, minutes and seconds to maintain fixed length. The decimal point and associated decimal-fraction are optional if full resolution is not required.
Defined field		Some fields are specified to contain pre-defined constants, most often alpha characters. Such a field is indicated in this standard by the presence of one or more valid characters. Excluded from the list of allowable characters are the following which are used to indicate field types within this standard: "A", "a", "c", "hh", "hhmmss.ss", "llll.ll", "x", "yyyyy.yy"
Numeric Value Field		
Variable numbers	x.x	Variable length integer or floating numeric field. Optional leading and trailing zeros. The decimal point and associated decimal-fraction are optional if full resolution is not required (example: 73.10 = 73.1 = 073.1 = 73)
Fixed HEX field	hh___	Fixed length HEX numbers only, MSB on the left
Information Fields		
Variable text	c--c	Variable length valid character field.
Fixed alpha field	aa___	Fixed length field of uppercase or lowercase alpha characters
Fixed number field	xx___	Fixed length field of numeric characters
Fixed text field	cc___	Fixed length field of valid characters

NOTES:

1. Spaces may only be used in variable text fields.
2. A negative sign "-" (HEX 2D) is the first character in a Field if the value is negative. The sign is omitted if value is positive.
3. All data fields are delimited by a comma (,).
4. Null fields are indicated by no data between two commas (,,). Null fields indicate invalid or no data available.
5. The NMEA Standard requires that message lengths be limited to 82 characters.

GPALM Almanac Data *B*

This log outputs raw almanac data for each satellite PRN contained in the broadcast message. A separate record is logged for each PRN, up to a maximum of 32 records. Following a GPSCard reboot, no records will be output until new broadcast message data is received from a satellite. It takes a minimum of 12.5 minutes to collect a complete almanac following GPSCard boot-up. (The almanac reported here has no relationship to the NovAtel $ALMA almanac injection command. Following a cold start, the log will output null fields until a new almanac is collected from a satellite.)

Structure:

```
$GPALM | # msg | msg # | PRN | GPS wk | SV hlth | ecc | alm ref time | incl angle
omegadot | rt axis | omega | long asc node | Mo | af0 | af1 | *xx | [CR][LF]
```

Field	Structure	Field Description	Symbol	Example
1	$GPALM	Log header		$GPALM
2	# msg	Total number of messages logged	x.x	17
3	msg #	Current message number	x.x	17
4	PRN	Satellite PRN number, 01 to 32	xx	28
5	GPS wk	GPS reference week number †	x.x	653
6	SV hlth	SV health, bits 17-24 of each almanac page ††	hh	00
7	ecc	e, eccentricity †††	hhhh	3EAF
8	alm ref time	toa, almanac reference time †††	hh	87
9	incl angle	$(sigma)_i$, inclination angle †††	hhhh	OD68
10	omegadot	OMEGADOT, rate of right ascension †††	hhhhhhhh	FFFFFD30
11	rt axis	$(A)^{1/2}$, root of semi-major axis †††	hhhhhh	A10CAB
12	omega	omega, argument of perigee †††	hhhhhh	6EE732
13	long asc node	$(OMEGA)^o$,longitude of ascension node †††	hhhhhh	525880
14	M_o	Mo, mean anomaly †††	hhhhhh	6DC5A8
15	a_{f0}	af0, clock parameter †††	hhh	009
16	a_{f1}	af1, clock parameter †††	hhh	005
17	*xx	Checksum	*hh	*37
18	[CR][LF]	Sentence terminator		[CR][LF]

† Variable length integer, 4-digits maximum from (2) most significant binary bits of Subframe 1, Word 3 reference Table 20-I, ICD-GPS-200, Rev. B, and (8) least significant bits from subframe 5, page 25, word 3 reference Table 20-I, ICD-GPS-200, Rev. B, paragraph 20.3.3.5.1.7.

†† Reference paragraph 20.3.3.5.1.3, Table 20-VII and Table 20-VIII, ICD-GPS-200, Rev. B.

††† Reference Table 20-VI, ICD-GPS-200, Rev. B for scaling factors and units.

Example:

```
$GPALM,17,17,28,653,00,3EAF,87,0D68,FFFFFD30,A10CAB,6EE732,525880,6DC5A8,009,
005*37[CR][LF]
```

NOTE: To obtain copies of ICD-GPS-200, refer to Appendix D, page 178, for address information.

GPGGA Global Position System Fix Data *B (R)*

Time, position and fix-related data of the GPS receiver. The information contained in this log is also available in the NovAtel GGAB log in binary format. This log will output all null data fields until the GPSCard has achieved first fix.

Structure:

```
$GPGGA utc lat lat dir lon lon dir GPS qual # sats hdop alt units null
null age stn ID *xx [CR][LF]
```

Field	Structure	Field Description	Symbol	Example
1	$GPGGA	Log header		$GPGGA
2	utc	UTC time of position (hours/minutes/seconds/ decimal seconds)	hhmmss.ss	220147.50
3	lat	Latitude (DDmm.mm)	llll.ll	5106.7194489
4	lat dir	Latitude direction (N = North, S = South)	a	N
5	lon	Longitude (DDDmm.mm)	yyyyy.yy	11402.3589020
6	lon dir	Longitude direction (E = East, W = West)	a	W
7	GPS qual	GPS Quality indicator 0 = fix not available or invalid 1 = GPS fix 2 = Differential GPS fix †	x	1
8	# sats	Number of satellites in use (00-12). May be different to the number in view	xx	08
9	hdop	Horizontal dilution of precision	x.x	0.9
10	alt	Antenna altitude above/below mean sea level (geoid)	x.x	1080.406
11	units	Units of antenna altitude, in metres	m	m
12	null	(This field not available on GPSCards)		,,
13	null	(This field not available on GPSCards)		,,
14	age	Age of Differential GPS data (in seconds) † ††	xx	,,
15	stn ID	Differential reference station ID, 0000-1023 †	xxxx	,,
16	*xx	Checksum	*hh	*48
17	[CR][LF]	Sentence terminator		[CR][LF]

† Fields 7, 14, and 15 will not report this data unless the GPSCard has the "R" option.

†† The maximum age reported here is limited to 99 seconds.

Example:

```
$GPGGA,220147.50,5106.7194489,N,11402.3589020,W,1,08,0.9,1080.406,M,,,,
*48[CR][LF]
```

GPGLL Geographic Position – Lat/Lon *B*

Latitude and longitude of present vessel position, time of position fix, and status. This log will output all null data fields until the GPSCard has achieved first fix.

Structure:

`$GPGLL` `lat` `lat dir` `lon` `lon dir` `utc` `data status` `*xx` `[CR][LF]`

Field	Structure	Field Description	Symbol	Example
1	$GPGLL	Log header		$GPGLL
2	lat	Latitude (DDmm.mm)	llll.ll	5106.7198674
3	lat dir	Latitude direction (N = North, S = South)	a	N
4	lon	Longitude (DDDmm.mm)	yyyyy.yy	11402.3587526
5	lon dir	Longitude direction (E = East, W = West)	a	W
6	utc	UTC time of position (hours/minutes/seconds/decimal seconds)	hhmmss.ss	220152.50
7	data status	Data status: A = Data valid, V = Data invalid	A	A
8	*xx	Checksum	*hh	*1B
9	[CR][LF]	Sentence terminator		[CR][LF]

Example:

```
$GPGLL,5106.7198674,N,11402.3587526,W,220152.50,A*1B[CR][LF]
```

GPGRS GPS Range Residuals for Each Satellite *B*

Range residuals can be computed in two ways, and this log reports those residuals. Under mode 0, residuals output in this log are used to update the position solution output in the GPGGA message. Under mode 1, the residuals are re-computed after the position solution in the GPGGA message is computed. The GPSCard computes range residuals in mode 1. An integrity process using GPGRS would also require GPGGA (for position fix data), GPGSA (for DOP figures), and GPGSV (for PRN numbers) for comparative purposes.

Structure:

`$GPGRS` `utc` `mode` `res` `res` `res` `res` `res` `res` `res` `res` `res` `res` `res` `res`
`*xx` `[CR][LF]`

Field	Structure	Field Description	Symbol	Example
1	$GPGRS	Log header		$GPGRS
2	utc	UTC time of position (hours/minutes/seconds/ decimal seconds)	hhmmss.ss	192911.0
3	mode	Mode 0 = residuals were used to calculate the position given in the matching GGA line (apriori) (not used by GPSCard) Mode 1 = residuals were recomputed after the GGA position was computed (preferred mode)	x	1
4 - 15	res	Range residuals for satellites used in the navigation solution. Order matches order of PRN numbers in GPGSA.	x.x,x.x,.....	-13.8,-1.9,11.4,-33.6,0.9, 6.9,-12.6,0.3,0.6, -22.3
16	*xx	Checksum	*hh	*65
17	[CR][LF]	Sentence terminator		[CR][LF]

Example:

```
$GPGRS,192911.0,1,-13.8,-1.9,11.4,-33.6,0.9,6.9,-12.6,0.3,0.6,-22.3,,
*65[CR][LF]
```

NOTES:

- If the range residual exceeds ± 99.9, then the decimal part will be dropped. Maximum value for this field is ± 999.
- The sign of the range residual is determined by the order of parameters used in the calculation as follows:
  range residual = calculated range – measured range.

GPGSA GPS DOP and Active Satellites *B*

GPS receiver operating mode, satellites used for navigation and DOP values.

Structure:

```
$GPGSA | mode MA | mode 123 | prn | prn | prn | prn | prn | prn | prn | prn | prn | prn | prn | prn
pdop | hdop | vdop | *xx | [CR][LF]
```

Field	Structure	Field Description	Symbol	Example
1	$GPGSA	Log header		$GPGSA
2	mode MA	A = Automatic 2D/3D (not used by GPSCard) M = Manual, forced to operate in 2D or 3D	M	M
3	mode 123	Mode: 1 = Fix not available; 2 = 2D; 3 = 3D	x	3
4 - 15	prn	PRN numbers of satellites used in solution (null for unused fields), total of 12 fields	xx,xx,.....	18,03,13,25,16, 24,12,20,,,,
16	pdop	Position dilution of precision	x.x	1.5
17	hdop	Horizontal position and time dilution of precision	x.x	0.9
18	vdop	Vertical dilution of precision	x.x	1.2
19	*xx	Checksum	*hh	*3F
20	[CR][LF]	Sentence terminator		[CR][LF]

Example:

```
$GPGSA,M,3,18,03,13,25,16,24,12,20,,,,,1.5,0.9,1.2*3F[CR][LF]
```

GPGST Pseudorange Measurement Noise Statistics *B*

Pseudorange measurement noise statistics are translated in the position domain in order to give statistical measures of the quality of the position solution.

Structure:

```
$GPGST | utc | rms | smjr std | smnr std | orient | lat std | lon std | alt std
*xx | [CR][LF]
```

Field	Structure	Field Description	Symbol	Example
1	$GPGST	Log header		$GPGST
2	utc	UTC time of position (hours/minutes/seconds/ decimal seconds)	hhmmss.ss	192911.0
3	rms	RMS value of the standard deviation of the range inputs to the navigation process. Range inputs include pseudoranges and DGPS corrections.	x.x	28.7
4	smjr std	Standard deviation of semi-major axis of error ellipse (metres)	x.x	21.6
5	smnr std	Standard deviation of semi-minor axis of error ellipse (metres)	x.x	12.0
6	orient	Orientation of semi-major axis of error ellipse (degrees from true north)	x.x	20.4
7	lat std	Standard deviation of latitude error (metres)	x.x	20.7
8	lon std	Standard deviation of longitude error (metres)	x.x	13.6
9	alt std	Standard deviation of altitude error (metres)	x.x	11.9
10	*xx	Checksum	*hh	*51
11	[CR][LF]	Sentence terminator		[CR][LF]

Example:

```
$GPGST,192911.0,28.7,21.6,12.0,20.4,20.7,13.6,11.9*51[CR][LF]
```

GPGSV GPS Satellites in View *B*

Number of SVs in view, PRN numbers, elevation, azimuth and SNR value. Four satellites maximum per message. When required, additional satellite data sent in second or third message. Total number of messages being transmitted and the current message being transmitted are indicated in the first two fields.

Structure:

```
$GPGSV | # msg | msg # | # sats
prn | elev | azimuth | SNR
:
prn | elev | azimuth | SNR | *xx | [CR][LF]
```

Field	Structure	Field Description	Symbol	Example
1	$GPGSV	Log header		$GPGSV
2	# msg	Total number of messages, 1 to 3	x	3
3	msg #	Message number, 1 to 3	x	1
4	# sats	Total number of satellites in view	xx	09
5	prn	Satellite PRN number	xx	**03**
6	elev	Elevation, degrees, 90° maximum	xx	51
7	azimuth	Azimuth, degrees True, 000 to 359	xxx	140
8	SNR	SNR (C/N_0) 00-99 dB, null when not tracking	xx	42
9-12		2nd satellite PRN number, elev, azimuth, SNR,	xx,xx,xxx,xx,	16,02,056,40,
13-16		3rd satellite PRN number, elev, azimuth, SNR,	xx,xx,xxx,xx,	17,78,080,42,
17-20		4th satellite PRN number, elev, azimuth, SNR	xx,xx,xxx,xx	21,25,234,00
21	*xx	Checksum	*hh	*72
22	[CR][LF]	Sentence terminator		[CR][LF]
1 - 22		2nd $GPGSV message (optional)		
1 - 22		3rd $GPGSV message (optional)		

Example:

```
$GPGSV,3,1,09,03,51,140,42,16,02,056,40,17,78,080,42,21,25,234,00*72[CR][LF]
$GPGSV,3,2,09,22,19,260,00,23,59,226,00,26,45,084,39,27,07,017,39*78[CR][LF]
$GPGSV,3,3,09,28,29,311,44*42[CR][LF]
```

NOTES:

- Satellite information may require the transmission of multiple messages. The first field specifies the total number of messages, minimum value 1. The second field identifies the order of this message (message number), minimum value 1.
- A variable number of 'prn-Elevation-Azimuth-snr' sets are allowed up to a maximum of four sets per message. Null fields are not required for unused sets when less than four sets are transmitted.
- GPGSV logs will not output until time of first fix.

GPRMB Navigation Information *B*

Navigation data from present position to a destination waypoint. The destination is set active by the GPSCard SETNAV command. If SETNAV has been set, a command to log either GPRMB or GPRMC will cause both logs to output data.

Structure:

```
$GPRMB | data status | xtrack | dir | origin ID | dest ID | dest lat | lat dir
dest lon | lon dir | range | bearing | vel | arr status | *xx | [CR][LF]
```

Field	Structure	Field Description	Symbol	Example
1	$GPRMB	Log header		$GPRMB
2	data status	Data status: A = data valid; V = navigation receiver warning	A	V
3	xtrack	Cross track error – nautical miles †	x.x	0.011
4	dir	Direction to steer to get back on track (L/R) ††	a	L
5	origin ID	Origin waypoint ID †††	c--c	START
6	dest ID	Destination waypoint ID †††	c--c	END
7	dest lat	Destination waypoint latitude (DDmm.mm) †††	llll.ll	5106.7074000
8	lat dir	Latitude direction (N = North, S = South) †††	a	N
9	dest lon	Destination waypoint longitude (DDDmm.mm) †††	yyyyy.yy	11402.3490000
10	lon dir	Longitude direction (E = East, W = West) †††	a	E
11	range	Range to destination, nautical miles ††††	x.x	0.0127611
12	bearing	Bearing to destination, degrees True	x.x	153.093
13	vel	Destination closing velocity, knots	x.x	0.3591502
14	arr status	Arrival status: A = perpendicular passed, V = destination not reached or passed	A	V
15	*xx	Checksum	*hh	*13
16	[CR][LF]	Sentence terminator		[CR][LF]

† – If cross track error exceeds 9.99 NM, display 9.99
– Represents track error from intended course
– one nautical mile = 1,852 m

†† Direction to steer is based on the sign of the crosstrack error, i.e., L = xtrack error (+); R = xtrack error (–)

††† Fields 5, 6, 7, 8, 9, and 10 are tagged from the GPSCard SETNAV command.

†††† If range to destination exceeds 999.9 NM, display 999.9

Example:

```
$GPRMB,V,0.011,L,START,END,5106.7074000,N,11402.3490000,W,0.0127611,153093,
0.3591502,V*13[CR][LF]
```

GPRMC GPS Specific Information *B*

Time, date, position, track made good and speed data provided by the GPS navigation receiver. RMC and RMB are the recommended minimum navigation data to be provided by a GPS receiver. This log will output all null data fields until the GPSCard has achieved first fix.

Structure:

```
$GPRMC | utc | pos status | lat | lat dir | lon | lon dir | speed Kn | track true | date
mag var | var dir | *xx | [CR][LF]
```

Field	Structure	Field Description	Symbol	Example
1	$GPRMC	Log header		$GPRMC
2	utc	UTC of position	hhmmss.ss	220216.50
3	pos status	Position status: A = data valid; V = data invalid	A	A
4	lat	Latitude (DDmm.mm)	llll.ll	5106.7187663
5	lat dir	Latitude direction (N = North, S = South)	a	N
6	lon	Longitude (DDDmm.mm)	yyyyy.yy	11402.3581636
7	lon dir	Longitude direction (E = East, W = West)	a	W
8	speed Kn	Speed over ground, knots	x.x	0.3886308
9	track true	Track made good, degrees True	x.x	130.632
10	date	Date: dd/mm/yy	xxxxxx	150792
11	mag var	Magnetic variation, degrees [2]	x.x	0.000
12	var dir	Magnetic variation direction E/W[1]	a	E
13	*xx	Checksum	*hh	*4B
14	[CR][LF]	Sentence terminator		[CR][LF]

Example:

```
$GPRMC,220216.50,A,5106.7187663,N,11402.3581636,W,0.3886308,130.632,150792,
0.000,E*4B[CR][LF]
```

NOTES:

- Easterly variation (E) subtracts from True course
  Westerly variation (W) adds to True course
- Note that this field is the actual magnetic variation East or West and is the inverse sign of the value entered into the MAGVAR command. See MAGVAR, page 37, for more information.

GPVTG   Track Made Good And Ground Speed   *B*

The track made good and speed relative to the ground.

Structure:

`$GPVTG` `track true` `T` `track mag` `M` `speed Kn` `N` `speed km` `K` `*xx` `[CR][LF]`

Field	Structure	Field Description	Symbol	Example
1	$GPVTG	Log header		$GPVTG
2	track true	Track made good, degrees True	x.x	24.168
3	T	True track indicator	T	T
4	track mag	Track made good, degrees Magnetic; Track mag = Track true + (MAGVAR correction) See MAGVAR command, page 37.	x.x	24.168
5	M	Magnetic track indicator	M	M
6	speed Kn	Speed over ground, knots	x.x	0.4220347
7	N	Nautical speed indicator (N = Knots)	N	N
8	speed km	Speed, kilometers/hour	x.x	0.781608
9	K	Speed indicator (K = km/hr)	K	K
10	*xx	Checksum	*hh	*7A
11	[CR][LF]	Sentence terminator		[CR][LF]

Example:

```
$GPVTG,24.168,T,24.168,M,0.4220347,N,0.781608,K*7A[CR][LF]
```

GPZDA   UTC Time and Date   *B*

This log will output all null data fields until the GPSCard has achieved first fix.

Structure:

`$GPZDA` `utc` `day` `month` `year` `null` `null` `*xx` `[CR][LF]`

Field	Structure	Field Description	Symbol	Example
1	$GPZDA	Log header		$GPZDA
2	utc	UTC time	hhmmss.ss	220238.00
3	day	Day, 01 to 31	xx	15
4	month	Month, 01 to 12	xx	07
5	year	Year	xxxx	1992
6	null	Local zone description - not available	xx	, ,
7	null	Local zone minutes description [1] - not available	xx	, ,
8	*xx	Checksum	*hh	*6F
9	[CR][LF]	Sentence terminator		[CR][LF]

Example:

```
$GPZDA,220238.00,15,07,1992,00,00*6F[CR][LF]
```

[1] **NOTE**: The GPSCard does not support Local time zones. Fields 6 and 7 will always be null.

GPZTG UTC & Time to Destination Waypoint *B*

This log reports time to destination waypoint. Waypoint is set using the GPSCard SETNAV command. If destination waypoint has not been set with SETNAV, time-to-go and destination waypoint ID will be null. This log will output all null data fields until the GPSCard has achieved first fix.

Structure:

`$GPZTG` `utc` `time` `dest ID` `*xx` `[CR][LF]`

Field	Structure	Field Description	Symbol	Example
1	$GPZTG	Log header		$GPZTG
2	utc	UTC of position	hhmmss.ss	220245.00
3	time	Time to go (995959.00 maximum reported)	hhmmss.ss	994639.00
4	dest ID	Destination waypoint ID	c--c	END
5	*xx	Checksum	*hh	*36
6	[CR][LF]	Sentence terminator		[CR][LF]

Example:

```
$GPZTG,220245.00,994639.00,END*36[CR][LF]
```

8 RTCM STANDARD COMMANDS AND LOGS

The Global Positioning System is a world-wide positioning service developed by the U.S. Department of Defense (DOD) and is operated and maintained by the U.S. Air Force Space Division. As usage of the GPS Standard Positioning Service (SPS) has gained world wide commercial acceptance, the applications have become wide and varied. Of special importance have been the developments in the use of differential GPS (DGPS). DGPS enables system users to leap from nominal 100 m system accuracies (single point) to the more desirable 1 - 5 m nominal accuracies possible from utilizing differential corrections between reference and remote stations.

As DGPS systems exist all over the world, the need arose to establish a set of operating standards that all DGPS receivers could use for the purpose of transmitting and receiving differential corrections between GPS receivers of various types, regardless of receiver design or manufacturer.

The Radio Technical Commission for Maritime Services (RTCM) was established to facilitate the establishment of various radionavigation standards, which includes recommended GPS differential standard formats.

The standards recommended by the Radio Technical Commission for Maritime Services Special Committee 104, Differential GPS Service (RTCM SC-104,Washington, D.C.), have been adopted by NovAtel for implementation into the GPSCard receivers with the "R" option. Because the GPSCard is capable of utilizing RTCM formats, it can easily be integrated into positioning systems around the globe.

As it is beyond the scope of this manual to provide in-depth descriptions of the RTCM data formats, it is recommended that anyone requiring explicit descriptions of such, should obtain a copy of the published RTCM specifications. See Appendix D, page 178, for reference information.

RTCM GENERAL MESSAGE FORMAT

All GPSCard RTCM standard format logs adhere to the structure recommended by RTCM SC-104. Thus, all RTCM message are composed of 30 bit words. Each word contains 24 data bits and 6 parity bits. All RTCM messages contain a 2-word header followed by 0 to 31 data words for a maximum of 33 words (990 bits) per message.

Message Frame Header	Data	Bits
Word 1	– Message frame preamble for synchronization – Frame/message type ID – Reference station ID – Parity	8 6 10 6
Word 2	– Modified z-count (time tag) – Sequence number – Length of message frame – Reference station health – Parity	13 3 5 3 6

The remainder of this chapter will provide further information concerning GPSCard commands and logs that utilize the RTCM data formats.

GPSCard COMMANDS

All of the GPSCard commands that follow are only available with the “R” option.

RTCMRULE *R*

The RTCM standard states that all equipment shall support the use of the “6 of 8” format (data bits a_1 through a_6 where bits a_1 through a_6 are valid data bits and bit a_7 is set to mark and bit a_8 is set to space.

The GPSCard RTCMRULE command allows for flexibility in the use of the bit rule to accommodate compatibility with equipment that does not strictly adhere to the RTCM stated rule.

Syntax:

```
RTCMRULE  rule
```

Syntax	Range Value	Description	Default
RTCMRULE	-	Command	
rule	6CR	6CR is for 6 bits of valid data per byte. A <CR> character follows each frame.	6CR
	6SP	6SP (6 bit special); the RTCM decoder of the remote receiver will ignore the two MSB of the data and hence all 6 bit data will be accepted. This allows users with non-conforming 6 bit rule data to use the NovAtel receiver to accept their RTCM data. The user will not be allowed to enter extra control data such as CR/LF, as this will be treated as RTCM data and cause the parity to fail. This option does not affect RTCM generation. The output will be exactly the same as if the RTCMRULE 6 option was chosen. The upper two bits are always encoded as per RTCM specification.	
	6	6 is for 6 bits of valid data per byte	
	8	8 is for 8 bits of valid data per byte	

Example:

```
rtcmrule 6cr
```

RTCM16T *R*

This is a NovAtel GPSCard command that relates to the RTCM Type 16 – Special Message.

This command allows the GPSCard user to set an ASCII text string. Once set, the text string can be transmitted as standard format RTCM Type 16 data (refer to the RTCM16 log, page 100). The text string entered is limited to a maximum of 90 ASCII characters. This message is useful for a reference station wanting to transmit special messages to remote users.

The text string set here can be verified by observing the RCCA command configuration log. As well, the message text can be transmitted as a NovAtel Format ASCII log by utilizing the “LOG *port* RTCM16T” command.

Syntax:

```
RTCM16T  message
```

Syntax	Range Value	Description
RTCM16T	-	Command
message	up to 90 characters	ASCII text message

Example:

```
rtcm16t This is a test of the RTCM16T Special Message.
```

GPSCard LOGS

All of the GPSCard logs that follow are only available with the "R" option.

RTCM *R*

This is the primary RTCM log used for pseudorange differential corrections. This log follows RTCM Standard Format for Type 1 messages. It contains the pseudorange differential correction data computed by the reference station generating this Type 1 log. The log, depending on the number of satellites visible and pseudoranges corrected by the reference station, is of variable length. Satellite specific data begins at word 3 of the message.

Structure:

```
(Follows RTCM Standard for Type 1 message)
```

Type 1 messages contain the following information <u>for each satellite in view</u> at the reference station:

- Satellite ID
- Pseudorange correction
- Range-rate correction
- Issue of Data (IOD)

When operating as a reference station, the GPSCard must be in FIX POSITION mode before the data can be correctly logged.

When operating as a remote station, the GPSCard COM port receiving the RTCM data must have its ACCEPT command set to "ACCEPT *port* RTCM".

REMEMBER: Upon a change in ephemeris, GPSCard reference stations will transmit Type 1 messages based on the old ephemeris for a period of time defined by the dgpstimeout command. After the timeout, the reference station will begin to transmit the Type 1 messages based on new ephemeris.

RTCMA *R*

This log contains the same data available in the RTCM Standard Format Type 1 messages, but has been modified to allow flexibility in using the RTCM data. The RTCM data has been reformatted to be available in ASCII hexadecimal, utilizing a NovAtel header and terminates with a checksum.

This message was designed so that RTCM data can be intermixed with other NovAtel ASCII data over a common communications port. The log is not in pure RTCM SC104 format. The header ($RTCM) and terminator (*xx) must be stripped off at the receiving end, then the data will need to be converted from hexadecimal to binary before the RTCM information is retrieved. The RTCM data is further defined by the RTCM rule (refer to the RTCMRULE command, page 40).

Other NovAtel GPSCard receivers operating as remote stations can directly decode The RTCMA log. They will recognize the $RTCM header as a special data input command and the differential correction data will be directly applied. The GPSCard remote station receiving this log must have the ACCEPT command set to "ACCEPT *port* COMMANDS".

Structure:

$RTCM	rtcm data	*xx	[CR][LF]

Field #	Field Type	Data Description	Example
1	$RTCM	NovAtel format ASCII header	$RTCM
2	rtcm data	hexadecimal representation of binary format RTCM SC104 data	664142406B61455F565F7140607E5D526A5366C7 C7F6F5A5B766D587D7F535C4B697F54594060685 652625842707F77555B766558767F715B7746656B
3	*xx	Checksum	*54
4	[CR][LF]	Sentence terminator	[CR][LF]

Example:

```
$RTCM,664142406B61455F565F7140607E5D526A5366C7C7F6F5A5B766D587D7F535C4B6
97F54594060685652625842707F77555B766558767F715B7746656B*54[CR][LF]
```

RTCMB *R*

This log contains the same data available in the RTCM Standard Format Type 1 messages, but has been modified to allow flexibility in using the RTCM data. The RTCM data has been reformatted to be available in NovAtel Binary Format, utilizing a NovAtel binary header.

This message was designed so that RTCM data can be transmitted intermixed with other NovAtel binary data over a common communications port. The log is not in pure RTCM SC104 format and is not directly usable as such. GPSCard remote receivers cannot decode or interpret the RTCMB data (however, the GPSCard can directly interpret RTCM and RTCMA). The 12 byte NovAtel binary header must be stripped off before the RTCM information can be retrieved. The RTCM data is further defined by the RTCM rule (refer to the RTCMRULE command, page 40).

REMEMBER: Ensure that the RTCM rule is the same between all equipment.

Format: Message ID = 10 Message byte count = variable

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer	bytes	8
2	Data	variable		RTCM SC104 data	12

RTCM3 *R*

The RTCM Type 3 log contains the reference position of the reference station expressed in ECEF XYZ WGS-84 parameters (regardless of the local operating datum).

This log uses four RTCM data words following the header, for a total frame length of six 30 bit words (180 bits maximum).

The GPSCard only transmits the RTCM Type 3 message (RTCM3) when operating as a reference station paired with GPSCard remote receivers operating in RT-20 Carrier Phase Mode. (Refer to Chapter 11, page 148, for more information.)

GPSCard remote receivers must utilize the “ACCEPT *port* RT20” before the RTCM3 data can be decoded and processed.

NOTE: This log is intended for use when operating in RT-20 mode.

RTCM16 *R*

This log contains special ASCII text information as set by the reference station. The default setting for the RTCM16 data log follows RTCM Standard Format. Words 1 and 2 contain RTCM header information followed by words 3 to n (where n is variable from 3 to 32) which contain the special message ASCII text. Up to 90 ASCII characters can be sent with each RTCM Type 16 message frame.

Structure (variable):

- RTCM Standard format Type 16 message when used with RTCM Type 1 log.
- NovAtel ASCII hex version when used with RTCMA Type 1 log.
- NovAtel binary version when used with RTCMB Type 1 log.

For GPSCards operating as a reference station, the RTCM16 message can be logged out to remote stations capable of receiving RTCM Type 16 messages. The GPSCard reference station must use the RTCM16T command to set the required ASCII text message. Once set, the message can then be issued at the required intervals with the "LOG *port* RTCM16 *interval*" command. If the reference station desires that only updated text messages be transmitted, it is recommended that the GPSCard log interval be set to "onnew" or "onchanged".

GPSCard receivers operating as remote stations must have the ACCEPT command set to ACCEPT *port* RTCM before the GPSCard will decode the RTCM Standard Format messages.

GPSCard receivers, operating as remote stations, do not require any special settings to receive the RTCM16 message when received as NovAtel ASCII hexadecimal format (refer to the RTCMA log, page 100, for handling of RTCMA ASCII hexadecimal data). However the ACCEPT command must be set to "COMMANDS".

The NovAtel binary version of RTCM16 cannot be directly decoded by a GPSCard receiver (refer to the RTCMB log, page 100, for handling of RTCMB binary data).

REMEMBER: The default format is RTCM16 Standard Format. However, the format of the RTCM16 message will change to be the same as the last RTCM differential corrections format used for differential corrections (RTCM, RTCMA, or RTCMB). For example, if an RTCMA log was the last log format transmitted on com1 to send differential corrections, then issuing the command "log com1 rtcm16" will transmit the message in NovAtel ascii hex format.

RTCM16T *R*

This NovAtel Format ASCII log is used to report the contents of the RTCM Type 16 Special Message. If the GPSCard sending this log is operating as a reference station, the log is used to report the Special Message settings of the GPSCard RTCM16T command. (The Special Message setting can also be verified in the RCCA configuration log.)

If the GPSCard sending this log is operating as a remote station, it can be used to report to the user the RTCM Type 16 Special Message received over the data link from the reference station.

Structure:

`$RTCM16T`	`ASCII Special Message of up to 90 characters`	`*xx`	`[CR][LF]`

When logging RTCM16T messages, it is recommended that you use the "onnew" or "onchanged" logging trigger; this will avoid unnecessary repetition of old messages.

RTCM59 *RT20 (51)*

RTCM Type 59 messages are reserved for proprietary use by RTCM reference station operators. NovAtel has defined this message as a Type 59N message and has dedicated its use for operation in GPSCard receivers capable of operating in RT-20 Carrier Phase Differential Positioning Mode.

This log is primarily used by GPSCard receivers to broadcast RT-20 reference station observation data to remote RT-20–capable GPSCard receivers. This log may be variable in length, up to the RTCM maximum of 990 data bits (33 words maximum).

Remote GPSCard receivers must utilize the “ACCEPT *port* RT20” command to decode the Type 59N data.

NOTES:

- The CDSA/B log is very useful for monitoring the serial data link, as well as differential data decode success.
- This log is intended for use when operating in RT-20 mode. GPSCards with the RT-20 option can transmit or receive this log, however GPSCard models xx51r can only transmit this log.

RTCM RECEIVE ONLY DATA

The following RTCM data types can be received and decoded by the GPSCard, however these log types are no longer transmitted.

RTCM Type 2 *R*

Quite often a reference station may have new ephemeris data before remote stations have collected the newer ephemeris. The purpose of Type 2 messages is to act as a bridge between old and new ephemeris data. A reference station will transmit this Type 2 bridge data concurrently with Type 1’s for a few minutes following receipt of a new ephemeris. The remote station adds the Type 2 data (delta of old ephemeris minus new ephemeris) to the Type 1 message data (new ephemeris) to calculate the correct pseudorange corrections (based on the old ephemeris). Once the remote receiver has collected its own updated ephemeris, it will no longer utilize the Type 2 messages.

The GPSCard will accept and decode RTCM Standard Type 2 messages, when available and if required. However, the GPSCard no longer transmits Type 2 messages.

Type 2 messages are variable in length, depending on the number of satellites being tracked by the reference station.

RTCM Type 9 *R*

RTCM Type 9 messages follow the same format as Type 1 messages. However, unlike Type 1 messages, Type 9’s do not require a complete satellite set. This allows for much faster differential correction data updates to the remote stations, thus improving performance and reducing latency.

The reference station transmitting the Type 9 corrections must be operating with a high stability clock to prevent degradation of navigation accuracy due to unmodelled clock drift that can occur between Type 9 messages.

All GPSCards with the “R” option are capable of receiving and decoding Type 9 messages.

NOTE: Currently, Type 9 messages are not transmitted from GPSCard reference stations (unless specially configured).

9 RTCA STANDARD LOGS

The RTCA (Radio Technical Commission for Aviation Services) Standard is being designed to support Differential Global Navigation Satellite System (DGNSS) Special Category I (SCAT-I) precision instrument approaches. The RTCA Standard is in a preliminary state. Described below is NovAtel's current support for this Standard. It is based on "Minimum Aviation System Performance Standards DGNSS Instrument Approach System: Special Category I (SCAT-I)" dated August 27, 1993 (RTCA/DO-217).

GPSCard LOGS

Only GPSCard receivers with the "R" option can generate or utilize RTCA logs.

RTCA *R*

This log enables transmission of RTCA Standard format Type 1 messages from the GPSCard when operating as a reference station. Before this message can be transmitted, the GPSCard FIX POSITION command must be set. The RTCA log will be accepted by a GPSCard operating as a remote station over a COM port after an ACCEPT *port* RTCA command is issued.

The RTCA Standard for SCAT-I stipulates that the maximum age of differential correction (Type 1) messages accepted by the remote station cannot be greater than 22 seconds. Refer to the DGPSTIMEOUT command, page 27, in Chapter 2, for information regarding DGPS delay settings.

The RTCA Standard also stipulates that a reference station shall wait five minutes after receiving a new ephemeris before transmitting differential corrections. Refer to the DGPSTIMEOUT command, page 27, for information regarding ephemeris delay settings.

The basic SCAT-I Type 1 differential correction message is as follows:

Format: Message length = 11 + (6*obs) : (83 bytes maximum)

Field Type	Data	Bits	Bytes
SCAT-I header	– Message block identifier – Reference station ID – Message type (this field will always report 00000001) – Message length	8 24 8 8	6
Type 1 header	– Modified z-count – Acceleration error bound (In the GPSCard, this field will report 000)	13 3	2
Type 1 data	– Satellite ID – Pseudorange correction † – Issue of data – Range rate correction † – UDRE	6 16 8 12 6	6 * obs
CRC	Cyclic redundancy check		3

† The pseudorange correction and range rate correction fields have a range of ±655.34 m and ±4.094 m/s respectively. Any satellite that exceeds these limits will not be included.

RTCAA *R*

This log contains the same data available in the RTCA SCAT-I message, but has been modified to allow flexibility in using the RTCA data. The RTCA data has been reformatted to be available in ASCII hexadecimal, utilizing a NovAtel header and terminates with a checksum.

This message was designed so that RTCA data can be intermixed with other NovAtel ASCII data over a common communications port. The log is not in pure RTCA format. The header ($RTCA) and terminator (*xx) must be stripped off at the receiving end, then the data will need to be converted from hexadecimal to binary before the RTCA information is retrieved.

Other NovAtel GPSCard receivers, operating as remote stations, can directly decoded the RTCAA log. They will recognize the $RTCA header as a special data input command and the differential correction data will be directly applied. The GPSCard remote station receiving this log must have the ACCEPT command set to “ACCEPT *port* COMMANDS”.

Structure:

$RTCA	rtca data	*xx	[CR][LF]

Field #	Field Type	Data Description	Example
1	$RTCA	Log header	$RTCA
2	SCAT-I	SCAT-I type 1 differential corrections	990000000447520607BE7C92FA0B82423E9FE507DF5F3FC9FD0 71AFC7FA0D207D090808C0E045BACC055E9075271FFB020041 3F43FF810049C9DFF8FFD074FCF3C940504052DFB
3	*xx	Checksum	*20
4	[CR][LF]		[CR][LF]

Example:

```
$RTCA,990000000447520607BE7C92FA0B82423E9FE507DF5F3FC9FD071AFC7FA0D207D090808C0E
045BACC055E9075271FFB0200413F43FF810049C9DFF8FFD074FCF3C940504052DFB*20[CR][LF]
```

RTCAB *R*

The RTCAB log contains the SCAT-I differential corrections message with the standard NovAtel binary log preamble (header) added. The GPSCard, over a COM port, after an “ACCEPT PORT RTCA” command is issued, will accept the RTCAB log.

Format: Message ID = 38 Message byte count = 12 + (11+(6*obs)) : 95 bytes maximum

Field #	Data	Bytes	Format	Units	Offset
1	Sync	3	char		0
(header)	Checksum	1	char		3
	Message ID	4	integer		4
	Message byte count	4	integer	bytes	8
2	– Message block identifier – Reference station ID – Message type – Message length	6			12
3	– Modified z-count – Acceleration error bound	2			18
4	– Satellite ID – Pseudorange correction – Issue of data – Range rate correction – UDRE	6			20
5	Next PRN offset = 26 + (6*obs) where obs varies from 0 to (obs1)				
6	CRC	3			

10 PSEUDORANGE DIFFERENTIAL POSITIONING

GPS SYSTEM ERRORS

In general, GPS SPS C/A code single point pseudorange positioning systems are capable of absolute position accuracies of about 100 m or less. This level of accuracy is really only an estimation, and may vary widely depending on numerous GPS system biases, environmental conditions, as well as the GPS receiver design and engineering quality.

There are numerous factors that influence the single point position accuracies of any GPS C/A code receiving system. As the following list will show, a receiver's performance can vary widely when under the influences of these combined system and environmental biases.

- **Ionospheric Group Delays** – The earth's ionospheric layers cause varying degrees of GPS signal propagation delay. Ionization levels tend to be highest during daylight hours causing propagation delay errors of up to 30 m, whereas night time levels are much lower and may be up to 6 m.
- **Tropospheric Refraction Delays** – The earth's tropospheric layer causes GPS signal propagation delays that biases the range measurement. The amount of delay is at the minimum (about 3 m) for satellite signals arriving from 90 degrees above the horizon (overhead), and progressively increases as the angle above the horizon is reduced to zero where delay errors may be as much as 50 m at the horizon.
- **Ephemeris Errors –** Some degree of error always exists between the broadcast ephemeris' predicted satellite position and the actual orbit position of the satellites. These errors will directly affect the accuracy of the range measurement.
- **Satellite Clock Errors** – Some degree of error also exists between the actual satellite clock time and the clock time predicted by the broadcast data. This broadcast time error will cause some bias to the pseudorange measurements.
- **Receiver Clock Errors –** Receiver clock error is the time difference between GPS receiver time and true GPS time. All GPS receivers have differing clock offsets from GPS time that vary from receiver to receiver by an unknown amount depending on the oscillator type and quality (TCXO vs. OCXO, etc.). However, because a receiver makes all of its single point pseudorange measurements using the same common clock oscillator, all measurements will be equally offset, and this offset can generally be modeled or quite accurately estimated to effectively cancel the receiver clock offset bias. Thus, in single point positioning, receiver clock offset is not a significant problem. However, in pseudorange differential operation, between-receiver clock offset is a source of uncorrelated bias.
- **Selective Availability (SA)** – Selective availability is when the GPS Control Segment intentionally dithers satellite clock timing and broadcast orbit data to cause reduced positioning accuracy for general purpose GPS SPS users (non-military). When SA is active, range measurements may be biased by as much as 30 m.
- **Multipath Signal Reception** – Multipath signal reception can potentially cause large pseudorange and carrier phase measurement biases. Multipath conditions are very much a function of specific antenna site location versus local geography and man-made structural influences. Severe multipath conditions could skew range measurements by as much as 100 m or more. (See Chapter 12, page 158, for more information about multipath).

The NovAtel GPSCard Series of receivers are capable of absolute single point positioning accuracies of 15 m CEP (GDOP < 2; no multipath) when SA is off and 40 m CEP while SA is on. (As the status of selective availability is generally unknown by the real-time GPS user, the positioning accuracy should be considered to be that of when SA is on).

The general level of accuracy available from single point operation may be suitable for many types of positioning such as ocean going vessels, general aviation, and recreational vessels that do not require position accuracies of better than 100 m CEP. However, increasingly more and more applications desire and require a much higher degree of accuracy and position confidence than is possible with single point pseudorange positioning. This is where differential GPS (DGPS) plays a dominant role in higher accuracy real-time positioning systems.

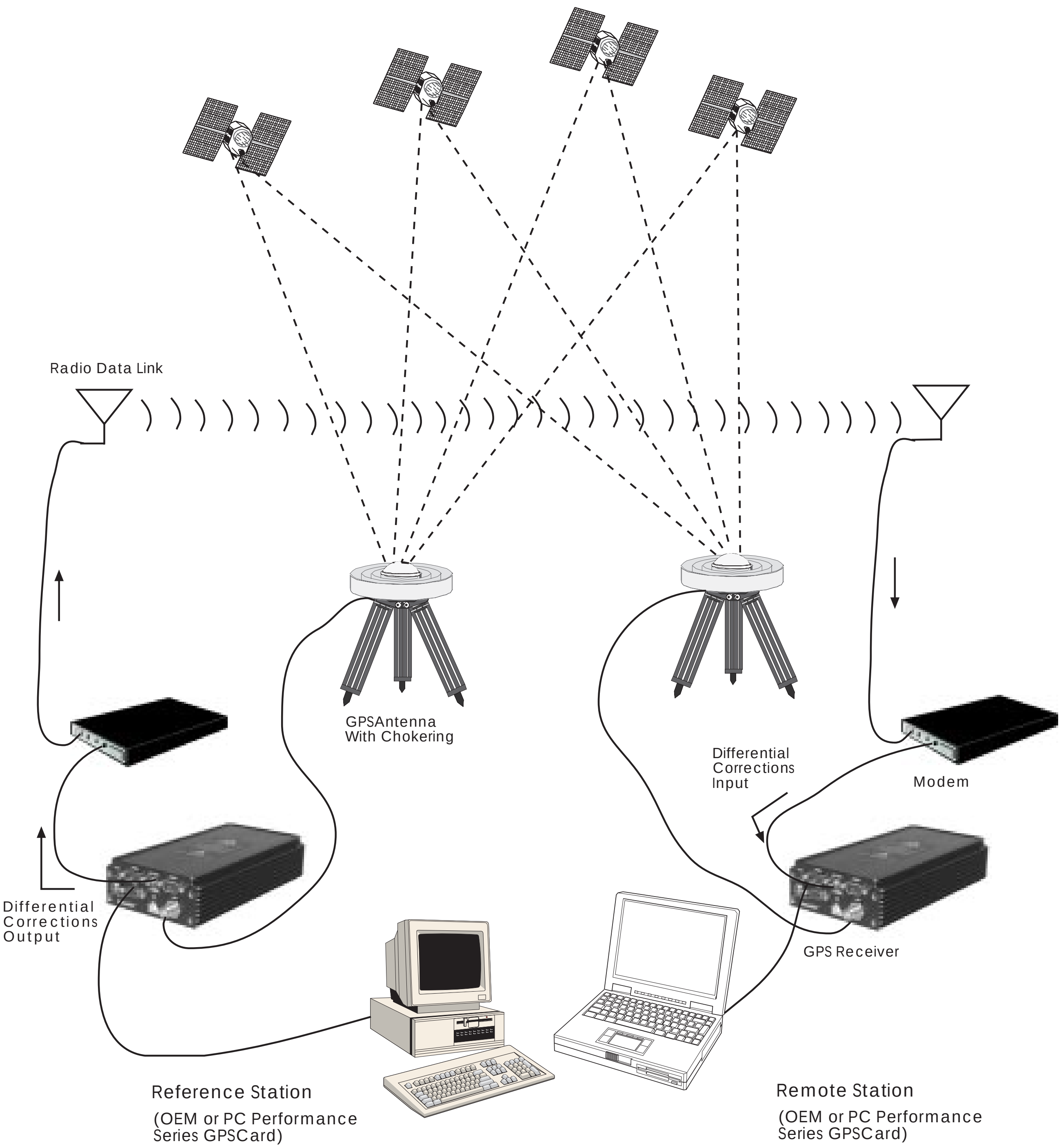
DUAL STATION DIFFERENTIAL POSITIONING

It is the objective of operating in differential mode to either eliminate or greatly reduce most of the errors introduced by the above types of system biases. Pseudorange differential positioning is quite effective in largely removing most of the biases caused by satellite clock error, ionospheric and tropospheric delays (for baselines less than 50 km), ephemeris prediction errors, and SA. However, the biases caused by multipath reception and receiver clock offset are uncorrelated between receivers and thus cannot be cancelled by "between receiver single differencing" operation.

Differential operation requires that stations operate in pairs. Each pair consists of a reference station and a remote station. A differential network could also be established when there is more than one remote station linked to a single reference station.

In order for the differential pair to be effective, differential positioning requires that both reference and remote station receivers track and collect satellite data simultaneously from common satellites. When the two stations are in relatively close proximity (< 50 km), the pseudorange bias errors are considered to be nearly the same and can be effectively cancelled by the differential corrections. However, if the baseline becomes excessively long, the bias errors begin to decorrelate, thus reducing the accuracy or effectiveness of the differential corrections.

Figure 10-1 Typical Differential Configuration



THE REFERENCE STATION

The nucleus of the differential network is the reference station. To function as a reference station, the GPS receiver antenna must be positioned at a bench-mark whose position is fixed and of known precision. Typically, the fixed position will be that of a geodetic marker or a pre-surveyed point of known accuracy.

The reference receiver must then be initialized to fix its position to agree with the latitude, longitude, and height of the phase centre of the reference station GPS receiver antenna. Of course, the antenna offset position from the marker must be accurately accounted for.

Because the reference station's position is fixed at a known location, it can now *compute* the range of its known position to the satellite. The reference station now has two range measurements with which to work: *computed pseudoranges* based on its known position relative to the satellite, and *measured pseudoranges* which assumes the receiver position is unknown. Now, the reference station's measured pseudorange (unknown position) is differenced against the computed range (based on known position) to derive the differential correction which represents the difference between known and unknown solutions for the same antenna. This difference between the two ranges represents the combined pseudorange measurement errors resulting from atmospheric delays, satellite clock error, orbital errors, and SA.

The reference station will derive pseudorange corrections for each satellite being tracked. These corrections can now be transmitted over a data link to one or more remote stations. It is important to ensure that the reference station's FIX POSITION setting be as accurate as possible, as any errors here will directly bias the pseudorange corrections computed. As well, the reference station's pseudorange measurements may be biased by multipath reception. Refer to Chapter 12, page 158, for further discussions on multipath issues.

THE REMOTE STATION

A remote station is generally any receiver whose position is of unknown accuracy, but has ties to a reference station through an established data link. If the remote station is not receiving differential corrections from the reference station, it is essentially utilizing single point positioning measurements for its position solutions, thus is subject to the various GPS system biases. However, when the remote GPS receiver is receiving a pseudorange correction from the reference station, this correction is algebraically summed against the local receiver's measured pseudorange, thus effectively canceling the effects of orbital and atmospheric errors (assuming baselines < 50 km), as well as eliminating satellite clock error.

The remote must be tracking the same satellites as the reference in order for the corrections to take effect. Thus, only common satellites will utilize the differential corrections. When the remote is able to compute its positions based on pseudorange corrections from the reference, its position accuracies will approach that of the reference station. Remember, the computed position solutions are always that of the GPS receiving antenna phase centre.

THE GPSCard AND DIFFERENTIAL POSITIONING

The NovAtel GPSCard Performance Series receivers with the "R" option are capable of operation utilizing pseudorange "between-receiver single differencing" techniques. The accuracy gains are quite substantial for GPSCard receivers operating as a differential "remote station" as compared to single point positioning. Previously, it was stated that a GPSCard operating in single point mode is capable of absolute position accuracies of about 40 m CEP (SA on). Now, when two GPSCards are operated as a differential pair (one reference and one remote), the remote receiver is capable of absolute position accuracies of 2 m or less when operated with the GPSAntenna model 501 (no choke ring ground plane, low multipath). And, when operated with the GPSAntenna 501 *with* the NovAtel Choke Ring Ground Plane, pseudorange position accuracies of less than 1 m are possible. If the receivers have the "RM" option (Real-time differential, and MET - Multipath Elimination Technology), then absolute position accuracies of 0.75 m are achievable. To achieve accuracies better than 0.75 m, the GPSCard user will require the GPSCard RT-20 option. Refer to Chapter 11, page 148, for more information about RT-20.

OPERATING THE GPSCard IN DIFFERENTIAL MODES

Any OEM or PC Series GPSCard with the "R" option is capable of operating in differential mode. As well, these receivers are capable of operating as either a reference station or a remote station. This makes the GPSCard Series ideal for design into DGPS systems.

The GPSCard is capable of utilizing various formats of differential corrections. These formats are divided into three primary groups. Refer to Table 10-1, page 141, for a list of these formats.

For detailed data structure information concerning these logs, please refer to Chapter 4, page 52, Chapter 5, page 54, and Chapter 8, page 129.

Table 10-1 Summary of GPSCard Differential Corrections Formats

NovAtel Proprietary Format				RTCM Formats		RTCA Formats	
ASCII	**Tx/Rx**	**Binary**	**Tx/Rx**	**All Binary**	**Tx/Rx**	**All Binary**	**Tx/Rx**
DCSA	Tx/Rx	DCSB	Tx/Rx	RTCM(1)	Tx/Rx	RTCA	Tx/Rx
RTCMA	Tx/Rx	RTCMB	Tx	RTCM(2)	Rx		
RTCAA	Tx/Rx	RTCAB	Tx/Rx	RTCM(3)	Tx/(Rx)		
				RTCM(9)	Rx see notes		
				RTCM(16)	Tx/Rx		
				RTCM(59)	Tx/(Rx)		

NOTES:

- Tx = GPSCard capable of transmitting this log.
- Rx = GPSCard capable of decoding this log.
- RTCMA and RTCMB differential logs contain RTCM type 1 data formatted in NovAtel ASCII/Binary formats.
- RTCAA and RTCAB differential logs contain RTCA data formatted into NovAtel ASCII/Binary formats.
- RTCM(3) and RTCM(59) differential logs can only be received by GPSCards with the RT-20 option.
- Only GPSCards specially configured for OCXO operation can transmit RTCM(9) data.
- To utilize differential corrections, the GPSCard must have the "R" option.

ESTABLISH A DATA LINK

Operating the GPSCard with a DGPS system requires that the reference station broadcast differential correction data messages to one or more remote receivers. As there are many methods by which this can be achieved, it is left to the responsibility of the system provider to establish an appropriate data link that best suits the system remote user requirements.

Whatever data link is chosen, the reference station will want to ensure that the bit rate of data transmission is suitable for the anticipated data link and remote users. Use the GPSCard COMn command to change the COM port default bit rate (default is 9600 bps, no parity, 8 data bits, 1 stop bit, no handshake, echo off).

Note that the GPSCard COMn_DTR and COMn_RTS commands are available for remote device keying (such as a radio transmitter). These commands allow for flexible control of the DTR and RTS lines to be precisely timed with log transmissions.

INITIALIZATION – REFERENCE STATION

Differential mode of operation is established at the reference station through a two step process: fix position and logging observation and correction data.

FIX POSITION

The reference station must initialize the precise position of its reference antenna phase centre (lat/lon/hgt). This is accomplished by utilizing the GPSCard FIX POSITION command. The syntax is as follows:

Syntax:

```
FIX POSITION  lat  lon  height  station id  health
```

Example:

```
fix position 51.3455323,-114.2895345,1201.123,555,0
```

NOTES:

- Entry of the station ID and health are optional.
- The accuracy of the reference station's fix position setting will directly affect the accuracy of its computed differential corrections. Good results at the remote station are dependent on the reference station's combined position errors being kept to a minimum (e.g., fix position error + multipath errors).
- The GPSCard performs all computations based on WGS-84 and is defaulted as such, regardless of datum command setting. The datum in which you choose to operate is converted to and from WGS-84; therefore, all differential corrections are based on WGS-84. Ensure that any change in your operating datum is set prior to fix position.
- When transmitting RTCM type data, the GPSCard has various options for assigning the number of data bits per byte. Please refer to the GPSCard command rtcmrule, page 40, for further information concerning RTCM data bit rule settings.
- The fix position "health" field entered will be reported in word 2 of the RTCM message frame header.

Once the GPSCard has its position fixed and is tracking three or more satellites, it is now ready to transmit differential correction and observation data to the remote stations.

LOG BROADCAST DATA

Assuming that a data link has been established, use the GPSCard LOG command to send observation and differential corrections data for broadcast to the remote stations.

Syntax:

```
LOG   port  data  ontime  seconds
```

Example:

```
log com1 dcsb ontime 5
```

REMINDER: Ensure that the bit rate of the data link is suitable for the differential data type, logging rate and maximum message length of the data type being logged.

OPTIONS FOR LOGGING DIFFERENTIAL CORRECTIONS

The logging method used for sending differential corrections from the reference station to a remote station will depend on various factors that the user will weigh for optimal advantage. The GPSCard is capable of sending differential corrections data types listed in *Table 10-1* to its paired remote stations.

The remote station may or may not be a NovAtel GPSCard receiver. The GPSCard, whether it be a PC Series or OEM Series, is capable of sending logs in various formats to accommodate varying situations and requirements. The following chapters will give an overview of each type of differential corrections log provided by the GPSCard and its intended applications.

SET DGPSTIMEOUT

The DGPSTIMEOUT command allows the reference station to set the delay period by which it will inhibit utilization of new ephemeris data in its differential corrections. This delay ensures that the remote receivers have had sufficient time to collect updated ephemeris data as well.

A delay of 120 to 300 seconds will typically ensure that the remote stations have collected updated ephemeris. After the delay period is passed, the reference station will begin using new ephemeris data. To enter an ephemeris delay value, you must first enter a numeric placeholder in the DGPS delay field (e.g., 2). When operating as a reference station, DGPS delay will be ignored (refer to the DGPSTIMEOUT command, page 27, for further information on using this command at remote stations).

Syntax:

```
DGPSTIMEOUT  dgps delay  ephem delay
```

Command	Option	Description	Default
DGPSTIMEOUT		Command	
dgps delay	min. 2 max. 1000	Maximum age in seconds	60
ephem delay	min. 0 max. 600	Minimum time delay in seconds	120

Example:

```
dgpstimeout 2,300
```

USING THE DCSA DIFFERENTIAL CORRECTIONS LOG

This data type can be logged out any port of the GPSCard reference station and accepted through any port of the GPSCard remote station without dedicating a port for this purpose. The DCSA data type is *directly digestible* by any NovAtel GPSCard Series of receivers and will be recognized as a Special Data Input Command ($DCSA). The remote receiver accepting this data log must have its ACCEPT command set to “ACCEPT *port* COMMANDS”.

If you wish to redirect the DCSA log through the host PC COM ports or MODEM, then you will be required to log to the Console and write your own custom user interface program to properly route the console log to the appropriate destination port.

USING THE DCSB DIFFERENTIAL CORRECTIONS LOG

The DCSB log transmits differential corrections in NovAtel Binary Format. The DCSB binary format is more efficient than DCSA because the DCSB format more closely matches the internal data structure of the GPSCard receiver and requires minimal CPU power to process.

To utilize the DCSB log, the remote station must issue the ACCEPT *port* DCSB command and dedicate one of the GPSCard COM ports for receiving the differential data. Once the ACCEPT *port* DCSB command has been issued, the designated COM port cannot be used for any other command type input.

If the reference station wishes to redirect the DCSB log through the host PC COM ports or MODEM, then you will be required to log to the Console and write your own custom user interface program to properly route the console log to the appropriate destination port.

Remember that even though you may be able to route the DCSB log through your remote station host PC ports, the log can only be interpreted directly into a GPSCard COM1 or COM2 port in conjunction with the remote station ACCEPT *port* DCSB command. If the remote station's *customized user interface program* requires that the received DCSB data be sent across the console bus interface, the custom program running the PC will need to convert the DCSB data to DCSA format and then send them across as $DCSA commands.

NOTE:

- The DCSA/B log is specific to NovAtel cards and cannot be interpreted by GPS receivers supplied by other manufacturers.
- As the checksum of the DCSB log is 1 byte, there is a 1 in 255 possibility that a complete DCSB log will contain an error.
- In previous software releases, this log was recommended as the most efficient differential format because the DCSB format most closely matches the internal data structure of the GPSCard receiver, and requires minimal CPU power to process. However with the introduction of the RTCA Standard, the RTCA log is now the recommended format for greatest efficiency combined with data integrity.

USING RTCM SC-104 LOG TYPES

RTCM SC-104 is a standard for transmitting differential corrections between equipment from different manufacturers. The NovAtel GPSCard is capable of transmitting or receiving RTCM data.

To facilitate transmitting the RTCM data over shared data links, the GPSCard is also capable of sending the RTCM log in NovAtel ASCII format (RTCMA) or with the NovAtel Binary Header (RTCMB) added to allow synchronous transmission and reception along with other data types.

REMEMBER: When sending or receiving RTCM log types, it is important to ensure that all connected equipment are using the same rtcmrule for compatibility.

The easiest method to send **RTCM Standard** logs is from the COM1 or COM2 ports of the reference GPSCard. The easiest method to receive the RTCM data is through the COM1 or COM2 port of the remote GPSCard. The remote GPSCard must issue the “ACCEPT *port* RTCM” command to dedicate a port before it will accept the RTCM data input to that port.

The **RTCMA** log can be intermixed with other NovAtel ASCII data over a common communications port. It will be directly interpreted by a remote GPSCard as a Special Data Input Command ($RTCM). “ACCEPT *port* COMMANDS” must be used with this input command. A non-NovAtel remote station will need to strip off the header ($RTCM) and terminator (*xx), then convert the hexadecimal data to binary before the RTCM Standard data can be retrieved.

The **RTCMB** log can be intermixed with other NovAtel Binary data over a common communications port. A GPSCard operating as a remote station does not directly interpret this log. To accept this log type, the remote station must first strip off the 12 byte NovAtel Binary Header before it can be used as an RTCM Standard differential correction.

REMEMBER: Use the CDSA/B logs to monitor the COM port activity, success, and decoding errors.

USING RTCA LOG TYPES

RTCA logs are currently under development and therefore their format is preliminary. The RTCA (Radio Technical Commission for Aviation Services) Standard is being designed to support Differential Global Navigation Satellite System (DGNSS) Special Category I (SCAT-I) precision approaches. The perceived advantage to using RTCA type messages for transmitting and receiving differential corrections versus using RTCM type messages is that RTCM transmits 30-bit words, and the data is difficult to decode and process because of the parity algorithm used and regular word sizes used. RTCA is transmitted in 8-bit words, which are easier to generate and process decode. The RTCA messages are therefore smaller, they have a 24 bit CRC that is much more robust than RTCM messages, and they permit the use of a four-alpha-character station ID.

RTCA Standard logs can be received through the COM1 or COM2 port of the remote GPSCard. The remote GPSCard must issue the “ACCEPT *port* RTCA” command to dedicate a port before it will accept the RTCA data input to that port. The RTCA logs cannot be intermixed with other logs.

The **RTCAA** log can be intermixed with other NovAtel ASCII data over a common communications port. It will be directly interpreted by a remote GPSCard as a Special Data Input Command ($RTCA). “ACCEPT *port* commands” must be used with this input command. A non-NovAtel remote station will need to strip off the header ($RTCA) and terminator (*xx), then convert the hexadecimal data to binary before the RTCA Standard data can be retrieved.

The **RTCAB** log can be intermixed with other NovAtel binary data. The COM1 or COM2 port of the remote GPSCard must be dedicated to receiving RTCA data only, and so the “ACCEPT *port* RTCA” command must be issued. The remote GPSCard will ignore any data bytes between RTCA messages, including the NovAtel binary log header. The remote GPSCard identifies the RTCAB log by the message block identifier contained in the message, and will interpret only the RTCA data portion of the log.

NOTE: The CDSA/B logs may be used to monitor the COM port activity and differential data decode success.

INITIALIZATION – REMOTE STATION

It is necessary to initialize the remote receiver to accept observation data from the reference station. If the receiver is not correctly initialized, it will proceed to compute solutions in single point positioning mode.

Before initializing, ensure that the data link with the reference station has been properly set up. As well, ensure that the COM port which is to receive the differential data is set up to match the bit rate and protocol settings of the reference station broadcast data.

Establishing differential mode of operation at the remote receiver is primarily a one-step process whereby the ACCEPT command is used to enable reception of observation data from the reference station.

ACCEPT COMMAND

The ACCEPT command is primarily used to set the GPSCard's COM port command interpreter for acceptance of various data formats. For example, if it is set to ACCEPT *port* COMMANDS, the COM port will accept all valid GPSCard ASCII format data (including $DCSA, $RTCM, and $RTCA differential corrections data). On the other hand, if it is set to ACCEPT *port* DCSB, the GPSCard will only accept the NovAtel format DCSB differential corrections data in NovAtel binary format. As well, if it is set to accept "RTCM", the GPSCard command interpreter (for that specified port) will only accept RTCM types 1, 2, 9 , and 16 RTCM Standard data (RTCM types 3 and 59 will not be utilized unless ACCEPT is set to "RT20").

Syntax:

```
ACCEPT    port  mode
```

Example:

```
accept com2 DCSB
```

Once initialized, the remote GPSCard receiver will operate in single point mode until the differential messages are received. If the data messages are lost, the GPSCard will revert to single point positioning until the pseudorange correction messages are restored.

NOTE: Ensure that the GPSCard RTCMRULE settings agree with the bit rule being transmitted by the RTCM reference station. Unless otherwise set, all GPSCards default to 6CR.

LOG POSITION DATA AND OTHER USEFUL DATA

The GPSCard remote receiver has many options for information data logging. To monitor position status, the user may find the PRTKA/B logs to be the most informative. Other options exist, such as POSA/B and GPGGA. As well, velocity data can be found in the VLHA/B, SPHA/B, and GPVTG logs. It is really up to the user's specific applications as to the full range of logs required by the user.

Table 10-2 GPSCard Pseudorange Differential Initialization Summary

REFERENCE STATION	REMOTE STATION
Required: FIX POSITION *lat lon hgt id (health)* LOG *port DATATYPE* ontime *5*	**Required:** ACCEPT *port DATATYPE*
Recommended Options: LOG *DATATYPES* (binary): DCSB RTCMB RTCAB RTCM RTCA LOG *DATATYPES* (ascii): DCSA RTCMA RTCAA	**Recommended Options:** ACCEPT *DATATYPES* (binary): DCSB RTCM RTCA ACCEPT COMMANDS (ascii): DCSA RTCMA RTCAA

REFERENCE STATION	REMOTE STATION
Related Commands /Logs: RTCMRULE DATUM	**Related Commands /Logs:** RTCMRULE DATUM POSA/B PRTKA/B VLHA/B CDSA/B GPGGA
Example 1: fix position 51.3455323 -114.2895345 1201.123 555 0 log com1 RTCM ontime 2 **Example 2:** fix position 51.3455323 -114.2895345 1201.123 555 log com2 dcsa ontime 2	**Example 1:** accept com2 rtcm log com1 posa ontime 1 **Example 2:** accept com2 commands log com1 posa ontime 0.2 log com1 vlha ontime 0.2

NOTE: *Italicized* entries indicate user definable.

Table 10-3 Latency-Induced Extrapolation Error

Time since last reference station observation	Typical extrapolation error (CEP)
0-2 seconds	1 cm/sec
2-7 seconds	2 cm/sec
7-30 seconds	5 cm/sec

11 RT-20 CARRIER PHASE MEASUREMENT SYSTEM

INTRODUCTION

The GPSCard RT-20 option has been developed to fill niche market needs for relatively low cost, real-time DGPS receivers capable of nominal positioning accuracies of 10 to 30 cm, while on-the-fly.

RT-20 provides high performance functionality intended for system developers who need the 10 to 30 cm level of accuracy built into their positioning systems. Allowing for ease of integration, RT-20 is a software option available as an upgrade to existing 12 channel PC Series and OEM Series GPSCards.

RT-20 OVERVIEW

It was discussed in the previous chapter that pseudorange (C/A code) single differencing techniques are capable of positioning accuracies of typically one to 5 m CEP, and NovAtel's 3951R/3151R receivers are capable of pseudorange single differencing accuracies of 0.75 m (real-time) when used with the GPSAntenna 501 and Choke Ring Ground Plane. To improve on this level of accuracy performance, more sophisticated ranging measurement techniques are required.

NovAtel's RT-20 Carrier Phase Measurement System incorporates specialized methods which improves the real-time positioning performance to < 20 cm CEP nominal accuracy. The GPSCard accomplishes this by using pseudorange and carrier phase measurements in a double difference algorithm.

By using carrier phase ranging measurements, sub-wavelength accuracies are easily achievable (one wavelength at L1 carrier frequency = 19.01 cm). It has been widely understood that carrier phase measurements in themselves are not difficult to achieve. However, the problem is in resolving the carrier cycle integer ambiguities (on which cycle are we measuring the phase?). Post processing packages have been doing this for a long time now – but what about in real-time static and kinematic modes where < 20 cm position solutions are required? RT-20 accomplishes this task with the use of its robust floating ambiguity resolution techniques.

To further improve its ranging and positioning confidence, RT-20 combines carrier phase measurements with double differencing techniques. Double differencing utilizes a combination of *observation differences between satellites and receivers*. For baselines less than 10 km, double differencing virtually eliminates all biases (with the exception of multipath) which includes the between-receiver clock errors that single differencing techniques are incapable of eliminating. This reduction of errors enables faster, more accurate and reliable carrier phase floating point ambiguity resolution.

RT-20 FEATURES SUMMARY

RT-20 mode provides the following features list:

- A robust system for applications requiring real-time kinematic accuracies in the 10 to 30 cm range
- Accuracy improves with longer periods of uninterrupted operation (down to 5 cm CEP)
- Nominal velocity accuracy of < 2 cm/sec RMS
- Utilizes double difference positioning techniques acting on GPS L1 carrier phase measurements.
- On-the-fly floating ambiguity resolution without the need for static initialization
- Cycle slip detection in the tracking loops

- OEM format resides on a single printed circuit board (Eurocard) for easy OEM integration into your customized positioning system.
- Utilizes an optimal data packet formatted as an RTCM message carrying both pseudorange and carrier phase data for real-time double-difference DGPS operation.
- Very low position latency (< 70 msec)
- Automatic motion detection allows improved on-the-fly kinematic specifications for seamless transition between RT-20 static and kinematic modes.
- System accuracy performance degrades gracefully as the length of the baseline increases.
- Very little (< 3 cm) degradation in accuracy for correction delays of up to 2.0 seconds
- Maintains a high position rate regardless of the differential link rate.

THE RT-20 SYSTEM

RT-20 is essentially a high performance mode of differential operation in which the GPSCard can be set up to operate. To utilize the benefits of RT-20 mode, the user must have already purchased a GPSCard (or RT-20 software upgrade) with the RT-20 option enabled.

To operate in RT-20 mode also requires that the GPSCard be operating as part of an "RT-20 system". The RT-20 system is comprised of a GPSCard **reference station** in conjunction with one or more GPSCard **RT-20 remote stations**. As well, some form of data link is required such that the GPSCard reference station can transmit differential observation data to the remote GPSCard stations.

To be fully functional, the RT-20 system requires that the reference station transmit its reference position, as well as observation data, to the remote receivers. This is accomplished with a data packet utilizing a modified message in the RTCM Standards data format. More specifically, the data packet is comprised of a minimum of an RTCM Type 3 message followed by an RTCM Type 59 "N" message. (For further information, refer to RTCM3, page 132, and RTCM59, page 134.) As well, RT-20 mode allows the reference station to transmit RTCM Type 1 messages. Transmitting Type 1 messages concurrently with Type 59 "N" messages allows the remote receivers to revert to "pseudorange single differencing mode" (≅ 1 m accuracy level) if the RT-20 filter is unable to generate a position.

OPERATING IN RT-20 MODE

Operating in RT-20 mode requires that the GPSCard reference and GPSCard remote receivers be appropriately "initialized" and linked by some form of data link (to be supplied by the user). The receivers must be tracking a minimum of four common satellites before the remote receivers will begin the double difference carrier phase ambiguity resolution convergence process.

ESTABLISH A DATA LINK

The RT-20 system requires that the GPSCard reference station broadcast RTCM type data messages to one or more RT-20 remote receivers. As there are many methods by which this can be achieved, it is left to the responsibility of the system provider to establish an appropriate data link that best suits the system remote user requirements.

Whatever data link is chosen, the reference station will want to ensure that bit rate of data transmission is suitable for the anticipated data link and remote users. Use the GPSCard COMn command to change the COM port default bit rate (default is 9600 bps, no parity, 8 data bits, 1 stop bit, no handshake, echo off).

It is worth noting that the GPSCard COMn_DTR and COMn_RTS commands are available for remote device keying (such as a radio transmitter). These commands allow for flexible control of the DTR and RTS lines to be precisely timed with log transmissions.

INITIALIZATION – REFERENCE STATION

RT-20 mode of operation is established at the reference station through a two step process: fixing position and logging observation and correction data.

FIX POSITION

The reference station must initialize the precise position of its reference antenna phase centre (lat/lon/hgt). This is accomplished by utilizing the GPSCard FIX POSITION command. The syntax is as follows:

Syntax:

```
FIX POSITION  [lat] [lon] [height] [station id] [health]
```

Example:

```
fix position 51.3455323,-114.2895345,1201.123,555,1
```

NOTES:

- Entry of the station ID and health are optional.
- The accuracy of the reference station's fix position setting will directly affect the accuracy of its computed differential corrections. Good results at the remote station are dependent on the reference station's combined position errors being kept to a minimum (e.g., fix position error + multipath errors).
- The GPSCard performs all computations based on wgs-84 and is defaulted as such, regardless of datum command setting. The datum in which you choose to operate is converted to and from wgs-84. Therefore all differential corrections are based on that datum. Ensure that any change in your operating datum is set prior to fix position.
- When transmitting RTCM type data, the GPSCard has various options for assigning the number of data bits per byte. Please refer to the GPSCard command rtcmrule, page 40, for further information concerning RTCM data bit rule settings.
- The fix position "health" field entered will be reported in word 2 of the RTCM message frame header.

LOG BROADCAST DATA

Once a data link has been established, use the GPSCard "LOG" command to send observation and differential corrections data for broadcast to the remote stations. There are two required logs and one optional log. The two logs required for RT-20 data broadcast are "RTCM3" and "RTCM59", whereas the optional log is "RTCM".

The RTCM3 data log reports the precise position of the reference station antenna as previously entered into the fix position command. Remote RT-20 receivers require this data message to establish the reference station's reference position before precise positioning computations can begin.

The RTCM59 data log is used to broadcast the reference station's satellite observation data to the RT-20 remote stations. This observation data contains the pseudorange and carrier phase for up to 12 satellites. The remote RT-20 receiver will require this data for performing the carrier phase double difference computations and the floating ambiguity resolution. (For further information about these data formats, refer to RTCM3, page 132, and RTCM59, page 134.)

The RT-20 reference station may also broadcast the optional differential correction log “RTCM”. This contains RTCM type 1 message data and may be used by the RT-20 remote receivers to quickly achieve 1 m position accuracy at start-up or during other periods when the RT-20 remote is unable to generate a position.

Syntax:

```
LOG [port][data][ontime][seconds]
```

Example:

```
log com2 rtcm3 ontime 10
log com2 rtcm59 ontime 2
log com2 rtcm ontime 5
```

NOTE: When transmitting RTCM type data, the GPSCard has various options for assigning the number of data bits per byte. Please refer to the GPSCard command rtcmrule, page 40, for further information concerning RTCM data bit rule settings. Unless otherwise set, the GPSCard default is 6cr (6 bits valid data per byte followed by <cr>).

REMINDER: Ensure that the bit rate of the data link is suitable for the logging rate and maximum message length of the RTCM data being logged. Refer to Table 11-2, page 155, or Chapter 8, page 129, for details on RTCM message lengths.

INITIALIZATION – REMOTE STATION

It is necessary to initialize the RT-20 remote receiver to accept observation data from the reference station. If the RT-20 receiver is not correctly initialized, it will proceed to compute solutions in single point positioning mode.

Before initializing for RT-20 mode, ensure that the data link with the reference station has been properly set up. As well, ensure that the COM port which is to receive the RTCM type data is set up to match the bit rate and protocol settings of the reference station broadcast data.

Establishing RT-20 mode of operation at the remote receiver is primarily a one-step process whereby the ACCEPT command is used to enable reception of observation data from the reference station.

ACCEPT COMMAND

The ACCEPT command is primarily used to set the GPSCard’s COM port command interpreter for acceptance of various data formats. For example, if it is set to accept “COMMANDS”, the COM port will accept all valid GPSCard ASCII format data (including $DCSA, $RTCA, and $RTCM differential corrections data). On the other hand, if it is set to accept “DCSB”, the GPSCard will only accept the NovAtel format DCSB differential corrections data in NovAtel binary format. As well, if it is set to accept “RTCM”, the GPSCard command interpreter (for that specified port) will only accept RTCM types 1, 2, 9, and 16 RTCM standard data (RTCM types 3 and 59 will not be utilized). To operate in RT-20 mode as a real-time double differencing carrier phase measurement system, the ACCEPT command must be set to accept “RT20”.

Syntax:

```
ACCEPT [port][mode]
```

Example:

```
accept com2 rt20
```

Once initialized, the remote RT-20 receiver will operate in single point mode until sufficient RT20 messages are received. If RTCM type 1 messages are concurrently being received as well, the receiver will immediately operate in single differencing pseudorange differential mode. Once sufficient RT20 messages are received, the GPSCard will begin the carrier phase double differencing convergence process. If an interruption in RT20 messages occurs, the GPSCard will utilize the concurrently received RTCM type 1 messages to maintain pseudorange differential accuracies. If the RTCM type 1 messages are not available, the GPSCard will revert to single point positions until the RT20 messages are restored.

NOTES:

- Each time rt20 mode reverts to single point or single differencing mode and then back to rt20 mode, the GPSCard will automatically perform an rt20 reset, which recommences the convergence process. (Convergence begins at the 1 m level and converges to < 20 cm in 3 - 5 minutes after reset occurs. See Table 11-3, page 156, for RT-20 convergence summary.)
- Ensure that the GPSCard rtcmrule settings agree with the bit rule being transmitted by the reference station. Unless otherwise set, all GPSCards default to 6cr.
- When accept is set to "accept port rt20", the GPSCard will also accept RTCM Type 1 corrections.

LOG POSITION DATA

RT-20 mode of operation utilizes two dedicated position data logs: RTKA/B and PRTKA/B. PRTKA/B log provides a best computed position available during RT-20 mode operation. RTKA/B logs will provide position solutions that have been computed from time matched reference and remote station observations. Refer to Chapter 5, RTKA/B, page 100, and PRTKA/B, page 83, for more specific information about these logs. (The POSA log, page 82, also contains the RT-20 position data, but is not as detailed.)

Table 11-1 RT-20 System Initialization Summary

RT-20 Reference Station	RT-20 Remote Station
Required:	**Required:**
FIX POSITION *lat lon hgt (id) (health)*	ACCEPT *port* RT20
LOG *port* rtcm3 ontime 10	LOG *port* PRTKA *period interval*
LOG *port* rtcm59 ontime 2	
Recommended Option:	**Recommended Option:**
LOG *port* rtcm *ontime 5*	LOG *port* RTKA *onchanged*
Related Commands / Logs:	**Related Commands / Logs:**
RTCMRULE	RESETRT20
DATUM	RTCMRULE
	DATUM
	VLHA/B
	CDSA/B
NOTE: *Italicized* entries indicate user definable.	

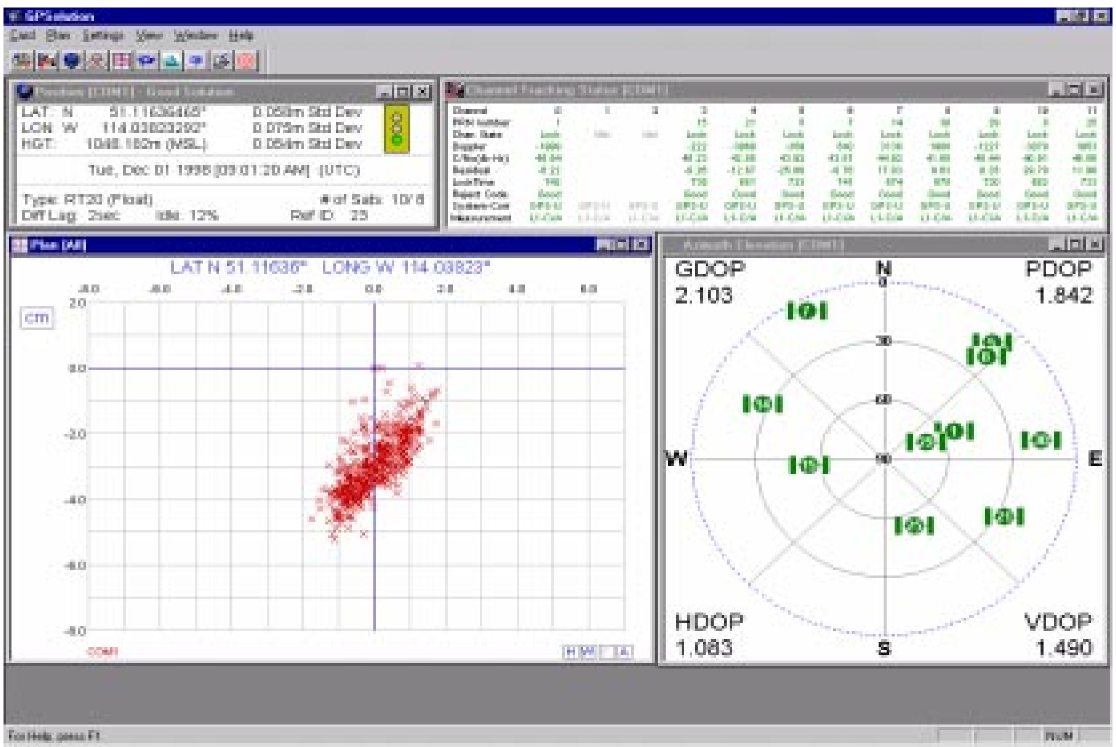
RT-20 PERFORMANCE

STEADY STATE

The RT-20 system provides nominal 20 cm accuracy (CEP) after 3 minutes of continuous lock in static mode. After an additional period of continuous tracking (from 10 to 20 minutes), the system reaches steady state and position accuracies in the order of 3 to 4 cm are typical. The time to steady state is about 3 times longer in kinematic mode.

Figure 11-1 shows the performance of the RT-20 system running with RTCM59 corrections received at a 1/2 Hz rate. The system by this time is in steady state and the position errors are well represented by the standard deviations shown in the position display.

Figure 11-1 Illustration of RT-20 Steady State Performance



PERFORMANCE DEGRADATION

The performance will degrade if satellites are lost at the remote or if breaks occur in the differential correction transmission link. The degradations related to these situations are described in the following paragraphs.

Provided lock is maintained on at least 4 SVs and steady state has been achieved, the only degradation will be the result of a decrease in the geometrical strength of the observed satellite constellation. If steady state has not been achieved, then the length of time to ambiguity resolution under only 4-satellite coverage will be increased significantly.

REMOTE TRACKING LOSS

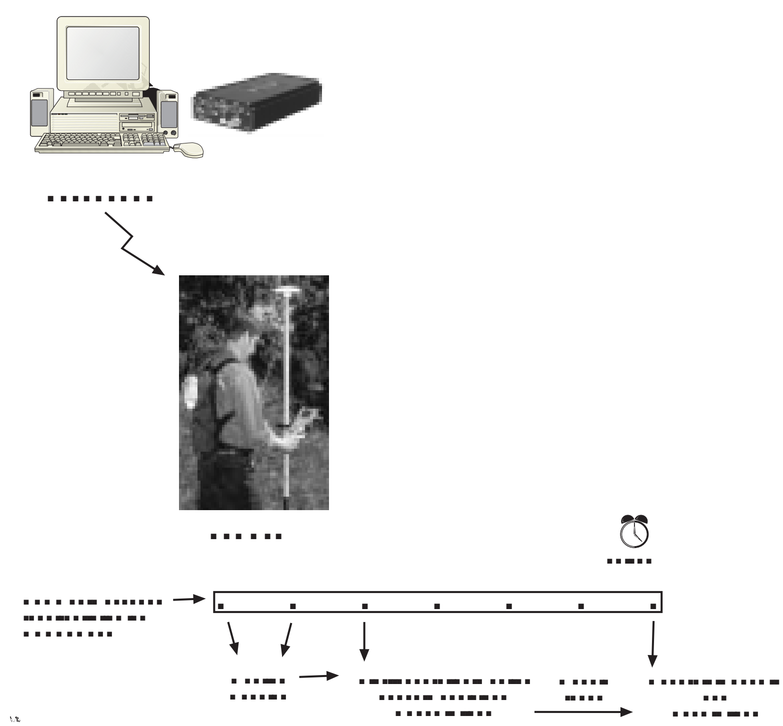
If less than 4 satellites are maintained, then the RT-20 filter will be reset and all ambiguity information for all satellites (tracked or not) will be lost. When this occurs, the POSA/B and P20A/B logs will be generated with differential (if RTCM Type 1 messages are transmitted with the Type 59 messages) or single point pseudorange solutions. When the satellites are reacquired, the RT-20 initialization process described below occurs (see Figure 11-2, page 154).

DIFFERENTIAL LINK BREAKDOWN

1. Provided the system is in steady state, and the loss of observation data is for less than 30 seconds, the RT-20 positions will degrade according to the divergence of the reference observation extrapolation filters. This causes a decrease in accuracy of about an order of magnitude per 10 seconds without a reference observation, and this degradation is reflected in the standard deviations of the POSA/B and P20A/B logs. Once the data link has been re-established, the accuracy will return to normal after several samples have been received.

2. If the loss of differential corrections lasts longer than 30 seconds, the RT-20 filter is reset and all ambiguity and reference model information is lost. The timeout threshold for RT-20 differential corrections is 30 seconds, but for Type 1 pseudorange corrections, the timeout is 60 seconds. Therefore, when the RT-20 can no longer function because of this timeout, the pseudorange filter can produce differential positions for an additional 30 seconds (provided RTCM Type 1 messages were transmitted along with the Type 59 messages) before the system reverts to single point positioning. Furthermore, once the link is re-established, the pseudorange filter produces an immediate differential position while the RT-20 filter takes an additional 14 seconds to generate its positions. The reference models require 7 reference observations before they are declared useable, and this will take 14 seconds, based on a 1/2 Hz differential correction rate. The reference model must be healthy before solutions are logged to the POSA/B and P20A/B logs, so there is a delay in the use of real time carrier positioning to the user once the link has been re-established. The RT20A/B log uses matched observations only (no extrapolated observations), and these will be available after three reference observations are received, but will have about 1.5 seconds latency associated with them.

Figure 11-2 RT-20 Re-initialization Process



The RT-20 system is based on a time-matched double difference observation filter. This means that observations at the remote site have to be buffered while the reference observation is encoded, transmitted, and decoded. Only two seconds of remote observations are saved, so the reference observation transmission process has to take less than 2 seconds if any time matches are to be made. In addition, only remote observations on even second boundaries are retained, so reference observations must also be sent on even seconds if time matches are to be made.

NOTES ON THE USE OF RT-20

- Note that the RT-20 processing in a remote receiver is specifically linked to corrections from a particular GPSCard reference station. Switching to a new GPSCard reference station will cause the algorithm to reset and start over again.
- For users on longer baselines (> 10 km), performance can be improved by downloading a recently stored almanac and ionospheric information into the receiver before starting operation. (12 channel OEM cards can save almanac in flash.)
- Although not essential, even very short periods of sitting still (1 to 3 minutes) during the convergence process can reduce the time to steady state dramatically.
- The following commands will have no effect on RT-20 positioning:
    - ECUTOFF
    - FIX HEIGHT
    - LOCKOUT
    - SETHEALTH
    - RESETHEALTH

Table 11-2 RT-20 Performance Specifications

Item	Specification
Operating Frequency:	1575.42 MHz (L1)
Channels:	12 (or 10, depending on GPSCard model option)
Time To First Fix:	< 70 seconds typical
Reacquisition:	3 seconds typical
Range Measurements:	C/A code pseudorange and carrier phase double differencing techniques
RT-20 Mode Resolution Time:	3 to 5 minutes typical (static)
RT-20 mode Position Accuracy:	0.20 m CEP[1] (also see Table 11-3, page 156)
Pseudorange Differential Accuracy:	0.75 m CEP
Single Point Positioning Accuracy:	40 m CEP (SA on)
Position Latency:	≅ 70 msec (independent of data link)
Velocity Accuracy:	< 2 cm/sec (nominal)
RT-20 Data Packet:	RTCM3 (180 data bits maximum) RTCM59 "N" (up to 990 data bits maximum) RTCM type 1 message (optional)
Position Logging Rate:	Check with dealer for maximum rate

NOTES:

- Nominal accuracy after 3 minutes static or 10 minutes kinematic minimum. Kinematic resolution with continuous good satellite coverage (6 SVs).
- RT-20 double difference accuracies are based on PDOP < 2 and continuous tracking of a minimum 5 satellites (6 preferred) and elevations > 15•.

PERFORMANCE SUMMARY – TABLES AND FIGURES

Table 11-3 RT-20 Convergence Summary

Tracking Time (sec)	S/K*	Data Delay (sec)	Distance (km)	Accuracy (cm) (CEP)
1 to 180	S	0	1	100 to 25
180 to 3000	S	0	1	25 to 5
3000 or more	S	0	1	5 or less [1]
1 to 600	K	0	1	100 to 25
600 to 3000	K	0	1	25 to 5
3000 or more	K	0	1	5 or less
	S/K	0 to 2	1	+1 per sec
	S/K	2 to 7	1	+2 per sec
	S/K	7 to 30	1	+5 per sec
	S/K	30 to 60	1	+7 per sec [2]
	S/K	60 or more	1	Single Point
	S/K	0	0 to 10	+0.5 per km
	S/K	0	10 to 20	+0.75 per km
	S/K	0	20 to 50	+1.0 per km

***** K = Kinematic (during initial ambiguity resolution)

S = Static (during initial ambiguity resolution)

[1] The accuracy specifications refer to the P20A/B logs, page 78, which include about 3 cm extrapolation error. RT20A/B logs, page 98, are more accurate but have more latency associated with them.

[2] Between 30 and 60 seconds assumes pseudorange differential positioning. If Type 1 corrections have not been transmitted, the accuracy drops to single point mode after 30 seconds.

Figure 11-3 CEP Accuracy Over Cumulative Tracking Time

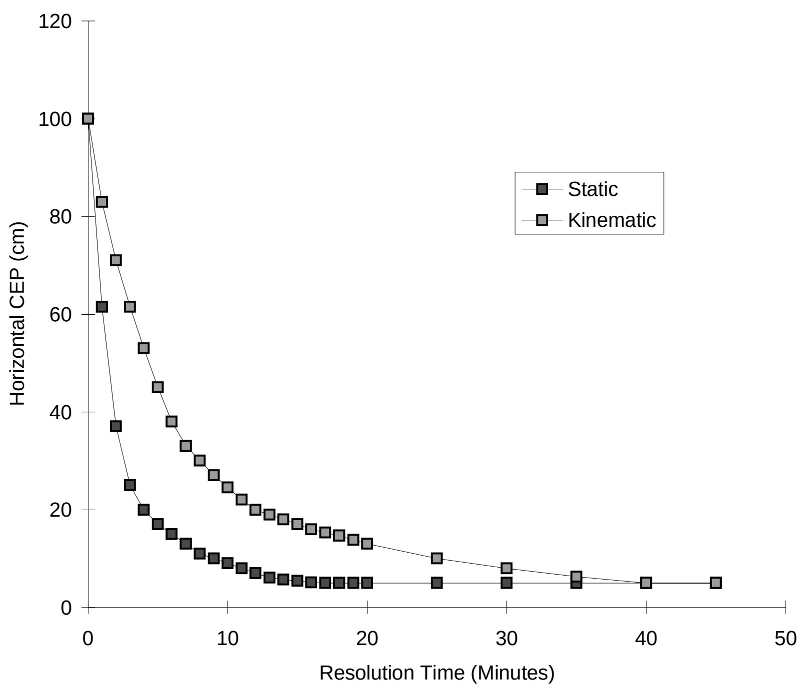


Figure 11-4 CEP Accuracy Degradation with Increasing Baseline

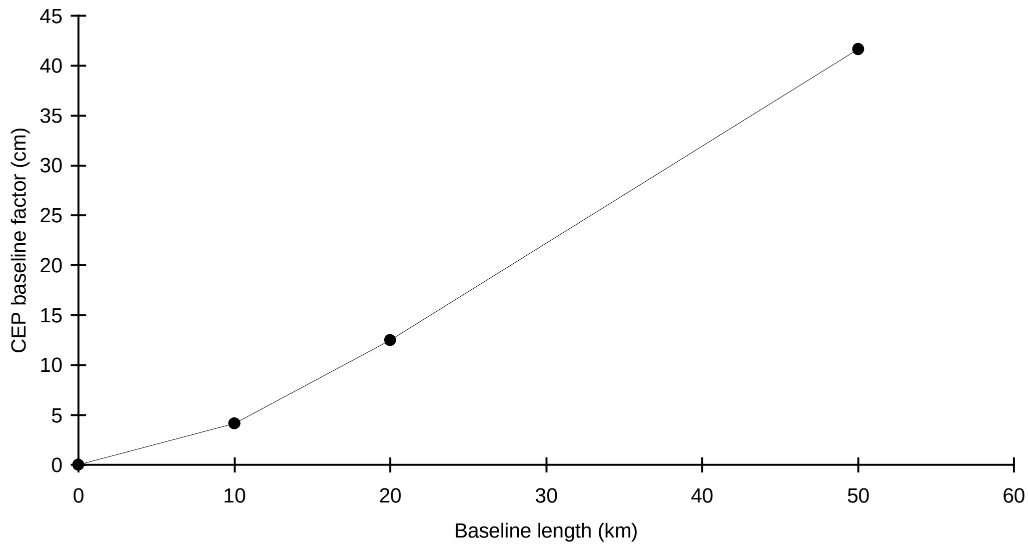
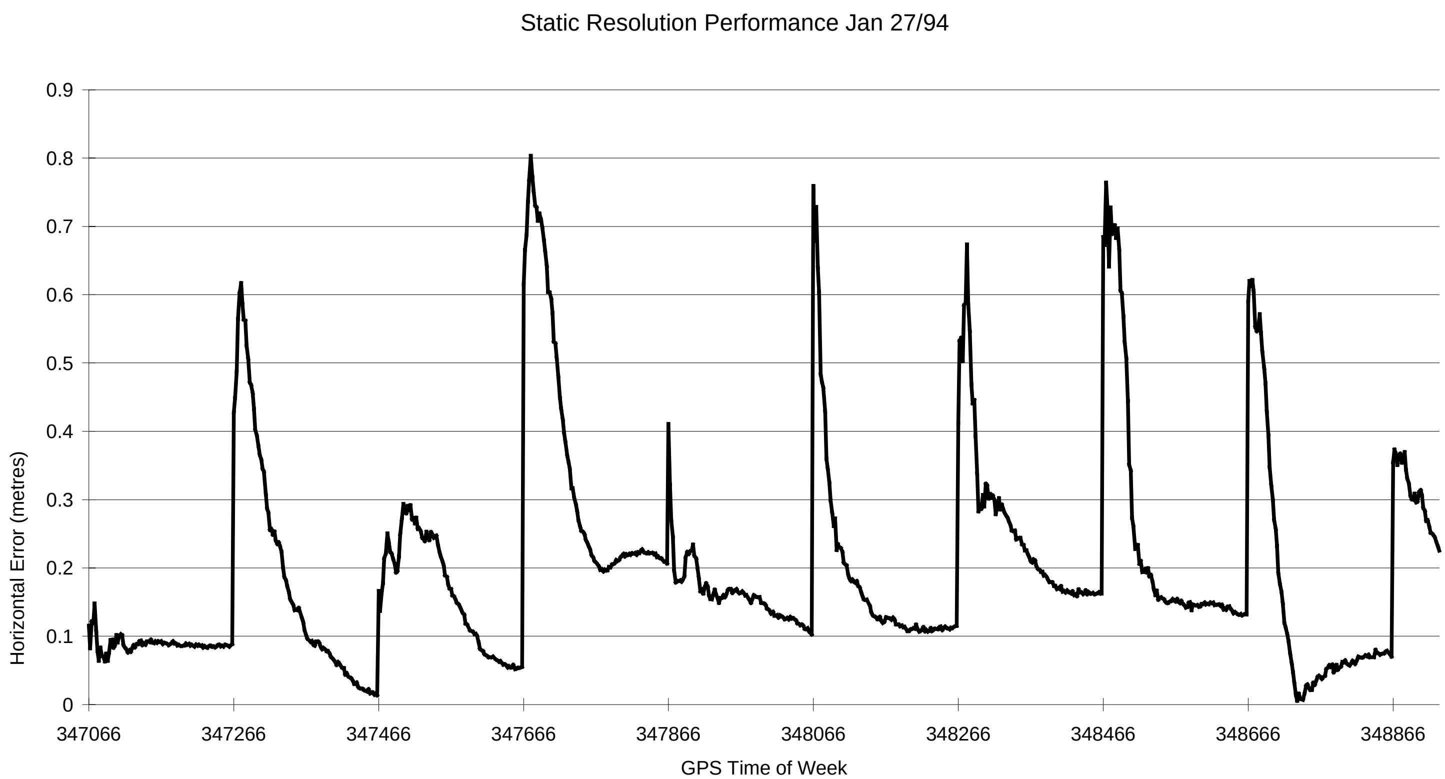


Figure 11-5 Typical Example of Static Resolution Performance

Jan 27/94
(reset RT-20 every 200 seconds)



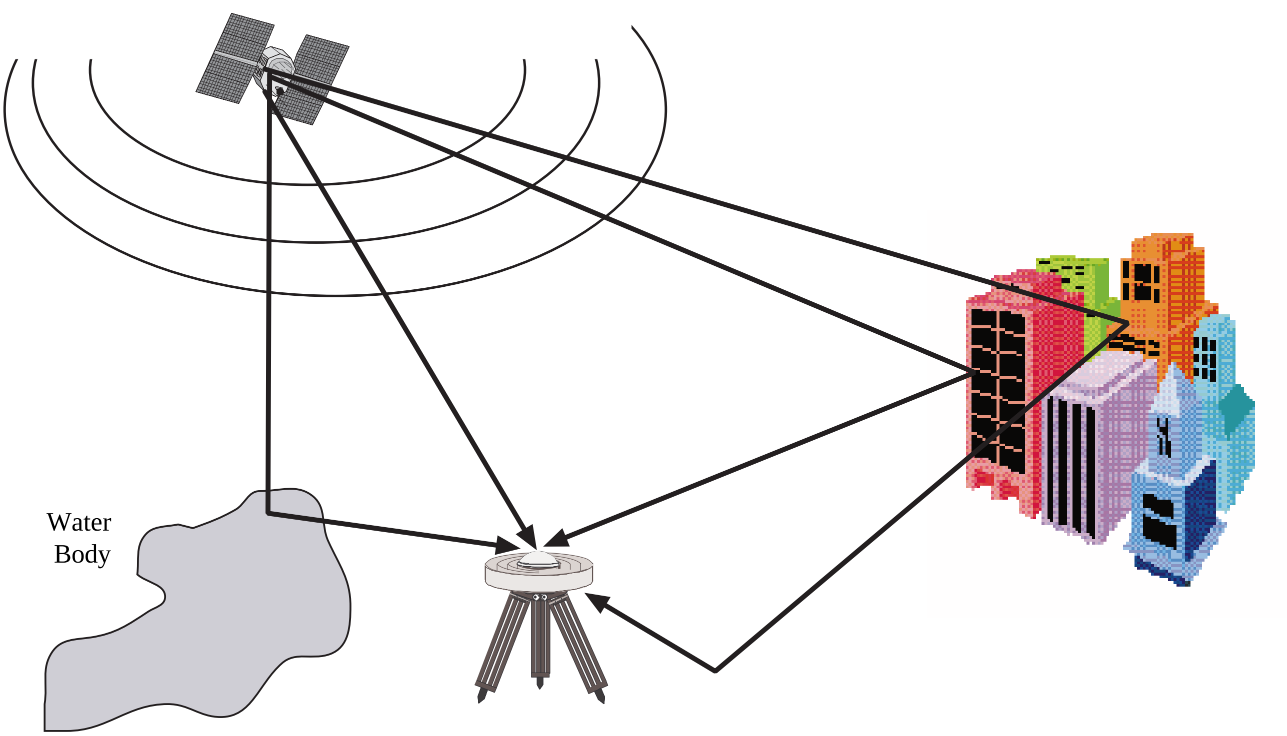
12 MULTIPATH ELIMINATION TECHNOLOGY

Multipath signal reception is one of the most plaguing problems that detracts from the accuracy potential of GPS pseudorange differential positioning systems. This chapter will provide a brief look at the problems of multipath reception and some solutions developed by NovAtel.

MULTIPATH

Multipath occurs when an RF signal arrives at the receiving antenna from more than one propagation route (multiple propagation paths – thus multipath).

Figure 12-1 Illustration of GPS Signal Multipath



WHY DOES MULTIPATH OCCUR?

When the GPS signal is emitted from the satellite antenna, the RF signal propagates away from the antenna in many directions. Because the RF signal is emitted in many directions simultaneously and is traveling different paths, these signals encounter various and differing natural and man-made objects along the various propagation routes. Whenever a change in medium is encountered, the signal is either absorbed, attenuated, refracted, or reflected.

Refraction and reflection cause the signals to change direction of propagation. This change in path directions often results in a convergence of the direct path signal with one or more of the reflected signals. When the receiving antenna is the point of convergence for these multipath signals, the consequences are generally not favorable.

Whenever the signal is refracted, some signal polarity shifting takes place; and when full reflection occurs, full polarity reversal results in the propagating wave. The consequences of signal polarity shifting and reversal at the receiving antenna vary from minor to significant. As well, refracted and reflected signals generally sustain some degree of signal amplitude attenuation.

It is generally understood that, in multipath conditions, both the direct and reflected signals are present at the antenna and the multipath signals are lower in amplitude than the direct signal. However, in some situations, the direct signal may be obstructed or greatly attenuated to a level well below that of the received multipath signal. Obstruction of direct path signals is very common in city environments where many tall buildings block the line of sight to the satellites. As buildings generally contain an abundance of metallic materials, GPS signal reflections are abundant (if not overwhelming) in these settings. Obstructions of direct path signals can occur in wilderness settings as well. If the GPS receiver is in a valley with nearby hills, mountains and heavy vegetation, signal obstruction and attenuation are also very common.

CONSEQUENCES OF MULTIPATH RECEPTION

Because GPS is a radio ranging and positioning system, it is imperative that ground station signal reception from each satellite be of direct line of sight. This is critical to the accuracy of the ranging measurements. Obviously, anything other than direct line of sight reception will skew and bias the range measurements and thus the positioning triangulation (or more correctly, trilateration). Unfortunately, multipath is almost always present to some degree, due to real world conditions.

When a GPS multipath signal converges at the GPS antenna, there are two primary problems that occur:

1. a multiple signal with amplitude and phase shifting, and
2. a multiple signal with differing ranges.

When the GPS antenna intercepts a direct signal and multipath signal, the two signals will sum according to the phase and amplitude of each. This summation of signals causes the composite to vary greatly in amplitude, depending on the degree of phase shift between the direct signal versus the multipath signal. If the multipath signal lags the direct path signal by less than 90º, the composite signal will increase in amplitude (relative to the direct signal, depending on the degree of phase shift between 0º and 90º). As well, if the multipath signal lags the direct path signal by greater than 90º, but less than 270º, the composite signal will decrease in amplitude. Depending on the relative amplitude of the multipath signal (or signals), the composite signal being processed by the receiver correlator may experience substantial amplitude variations, which can play havoc with the receiver's automatic gain control circuitry (AGC) as it struggles to maintain constant signal levels for the receiver correlator. A worst case scenario is when the multipath signal experiences a lag of 180º and is near the same strength as the direct path signal – this will cause the multipath signal to almost completely cancel out the direct path signal, resulting in loss of satellite phase lock or even code lock.

Because a multipath signal travels a greater distance to arrive at the GPS antenna, the two C/A code correlations are, by varying degrees, displaced in time, which in turn causes distortion in the correlation peak and thus ambiguity errors in the pseudorange (and carrier phase, if applicable) measurements.

As mentioned in previous paragraphs, it is possible that the received multipath signal has greater amplitude than the direct path signal. In such a situation the multipath signal becomes the dominant signal and receiver pseudorange errors become significant due to dominant multipath biases and may exceed 150 m. For single point pseudorange positioning, these occasional levels of error may be tolerable, as the accuracy expectations are at the 40 m CEP level (using standard correlator). However, for pseudorange single differencing DGPS users, the accuracy expectations are at the 1 - 5 m CEP level (with no multipath). Obviously, multipath biases now become a major consideration in trying to achieve the best possible pseudorange measurements and position accuracy.

If a differential reference station is subject to significant multipath conditions, this in turn will bias the range corrections transmitted to the differential remote receiver. And in turn, if the remote receiver also experiences a high level of multipath, the remote receiver position solutions will be significantly biased by multipath from both stations. Thus, when the best possible position solutions are required, multipath is certainly a phenomenon that requires serious consideration.

SOME HARDWARE SOLUTIONS FOR MULTIPATH REDUCTION

A few options exist by which GPS users may reduce the level of multipath reception. Among these include: antenna site selection, special antenna design, and ground plane options.

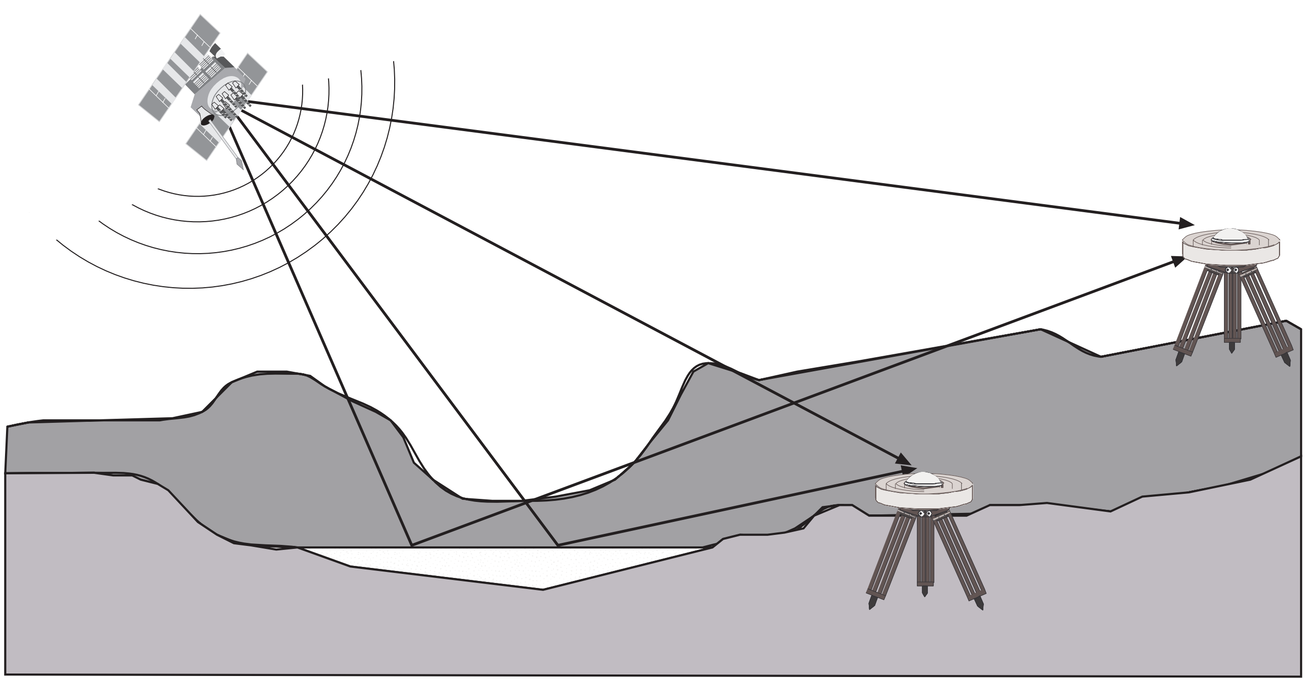
ANTENNA SITE SELECTION

Multipath reception is basically a condition caused by environmental circumstances. Some of these conditions you may have a choice about and some you may not.

Many GPS reception problems can be reduced, to some degree, by careful antenna site selection. Of primary importance is to place the antenna so that unobstructed line-of-sight reception is possible from horizon to horizon and at all bearings and elevation angles from the antenna. This is, of course, the ideal situation, which may not be possible under actual operating conditions.

Try to place the antenna as far as possible from obvious reflective objects, especially reflective objects that are above the antenna's radiation pattern horizon. Close-in reflections will be stronger, and typically have a shorter propagation delay allowing for autocorrelation of signals with a propagation delay of less than one C/A code chip (300 m).

Figure 12-2 Illustration of GPS Signal Multipath vs. Increased Antenna Height



When the antenna is in an environment with obstructions and reflective surfaces in the vicinity, it is advantageous to mount the antenna as high as possible to reduce the obstructions, as well as reception from reflective surfaces, as much as possible.

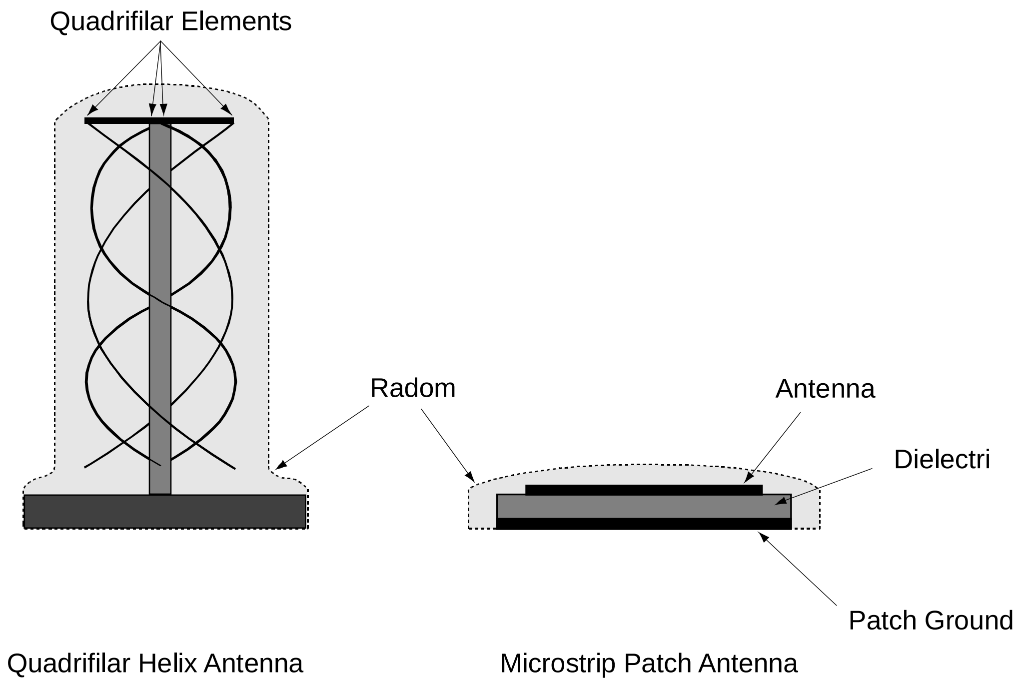
Water bodies are extremely good reflectors of GPS signals. Because of the short wavelengths at GPS frequencies, even small ponds and water puddles can be a strong source of multipath reception, especially for low angle satellites. Thus, it can be concluded that water bodies such as lakes and oceans are among the most troublesome multipath environments for low angle signal reception. Obviously, water body reflections are a constant problem for ocean going vessels.

ANTENNA DESIGNS

Low angle reflections, such as from water bodies, can be reduced by careful selection of antenna design. For example, flat plate microstrip patch antennas have relatively poor reception properties at low elevation angles near their radiation pattern horizon.

Quadrifilar helix antennas and other similar vertically high profile antennas tend to have high radiation gain patterns at the horizon. These antennas, in general, are more susceptible to the problems resulting from low angle multipath reception. So, for marine vessels, this type of antenna encourages multipath reception. However, the advantages of good low angle reception also means that satellites can be acquired more easily while rising in the horizon. As well, vessels subject to pitch and roll conditions will experience fewer occurrences of satellite loss of lock.

Figure 12-3 Illustration of Quadrifilar vs. Microstrip Patch Antennae



A good antenna design will also incorporate some form of left hand circular polarization (LHCP) rejection. Multipath signals change polarization during the refraction and reflection process. This means that generally, multipath signals may be LHCP oriented. This property can be used to advantage by GPS antenna designers. If a GPS antenna is well designed for RHCP polarization, then LHCP multipath signals will automatically be attenuated somewhat during the induction into the antenna. To further enhance performance, antennas can be designed to increase the rejection of LHCP signals. NovAtel's GPSAntenna model 501 is an example of an antenna optimized to further reject LHCP signals by more than 10 dB.

ANTENNA GROUND PLANES

Nearby objects can influence the radiation pattern of an antenna. Thus, one of the roles of the antenna ground plane is to create a stabilizing artificial environment on which the antenna rests and which becomes a part of the antenna structure and its resultant radiation pattern.

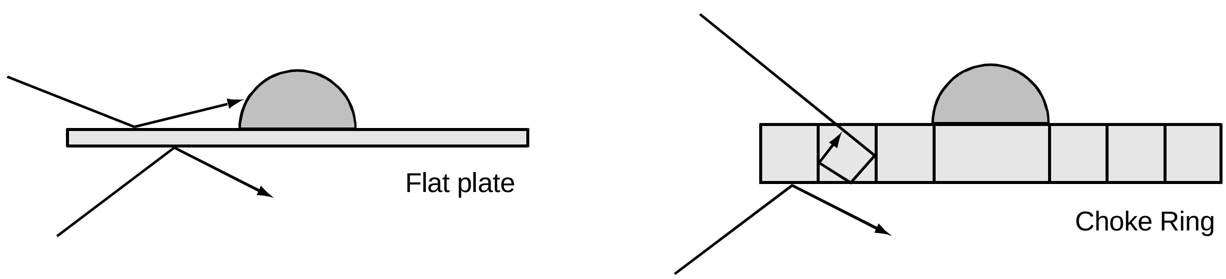
A small ground plane (relative to one wavelength at the operating frequency) may have minimal stabilizing effect, whereas a large ground plane (multiple wavelengths in size) will have a highly stabilizing effect.

Large ground planes also exhibit a shielding effect against RF signal reflections originating below the antenna's radiation pattern horizon. This can be a very effective low angle shield when the antenna is elevated on a hill or other structure above other reflecting surfaces such as vehicles, railway tracks, soil with high moisture content, water bodies, etc.

One of the drawbacks of a "flat plate" ground plane is that they do provide an above horizon reflective surface for low angle GPS signals. This means that the flat plate is also a multipath generating surface. For pseudorange code measurements, these multipath signals are too close to cause any significant range errors. However, for carrier phase measurements, the flat plate can cause significant biases. Even if carrier phase is not being used for range measurements, the flat plate reflections could be substantial enough to cause signal fades and drop-outs due to carrier phase reversals from the flat plate reflections (keeping in mind that these problems are most substantial for low angle signals). It should also be kept in mind that low profile antennas such as the patch antenna will obviously be less susceptible to this phenomenon than higher profile quadrifilar and bifilar helix antennas.

The most effective type of multipath reduction ground plane structure is the "choke ring" ground plane. Due to its surface cavity construction, surface reflections are essentially trapped, thus minimizing the problems encountered by flat plate ground planes. This is what makes NovAtel's GPSAntenna model 501 so successful when used with the NovAtel GPSAntenna Choke Ring Ground Plane.

Figure 12-4 Example of GPSAntenna on a Flat Plate vs. Choke Ring Ground Plane



NOVATEL'S INTERNAL RECEIVER SOLUTIONS FOR MULTIPATH REDUCTION

The multipath antenna hardware solutions described in the previous paragraphs are capable of achieving varying degrees of multipath reception reduction. These options, however, require specific conscious efforts on the part of the GPS user. In many situations, especially kinematic, few (if any) of the above solutions may be effective or even possible to incorporate. By far, the best solutions are those which require little or no special efforts in the field on the part of the GPS user. This is what makes NovAtel's internal receiver solutions so desirable and practical.

NovAtel has placed long term concerted effort into the development of internal receiver solutions and techniques that achieve multipath reduction, all of which are transparent to the GPSCard user. These achievements have led to three patented technologies:

- Narrow Correlator Technology
- MET Technology

- MEDLL Technology

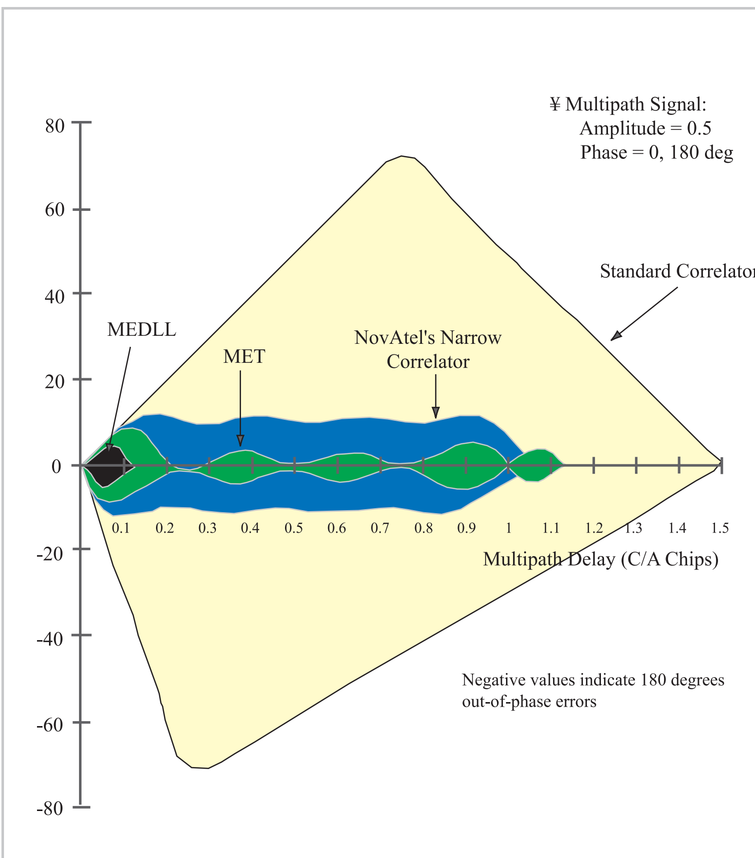
Each of the above listed solutions utilizes innovative patented correlator delay lock loop (DLL) techniques. As it is beyond the scope of this manual to describe in detail how the correlator techniques achieve the various levels of performance, the following paragraphs will provide highlights of the advantages of each technology.

NARROW CORRELATOR TECHNOLOGY

NovAtel's Performance Series of GPSCard receivers (900/3900/2100/3100 Series) achieve a higher level of pseudorange positioning "performance" vs. standard (wide) correlator, by virtue of its celebrated Narrow Correlator technology. By utilizing Narrow Correlator techniques, the GPSCard Performance Series is capable of pseudorange measurement improvements better than 2:1 when compared to standard correlation techniques. As well, the Narrow Correlator inherently reduces multipath reception (approaching a factor of eight compared to standard correlator) by virtue of its narrower autocorrelation function.

Figure 12-5 illustrates relative multipath-induced tracking errors encountered by standard correlators vs. NovAtel's Narrow Correlator. As can be seen, standard correlators are susceptible to substantial multipath biases for C/A code chip delays of up to 1.5 chip, with the most significant C/A code multipath bias errors occurring at about 0.25 and 0.75 chip (approaching 80 m error). On the other hand, the Narrow Correlator multipath susceptibility peaks at about 0.2 chip (about 10 m error) and remains relatively constant out to 0.95 chip, where it rapidly declines to negligible errors after 1.1 chip.

Figure 12-5 Comparison of Multipath Error Envelopes



While positioning in single point mode, the multipath and ranging improvement benefits of a Narrow Correlator receiver vs. standard correlator are overridden by a multitude of GPS system biases and errors (with or without an antenna choke ring ground plane). In either case, positioning accuracy will be in the order of 40 m CEP (SA on, no multipath). However, the benefits of the Narrow Correlator become most significant during pseudorange DGPS operation, where the GPS systematic biases are largely cancelled.

Receivers operating DGPS with standard correlator technology typically achieve positioning accuracies in the 2 - 5 m CEP range (low multipath environment and using choke ring ground plane), while NovAtel's Narrow Correlator receivers are able to achieve positioning accuracies in the order of 0.75 m CEP (low multipath environment and using choke ring ground plane). The Narrow Correlator achieves this higher accuracy through a combination of lower noise ranging measurements combined with its improved multipath resistance when compared to the standard correlator.

MET TECHNOLOGY

It has been recognized that the use of a choke ring ground plane is highly effective in reducing reception of low angle multipath signals. However, installation and usage of the choke ring is not always practical (or desirable) for many types of installations, such as on aircraft and other high dynamics vehicles. To help alleviate the necessity of a choke ring ground plane, NovAtel has developed a new technology called MET – Multipath Elimination Technology. MET is currently available as a software upgrade to existing non-MET Performance Series GPSCard receivers.

MET is a further enhancement of NovAtel's GPSCard Narrow Correlator technology. By means of software manipulation, MET is able to model the direct path signal's shape and slope, and thus model out the pseudorange multipath correlation distortions. By reducing the correlation distortions, there is less noise and ambiguity about the correlation peak, and thus greater confidence in the resultant ranging measurements.

Refer to Figure 12-5, page 163, for a comparative illustration of pseudorange multipath error envelopes. As can be seen in the figure, MET provides significant reductions in multipath-induced tracking errors for C/A code delays greater than 0.15 chip. As well, MET virtually rejects all multipath delays greater than 1.15 chip, whereas standard correlators are susceptible up to 1.50 chip.

In practice, a GPSCard utilizing the MET option can typically achieve pseudorange multipath error reductions of up to 30% (relative to NovAtel's Narrow Correlator) without the use of the GPSAntenna Choke Ring Ground Plane. This can be of real benefit to high dynamic installations where a choke ring ground plane is not practical to install. As well, because choke ring ground planes primarily reduce low angle multipath, MET's 30% reduction applies to multipath signals arriving from any propagation angle, which includes higher angles where choke ring and flat plate ground planes are less effective.

When used in combination with the choke ring ground plane, MET will typically provide up to 50% pseudorange multipath elimination. This 50% multipath error reduction will provide significant position confidence improvements when used at both the DGPS reference and remote differential stations. It should be noted that MET has no influence over carrier phase multipath biases.

Using a GPSCard with the MET option installed is exactly the same as non-MET GPSCard operation. This means that MET functions in the background without any operator intervention, while providing the user with enhanced performance.

MEDLL TECHNOLOGY

NovAtel has developed a multipath elimination technology that approaches the theoretical limits of multipath-free GPS signal reception. This new patented technology, called "Multipath Estimation Delay-Lock-Loop" (MEDLL), utilizes a combination of hardware and software techniques that are capable of reducing the combined effects of pseudorange and carrier-phase multipath errors by as much as 90% compared to a system using a narrow correlator. As well, MEDLL does all this *without* the need to mount the antenna on a choke ring ground plane.

The MEDLL technology takes further advantage of NovAtel's parallel channel Narrow Correlator sampling techniques, and goes far beyond the capabilities of MET. While utilizing a proprietary complex correlator sampling technique combined with "maximum likelihood estimation" techniques, MEDLL is able to deconvolve the received signals into their direct path and multipath components by determining the amplitude, delay, and phase angle of each of the composite signals. Once the composite signal has been broken down into its components, the signal with the least delay is determined to be the direct signal, and all other signals with greater delay are considered to be the multipath components (assuming that the direct path signal is available and unobstructed).

To do this, however, MEDLL utilizes a multicard hardware configuration which is housed in a standard 3U high by 28 HP wide "plug-in unit", designed for quick mounting into a standard 3U by 19" cabinet sub-rack. As well, optional packaging configurations are available. In addition to this configuration, MEDLL is available with, or without, an external OCXO oscillator to enhance its higher performance capabilities.

MEDLL can effectively remove all multipath signals that have a propagation delay of greater than 0.1 chip, relative to the direct path signal. The remaining multipath effect on the C/A code pseudorange measurements is now in the order of magnitude as a "P" code GPS receiver (without the use of a choke ring ground plane). Refer to Figure 12-5, page 163, for a comparative illustration of multipath error envelopes for MEDLL, MET, Narrow Correlator, vs. standard correlators.

SUMMARY

Any localized propagation delays or multipath signal reception cause biases to the GPS ranging measurements that cannot be differenced by traditional DGPS single or double differencing techniques. Generally speaking, single point positioning systems are not too concerned with multipath reception, as the system errors are quite large to begin with. However, multipath is recognized as the greatest source of errors encountered by a system operating in differential mode. It has been discussed that careful site selection and good antenna design combined with a choke ring ground plane are fairly effective means of reducing multipath reception.

Internal receiver solutions for multipath elimination are achieved through various types of correlation techniques, where the "standard correlator" is the reference by which all other techniques can be compared.

The Narrow Correlator has a two fold advantage over standard correlators: improved ranging measurements due to a sharper, less noisy correlation peak, and reduced susceptibility to multipath due to rejection of C/A code delays of greater than 1.0 chip. When used with a choke ring ground plane, the Narrow Correlator provides substantial performance gains over standard correlator receivers operating in differential mode.

The MET option incorporates further enhancements to the Narrow Correlator technique, and with the aid of software modeling, can provide multipath elimination of up to 30% without a choke ring ground plane, and as much as 50% when used with a choke ring ground plane (when compared to Narrow Correlation performance).

MEDLL is a very high performance pseudorange C/A code ranging system capable of reducing multipath bias errors by as much as 90% as compared to the Narrow Correlator – *without* the aid of a choke ring ground plane. Utilizing a combination of hardware and software techniques, MEDLL consists of a multicard configuration suitable for mounting in a standard 19" sub-rack (other configurations available).

A GEODETIC DATUMS

The following tables contain the internal ellipsoid parameters and transformation parameters used in the GPSCard. The values contained in these tables were derived from the following DMA technical reports:

1. TR 8350.2 — Department of Defense World Geodetic System 1984 – Its Definition and Relationships with Local Geodetic Systems - Revised March 1, 1988.
2. TR 8350.2B — Supplement to Department of Defense World Geodetic System 1984 Technical Report - Part II - Parameters, Formulas, and Graphics for the Practical Application of WGS-84 - December 1, 1987.

Table A-1 Reference Ellipsoid Constants

ELLIPSOID	ID CODE	a (metres)	1/f	f
Airy 1830	AW	6377563.396	299.3249647	0.00334085064038
Modified Airy	AM	6377340.189	299.3249647	0.00334085064038
Australian National	AN	6378160.0	298.25	0.00335289186924
Bessel 1841	BR	6377397.155	299.1528128	0.00334277318217
Clarke 1866	CC	6378206.4	294.9786982	0.00339007530409
Clarke 1880	CD	6378249.145	293.465	0.00340756137870
Everest (India 1830)	EA	6377276.345	300.8017	0.00332444929666
Everest (Brunei & E.Malaysia)	EB	6377298.556	300.8017	0.00332444929666
Everest (W.Malaysia & Singapore)	ED	6377304.063	300.8017	0.00332444929666
Geodetic Reference System 1980	RF	6378137.0	298.257222101	0.00335281068118
Helmert 1906	HE	6378200.0	298.30	0.00335232986926
Hough 1960	HO	6378270.0	297.00	0.00336700336700
International 1924	IN	6378388.0	297.00	0.00336700336700
South American 1969	SA	6378160.0	298.25	0.00335289186924
World Geodetic System 1972	WD	6378135.0	298.26	0.00335277945417
World Geodetic System 1984	WE	6378137.0	298.257223563	0.00335281066475

Table A-2 Transformation Parameters (Local Geodetic to WGS-84)

GPSCard Datum ID number	NAME	DX	DY	DZ	DATUM DESCRIPTION	ELLIPSOID
1	ADIND	-162	-12	206	Adindan (Ethiopia, Mali, Senegal & Sudan)	Clarke 1880
2	ARC50	-143	-90	-294	ARC 1950 (SW & SE Africa)	Clarke 1880
3	ARC60	-160	-8	-300	ARC 1960 (Kenya, Tanzania)	Clarke 1880
4	AGD66	-133	-48	148	Australian Geodetic Datum 1966	Australian National
5	AGD84	-134	-48	149	Australian Geodetic Datum 1984	Australian National
6	BUKIT	-384	664	-48	Bukit Rimpah (Indonesia)	Bessel 1841
7	ASTRO	-104	-129	239	Camp Area Astro (Antarctica)	International 1924
8	CHATM	175	-38	113	Chatum 1971 (New Zealand)	International 1924
9	CARTH	-263	6	431	Carthage (Tunisia)	Clarke 1880
10	CAPE	-136	-108	-292	CAPE (South Africa)	Clarke 1880
11	DJAKA	-377	681	-50	Djakarta (Indonesia)	Bessel 1841

GPSCard Datum ID number	NAME	DX	DY	DZ	DATUM DESCRIPTION	ELLIPSOID
12	EGYPT	-130	110	-13	Old Egyptian	Helmert 1906
13	ED50	-87	-98	-121	European 1950	International 1924
14	ED79	-86	-98	-119	European 1979	International 1924
15	GUNSG	-403	684	41	G. Segara (Kalimantan - Indonesia)	Bessel 1841
16	GEO49	84	-22	209	Geodetic Datum 1949 (New Zealand)	International 1924
17	GRB36	375	-111	431	Great Britain 1936 (Ordinance Survey)	Airy 1830
18	GUAM	-100	-248	259	Guam 1963 (Guam Island)	Clarke 1866
19	HAWAII	89	-279	-183	Hawaiian Hawaii (Old)	International 1924
20	KAUAI	45	-290	-172	Hawaiian Kauai (Old)	International 1924
21	MAUI	65	-290	-190	Hawaiian Maui (Old)	International 1924
22	OAHU	56	-284	-181	Hawaiian Oahu (Old)	International 1924
23	HERAT	-333	-222	114	Herat North (Afghanistan)	International 1924
24	HJORS	-73	46	-86	Hjorsey 1955 (Iceland)	International 1924
25	HONGK	-156	-271	-189	Hong Kong 1963	International 1924
26	HUTZU	-634	-549	-201	Hu-Tzu-Shan (Taiwan)	International 1924
27	INDIA	289	734	257	Indian (India, Nepal, Bangladesh)	Everest (EA)
28	IRE65	506	-122	611	Ireland 1965	Modified Airy
29	KERTA	-11	851	5	Kertau 1948 (West Malaysia and Singapore)	Everest (ED)
30	KANDA	-97	787	86	Kandawala (Sri Lanka)	Everest (EA)
31	LIBER	-90	40	88	Liberia 1964	Clarke 1880
32	LUZON	-133	-771	-51	Luzon (Philippines excluding Mindanoa Is.)	Clarke 1866
33	MINDA	-133	-70	-72	Mindanoa Island	Clarke 1866
34	MERCH	31	146	47	Merchich (Morocco)	Clarke 1880
35	NAHR	-231	-196	482	Nahrwan (Saudi Arabia)	Clarke 1880
36	NAD83	0	0	0	N. American 1983 (Includes Areas 37-42)	GRS-80
37	CANADA	-10	158	187	N. American Canada 1927	Clarke 1866
38	ALASKA	-5	135	172	N. American Alaska 1927	Clarke 1866
39	NAD27	-8	160	176	N. American Conus 1927	Clarke 1866
40	CARIBB	-7	152	178	N. American Caribbean	Clarke 1866
41	MEXICO	-12	130	190	N. American Mexico	Clarke 1866
42	CAMER	0	125	194	N. American Central America	Clarke 1866
43	MINNA	-92	-93	122	Nigeria (Minna)	Clarke 1880
44	OMAN	-346	-1	224	Oman	Clarke 1880
45	PUERTO	11	72	-101	Puerto Rica and Virgin Islands	Clarke 1866
46	QORNO	164	138	-189	Qornoq (South Greenland)	International 1924
47	ROME	-255	-65	9	Rome 1940 Sardinia Island	International 1924
48	CHUA	-134	229	-29	South American Chua Astro (Paraguay)	International 1924
49	SAM56	-288	175	-376	South American (Provisional 1956)	International 1924
50	SAM69	-57	1	-41	South American 1969	S. American 1969
51	CAMPO	-148	136	90	S. American Campo Inchauspe (Argentina)	International 1924
52	SACOR	-206	172	-6	South American Corrego Alegre (Brazil)	International 1924
53	YACAR	-155	171	37	South American Yacare (Uruguay)	International 1924
54	TANAN	-189	-242	-91	Tananarive Observatory 1925 (Madagascar)	International 1924
55	TIMBA	-689	691	-46	Timbalai (Brunei and East Malaysia) 1948	Everest (EB)
56	TOKYO	-128	481	664	Tokyo (Japan, Korea and Okinawa)	Bessel 1841
57	TRIST	-632	438	-609	Tristan Astro 1968 (Tristan du Cunha)	International 1924
58	VITI	51	391	-36	Viti Levu 1916 (Fiji Islands)	Clarke 1880
59	WAK60	101	52	-39	Wake-Eniwetok (Marshall Islands)	Hough 1960

GPSCard Datum ID number	NAME	DX	DY	DZ	DATUM DESCRIPTION	ELLIPSOID
60	WGS72	0	0	4.5	World Geodetic System - 72	WGS-72
61	WGS84	0	0	0	World Geodetic System - 84	WGS-84
62	ZANDE	-265	120	-358	Zanderidj (Surinam)	International 1924
63	USER	0	0	0	User Defined Datum Defaults	User *

* Default user datum is WGS 84.
* Also see commands DATUM, page 26, and USERDATUM, page 27, in Chapter 2.
* The GPSCard DATUM command sets the Datum value based on the name entered as listed in the "NAME" column in Table A-2 (e.g., NAD83).
* The following GPSCard logs report Datum used according to the "GPSCard Datum ID" column: POSA/B, P20A/B, RT20A/B, and MKPA/B.

B GPS GLOSSARY OF TERMS

ASCII – A 7 bit wide serial code describing numbers, upper and lower case alpha characters, special and non-printing characters.

Address field – for sentences in the NMEA standard, the fixed length field following the beginning sentence delimiter "$" (HEX 24). For NMEA approved sentences, composed of a two character talker identifier and a three character sentence formatter. For proprietary sentences, composed of the character "P" (HEX 50) followed by a three character manufacturer identification code.

Almanac – a set of orbit parameters that allows calculation of approximate GPS satellite positions and velocities. The almanac is used by a GPS receiver to determine satellite visibility and as an aid during acquisition of GPS satellite signals.

Arrival alarm – an alarm signal issued by a voyage tracking unit which indicates arrival at or at a pre-determined distance from a waypoint [see *arrival circle*].

Arrival circle – an artificial boundary placed around the destination waypoint of the present navigation leg, and entering of which will signal an arrival alarm.

Arrival perpendicular – crossing of the line which is perpendicular to the course line and which passes through the destination waypoint.

Attenuation – reduction of signal strength

Azimuth – the horizontal direction of a celestial point from a terrestrial point, expressed as the angular distance from 000° (reference) clockwise through 360°. The reference point is generally True North, but may be Magnetic North, or Relative (ship's head).

Bearing – the horizontal direction of one terrestrial point from another terrestrial point, expressed as the angular distance from a reference direction, usually measured from 000° at the reference direction clockwise through 360°. The reference point may be True North, Magnetic North, or Relative (ship's head).

Carrier – the steady transmitted RF signal whose amplitude, frequency, or phase may be modulated to carry information.

Checksum – by NMEA standard, a validity check performed on the data contained in the sentences, calculated by the talker, appended to the message, then recalculated by the listener for comparison to determine if the message was received correctly. Required for some sentences, optional for all others.

Circular Error Probable (CEP) – the radius of a circle, centered at the user's true location, that contains 50 percent of the individual position measurements made using a particular navigation system.

Coarse Acquisition (C/A) Code – a spread spectrum direct sequence code that is used primarily by commercial GPS receivers to determine the range to the transmitting GPS satellite. Uses a chip rate of 1.023 MHz.

Communication protocol – a method established for message transfer between a talker and a listener which includes the message format and the sequence in which the messages are to be transferred. Also includes the signaling requirements such a bit rate, stop bits, parity, and bits per character.

Control segment – the Master Control Station and the globally dispersed Reference Stations used to manage the GPS satellites, determine their precise orbital parameters, and synchronize their clocks.

Course – the horizontal direction in which a vessel is to be steered or is being steered; the direction of travel through the air or water. Expressed as angular distance from reference North (either true, magnetic, compass, or grid), usually 000° (north), clockwise through 360°. Strictly, the term applies to direction through the air or water, not the direction intended to be made good over the ground (see *track*). Differs from heading.

Course Made Good (CMG) – the single resultant direction from a given point of departure to a subsequent position; the direction of the net movement from one point to the other. This often varies from the track caused by inaccuracies in steering, currents, cross-winds, etc. This term is often considered to be synonymous with Track Made Good, however, track made good is the more correct term.

Course Over Ground (COG) – the actual path of a vessel with respect to the Earth (a misnomer in that courses are directions steered or intended to be steered through the water with respect to a reference meridian); this will not be a straight line if the vessel's heading yaws back and forth across the course.

Cross Track Error (XTE) – the distance from the vessel's present position to the closest point on a great circle line connecting the current waypoint coordinates. If a track offset has been specified in the GPSCard SETNAV command, the cross track error will be relative to the offset track great circle line.

Cycle slip – an error in the continuous count of carrier phase cycles.

Dead Reckoning (DR) – the process of determining a vessel's approximate position by applying from its last known position a vector or a series of consecutive vectors representing the run that has since been made, using only the courses being steered, and the distance run as determined by log, engine rpm, or calculations from speed measurements.

Destination – the immediate geographic point of interest to which a vessel is navigating. It may be the next waypoint along a route of waypoints or the final destination of a voyage.

Differential GPS (DGPS) – a technique to improve GPS accuracy that uses pseudorange errors measured at a known location to improve the measurements made by other GPS receivers within the same general geographic area.

Dilution of Precision (DOP) – A numerical value expressing the confidence factor of the position solution based on current satellite geometry. The lower the value, the greater the confidence in the solution. DOP can be expressed in the following forms.

GDOP - all parameters are uncertain (latitude, longitude, height, clock offset)
PDOP - 3D parameters are uncertain (latitude, longitude, height)
HTDOP - 2D parameters and time are uncertain (latitude, longitude, time)
HDOP - 2D parameters are uncertain (latitude, longitude)
VDOP - height is uncertain
TDOP - clock offset is uncertain

Doppler – the change in frequency of sound, light or other wave caused by movement of its source relative to the observer.

Doppler aiding – a signal processing strategy, which uses a measured Doppler shift to help a receiver smoothly track the GPS signal, to allow more precise velocity and position measurement.

Earth-Centered-Earth-Fixed (ECEF) – a right-hand Cartesian coordinate system with its origin located at the center of the Earth. The coordinate system used by GPS to describe three-dimensional location.

ECEF – Earth-Centered-Earth-Fixed coordinates are centered on the WGS-84 reference ellipsoid, have the "Z" axis aligned with the Earth's spin axis, the "X" axis through the intersection of the Prime Meridian and the Equator and the "Y" axis is rotated 90 degrees East of the "X" axis about the "Z" axis.

Ephemeris – a set of satellite orbit parameters that is used by a GPS receiver to calculate precise GPS satellite positions and velocities. The ephemeris is used in the determination of the navigation solution and is updated periodically by the satellite to maintain the accuracy of GPS receivers.

Field – a character or string of characters immediately preceded by a field delimiter.

Fixed field – a field in which the number of characters is fixed. For data fields, such fields are shown in the sentence definitions with no decimal point. Other fields that fall into this category are the address field and the checksum field (if present).

Flash ROM – Programmable read-only memory.

GDOP – Geometric Dilution of Precision – A numerical value expressing the confidence factor of the position solution based on current satellite geometry. Assumes that 3D position (latitude, longitude, height) and receiver clock offset (time) are variables in the solution. The lower the GDOP value, the greater the confidence in the solution.

Geodetic datum – the reference ellipsoid surface that defines the coordinate system.

Geoid – the figure of the earth considered as a sea level surface extended continuously through the continents. The actual geoid is an equipotential surface coincident with mean sea level to which at every point the plumb line (direction in which gravity acts) is perpendicular.

Geostationary – a satellite orbit along the equator that results in a constant fixed position over a particular reference point on the earth's surface. (GPS satellites are not geostationary.)

Global Positioning System (GPS) – full name NAVSTAR Global Positioning System, a space-based radio positioning system which provides suitably equipped users with accurate position, velocity and time data. When fully operational, GPS will provide this data free of direct user charge worldwide, continuously, and under all weather conditions. The GPS constellation will consist of 24 orbiting satellites, four equally spaced around each of six different orbiter planes. The Department of Defense under U.S. Air Force management is developing the system.

Great circle – the shortest distance between any two points along the surface of a sphere or ellipsoid, and therefore the shortest navigation distance between any two points on the Earth. Also called Geodesic Line.

HDOP – Horizontal Dilution of Precision - A numerical value expressing the confidence factor of the horizontal position solution based on current satellite geometry. Makes no constraint assumptions about time, and about height only if the FIX HEIGHT command has been invoked. The lower the HDOP value, the greater the confidence in the solution.

HTDOP – Horizontal position and Time Dilution of Precision – A numerical value expressing the confidence factor of the position solution based on current satellite geometry. Assumes height is known if the FIX HEIGHT command has been invoked. If not, it will give the normalized precision of the horizontal and time parameters given that nothing has been constrained. The lower the HTDOP value, the greater the confidence factor.

Heading – the direction in which a vessel points or heads at any instant, expressed in degrees 000° clockwise through 360° and may be referenced to True North, Magnetic North, or Grid North. The heading of a vessel is also called the ship's head. Heading is a constantly changing value as the vessel oscillates or yaws across the course due to the effects of the air or sea, cross currents, and steering errors.

L1 frequency – the 1575.42 MHz GPS carrier frequency, which contains the coarse acquisition (C/A) code, as well as encrypted P-code, and navigation, messages used by commercial GPS receivers.

L2 frequency – a secondary GPS carrier, containing only encrypted P-code, used primarily to calculate signal delays caused by the ionosphere. The L2 frequency is 1227.60 MHz.

Magnetic bearing – bearing relative to magnetic north; compass bearing corrected for deviation.

Magnetic heading – heading relative to magnetic north.

Magnetic variation – the angle between the magnetic and geographic meridians at any place, expressed in degrees and minutes east or west to indicate the direction of magnetic north from true north.

Mask angle – the minimum GPS satellite elevation angle permitted by a particular GPS receiver design. Satellites below this angle will not be used in position solution.

Measurement error variance – the square of the standard deviation of a measurement quantity. The standard deviation is representative of the error typically expected in a measured value of that quantity.

Multipath errors – GPS positioning errors caused by the interaction of the GPS satellite signal and its reflections.

Nanosecond – 1 x 10^{-9} second

Nautical mile – any of various units of distance for sea and air navigation; in the U.S. since 1959, an international unit of linear measure equal to 1 minute of arc of a great circle of the Earth, 1,852 m (6,076 feet).

Null field – by NMEA standard, indicates that data is not available for the field. Indicated by two ASCII commas, i.e., ",," (HEX 2C2C), or, for the last data field in a sentence, one comma followed by either the checksum delimiter "*" (HEX 2A) or the sentence delimiters <CR><LF> (HEX 0D0A). [Note: the ASCII Null character (HEX 00) is <u>not</u> to be used for null fields.]

Obscuration – term used to describe periods of time when a GPS receiver's line-of-sight to GPS satellites is blocked by natural or man-made objects.

Origin waypoint – the starting point of the present navigation leg, expressed in latitude and longitude.

P-Code (precise or protected) – a spread spectrum direct sequence code that is used primarily by military GPS receivers to determine the range to the transmitting GPS satellite. Uses a chipping rate of 10.23 MHz.

PDOP – Position Dilution of Precision – A numerical value expressing the confidence factor of the position solution based on current satellite geometry. 3D position (latitude, longitude, and height) is unknown. The lower the PDOP value, the greater the confidence factor.

PRN – PseudoRandom Noise number – the identity of the GPS satellites as determined by a GPS receiver. Since all GPS satellites must transmit on the same frequency, they are distinguished by their pseudorandom noise codes.

Parallel receiver – a receiver that monitors four or more satellites simultaneously with independent channels.

Precise Positioning Service (PPS) – the GPS positioning, velocity, and time service which will be available on a continuous, worldwide basis to users authorized by the U.S. Department of Defense (typically using P-Code).

Pseudolite – an Earth-based transmitter designed to mimic a satellite. May be used to transmit differential corrections.

Pseudorange – the calculated range from the GPS receiver to the satellite determined by taking the difference between the measured satellite transmit time and the receiver time of measurement, and multiplying by the speed of light. This measurement generally contains a large receiver clock offset error.

RT-20 – NovAtel's Double Differencing Technology for real-time kinematic (RTK) carrier phase floating ambiguity resolution.

Receiver channels – a GPS receiver specification that indicates the number of independent hardware signal processing channels included in the receiver design.

Relative bearing – bearing relative to heading or to the vessel.

Residual – in the context of measurements, the residual is the misclosure between the calculated measurements, using the position solution and actual measurements.

Route – a planned course of travel, usually composed of more than one navigation leg.

Satellite elevation – the angle of the satellite above the horizon.

Selected waypoint – the waypoint currently selected to be the point toward which the vessel is travelling. Also called **"to" waypoint, destination** or **destination waypoint**.

Selective Availability (SA) – the method used by the United States Department of Defense to control access to the full accuracy achievable by civilian GPS equipment (generally by introducing timing and ephemeris errors).

Sequential receiver – a GPS receiver in which the number of satellite signals to be tracked exceeds the number of available hardware channels. Sequential receivers periodically reassign hardware channels to particular satellite signals in a predetermined sequence.

Spherical Error Probable (SEP) – the radius of a sphere, centered at the user's true location, that contains 50 percent of the individual three-dimensional position measurements made using a particular navigation system.

Spheroid – sometimes known as ellipsoid; a perfect mathematical figure which very closely approximates the geoid. Used as a surface of reference for geodetic surveys. The geoid, affected by local gravity disturbances, is irregular.

Standard Positioning Service (SPS) – a positioning service made available by the United States Department of Defense which will be available to all GPS civilian users on a continuous, worldwide basis (typically using C/A Code).

SV - Space Vehicle ID, sometimes used as SVID; also used interchangeably with Pseudo-Random Noise Number (PRN).

TDOP – Time Dilution of Precision - A numerical value expressing the confidence factor of the position solution based on current satellite geometry. The lower the TDOP value, the greater the confidence factor.

Three-dimensional coverage (hours) – the number of hours-per-day when four or more satellites are available with acceptable positioning geometry. Four visible satellites are required to determine location and altitude.

Three-dimensional (3D) navigation – navigation mode in which altitude and horizontal position are determined from satellite range measurements.

Time-To-First-Fix (TTFF) – the actual time required by a GPS receiver to achieve a position solution. This specification will vary with the operating state of the receiver, the length of time since the last position fix, the location of the last fix, and the specific receiver design.

Track – a planned or intended horizontal path of travel with respect to the Earth rather than the air or water. The track is expressed in degrees from 000° clockwise through 360° (true, magnetic, or grid).

Track made good – the single resultant direction from a point of departure to a point of arrival or subsequent position at any given time; may be considered synonymous with Course Made Good.

True bearing – bearing relative to true north; compass bearing corrected for compass error.

True heading – heading relative to true north.

Two-dimensional coverage (hours) – the number of hours-per-day with three or more satellites visible. Three visible satellites can be used to determine location if the GPS receiver is designed to accept an external altitude input.

Two-dimensional (2D) navigation – navigation mode in which a fixed value of altitude is used for one or more position calculations while horizontal (2D) position can vary freely based on satellite range measurements.

Undulation – the distance of the geoid above (positive) or below (negative) the mathematical reference ellipsoid (spheroid). Also known as geoidal separation, geoidal undulation, geoidal height.

Universal Time Coordinated (UTC) – this time system uses the second-defined true angular rotation of the Earth measured as if the Earth rotated about its Conventional Terrestrial Pole. However, UTC is adjusted only in increments of one second. The time zone of UTC is that of Greenwich Mean Time (GMT).

Update rate – the GPS receiver specification, which indicates the solution rate, provided by the receiver when operating normally.

VDOP – Vertical Dilution of Precision - A numerical value expressing the confidence factor of the position solution based on current satellite geometry. The lower the VDOP value, the greater the confidence factor.

Variable field – by NMEA standards, a data field which may or may not contain a decimal point and which may vary in precision following the decimal point depending on the requirements and the accuracy of the measuring device.

WGS-84 – World Geodetic System 1984 is an ellipsoid designed to fit the shape of the entire Earth as well as possible with a single ellipsoid. It is often used as a reference on a worldwide basis, while other ellipsoids are used locally to provide a better fit to the Earth in a local region. GPS uses the center of the WGS-84 ellipsoid as the center of the GPS ECEF reference frame.

Waypoint – a reference point on a track.

C GPS GLOSSARY OF ACRONYMS

1PPS	One Pulse Per Second
2D	Two Dimensional
3D	Three Dimensional
A/D	Analog-to-Digital
ADR	Accumulated Doppler Range
AGC	Automatic Gain Control
ASCII	American Standard Code for Information Interchange
BIST	Built-In-Self-Test
bps	Bits per Second
C/A Code	Coarse/Acquisition Code
CEP	Circular Error Probable
CPU	Central Processing Unit
CR	Carriage Return
CRC	Cyclic Redundancy Check
CTS	Clear To Send
dB	Decibel
DCE	Data Communications Equipment
DGNSS	Differential Global Navigation Satellite System
DGPS	Differential Global Positioning System
DOP	Dilution Of Precision
DSP	Digital Signal Processor
DSR	Data Set Ready
DTR	Data Terminal Ready
ECEF	Earth-Centered-Earth-Fixed
ESD	Electrostatic Discharge
GDOP	Geometric Dilution Of Precision
GMT	Greenwich Mean Time
GND	Ground
GPS	Global Positioning System
HDOP	Horizontal Dilution Of Precision
hex	Hexadecimal
HTDOP	Horizontal position and Time Dilution Of Precision
Hz	Hertz
IC	Integrated Circuit
IF	Intermediate Frequency
I/O	Input/Output
IODE	Issue of Data (Ephemeris)
IRQ	Interrupt Request

LF	Line Feed
LHCP	Left Hand Circular Polarization
LNA	Low Noise Amplifier
LO	Local Oscillator
lsb	Least significant bit
MET	Multipath Elimination Technology
MEDLL	Multipath Estimation Delay Lock Loop
MKI	Mark In
MKO	Mark Out
msb	Most significant bit
msec	millisecond
MSL	Mean sea level
N. mi.	Nautical mile
NAVSTAR	NAVigation Satellite Timing And Ranging (synonymous with GPS)
NCO	Numerically Controlled Oscillator
NMEA	National Marine Electronics Association
nsec	nanosecond
OCXO	Oven Controlled Crystal Oscillator
OEM	Original Equipment Manufacturer
PC	Personal Computer
P Code	Precise Code
PDOP	Position Dilution Of Precision
PLL	Phase Lock Loop
PPS	Precise Positioning Service or Pulse Per Second
PRN	PseudoRandom Noise number
RAM	Random Access Memory
RF	Radio Frequency
RHCP	Right Hand Circular Polarization
ROM	Read Only Memory
RTCA	Radio Technical Commission for Aviation Services
RTCM	Radio Technical Commission for Maritime Services
RTK	Real Time Kinematic
RTS	Request To Send
RXD	Received Data
SA	Selective Availability
SCAT-I	Special Category I
SEP	Spherical Error Probable
SNR	Signal-to-Noise Ratio
SPS	Standard Positioning Service
SV	Space Vehicle
SVN	Space Vehicle Number
TCXO	Temperature Compensated Crystal Oscillator
TDOP	Time Dilution Of Precision
TTFF	Time-To-First-Fix
TXD	Transmitted Data
UART	Universal Asynchronous Receiver Transmitter
UDRE	User Differential Range Error
UTC	Universal Time Coordinated

VARF	Variable Frequency
VDOP	Vertical Dilution of Precision
WGS	World Geodetic System
wpt	Waypoint
XTE	Crosstrack Error

D STANDARDS AND REFERENCES

RTCM STANDARDS REFERENCE

For detailed specifications of RTCM, refer to RTCM SC104 Version 2.1 of "RTCM Recommended Standards For Differential NAVSTAR GPS Service", January 3, 1994

Radio Technical Commission for Maritime Services
1800 Diagonal Road, Suite 600
Alexandria, VA 22314 U.S.A
Telephone: (703) 684-4481
Fax: (703) 836-4229
Website: http://www.navcen.uscg.mil/faq/dgpsfaq1.htm#Where

RTCA STANDARDS REFERENCE

For copies of the Minimum Aviation System Performance Standards DGNSS Instrument Approach System: Special Category-I (SCAT-I), contact:

RTCA, Incorporated
1140 Connecticut Avenue N.W., Suite 1020
Washington, D.C. 20036-4001 U.S.A.
Telephone: (202) 833-9339
Fax: (202) 833-9434
Website: http://www.rtca.org

GPS SPS SIGNAL SPECIFICATION REFERENCE

For copies of the Interface Control Document (ICD)-GPS-200, contact:

ARINC Research Corporation
2551 Riva Road
Annapolis, MD 21401-7465 U.S.A.
Telephone: (410) 266-4000
Fax: (410) 266-4049
Website: http://www.arinc.com

NMEA REFERENCE

National Marine Electronics Association, NMEA 0183 Standard for Interfacing Marine Electronic Devices, Version 2.00, January 1, 1992

NMEA Executive Director
P.O. Box 3435
New Bern, NC 28564-3435 U.S.A.
Telephone: (252) 638-2626
Fax: (252) 638-4885
Website: http://www4.coastalnet.com/nmea

GEODETIC SURVEY OF CANADA

Geodetic Survey of Canada
615 Boothe Street
Ottawa, ON K1A 0E9 Canada

Telephone: (613) 995-4410
Fax: (613) 995-3215
Website: http://www.geocan.nrcan.gc.ca/ps/geode.html

U.S. NATIONAL GEODETIC SURVEY

NGS Information Services
1315 East-West Highway
Station 9244
Silver Springs, MD 20910-3282 U.S.A.
Telephone: (301) 713-2692
Fax: (301) 713-4172
Website: http://www.ngs.noaa.gov

NOVATEL REFERENCE

NovAtel Inc.
1120-68th Avenue NE
Calgary, Alberta, Canada
T2E 8S5

Telephone:
Canada or USA 1-800-NOVATEL
International 403-295-4900
Fax: 403-295-4901
Internet: http://www.novatel.ca
E-mail: gps@novatel.ca

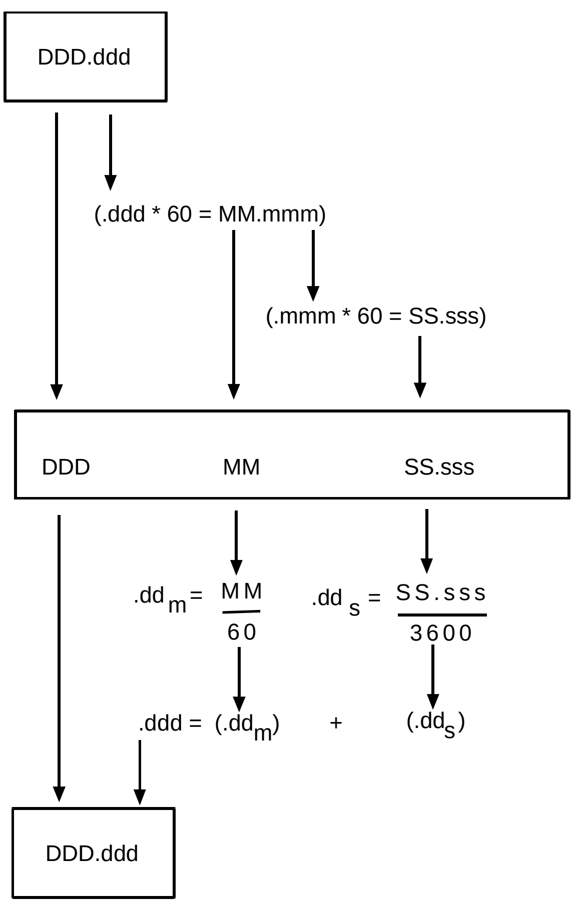
Note: Website addresses, postal addresses, and telephone numbers may be subject to change. However, they are accurate at the time of publication.

E CONVERSIONS

Section E.1 shows the conversion from Degrees to Decimal degrees. Sections E.2 to E.5 list commonly used equivalents between the SI (Systeme Internationale) units of weights and measures used in the metric system, and those used in the imperial system. An example of the conversion from GPS time of week to calendar day is shown in Section E.6, while a complete list of hexadecimal values with their binary equivalents is given in Section E.7.

E.1 DEGREES TO DECIMAL DEGREES

Degrees/decimal degrees ←→ Degrees/Minutes/Seconds



DDD = Degrees (000 - 360)
DD = Degrees (00 - 90)

MM = Minutes (00 - 60)
.mmm = decimal minutes (variable length)

SS = Seconds (00 - 60)
.sss = decimal seconds (variable length)

$.dd_m$ = decimal degrees derived from minutes

$.dd_s$ = decimal degrees derived from seconds

.ddd = decimal degrees ($.dd_m + .dd_s$)

E.2 DISTANCE MEASUREMENTS

1 meter (m) = 100 centimeters (cm) = 1000 millimeters (mm)
1 kilometer (km) = 1000 meters (m)
1 nautical mile = 1852 meters
1 international foot = 0.3048 meters
1 statute mile = 1609 meters
1 US survey foot = 0.3048006096 meters

E.3 VOLUME

1 litre (l) = 1000 cubic centimeters (cc)
1 gallon (Imperial) = 4.546 litres
1 gallon (US) = 3.785 litres

E.4 TEMPERATURE

degrees Celsius = (5/9) x [(degrees Fahrenheit) – 32]
degrees Fahrenheit = [(9/5) x (degrees Celsius)] + 32

E.5 WEIGHT

1 Kilogram (kg) = 1000 grams
1 pound = 0.4536 kilogram (kg)

E.6 GPS TIME OF WEEK TO CALENDAR DAY

example:

Day 5 (Thursday) + 22 hours, 0 minutes, 0 seconds into Friday.

511200 seconds	Day	511200 / 86400 seconds per day	=	**5**.9166666667	**days**
	Hour	.9166666667 x 86400 / 3600 seconds per hour	=	**22**.0000	**hours**
	Minute	.000 x 3600 / 60 seconds per minute	=	**0**.000	**minutes**
	Second	.000 x 60	=	0.00	**seconds**

E.6.1 Calendar Date To GPS Time

example:

January 22, 1995 at 11:30 hours

Days from January 6, 1980 to January 22, 1995		=	15 years x 365 days/year		=	5475 days
Add one day for each leap year (a year which is divisible by 4 or 400 but not by 100; every 100 years a leap year is skipped)						4 days
Days into 1995 (22nd day is not finished)						21 days
Total days:						5500 days
Deduct 5 days: Jan 1 through 5, 1980						5495 days
GPS Week:	5495 x 86400 seconds per day	=	474768000 seconds/ 604800 sec per week		=	**785**
Seconds into week:	22nd day :		11.5 hrs x 3600 sec/hr			**41400** seconds
GPS time of week:						**Week 785, 41400 seconds**

E.7 HEXADECIMAL AND BINARY EQUIVALENTS

Hexadecimal	Binary
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
A	1010
B	1011
C	1100
D	1101
E	1110
F	1111

F COMMAND AND LOG SUMMARY CHARTS

Table F-1 GPSCard Command Summary

Command	Description	Syntax
$ALMA	Injects almanac	(follows NovAtel ASCII log format)
$DCSA	Injects NovAtel format differential corrections	(follows NovAtel ASCII log format)
$IONA	Injects ionospheric refraction corrections	(follows NovAtel ASCII log format)
$RTCA	Injects RTCA format DGPS corrections in ASCII (Type 1)	(follows NovAtel ASCII log format)
$RTCM	Injects RTCM format differential corrections in ASCII (Type 1)	(follows NovAtel ASCII log format)
$UTCA	Injects UTC information	(follows NovAtel ASCII log format)
ACCEPT	Port input control (set command interpreter)	**accept** *port,option*
ASSIGN	Assign a prn to a channel #	**assign** *channel,prn,doppler, search window*
UNASSIGN	Un-assign a channel	**unassign** *channel*
UNASSIGNALL	Un-assign all channels	**unassignall**
CLOCKADJUST	Adjust 1PPS continuously	**clockadjust** *switch*
COMn	Initialize Serial Port (1 or 2)	**com***n bps,parity,databits,stopbits, handshake,echo*
COMn_DTR	Programmable DTR lead/tail time	**comn_dtr** *control,active,lead,tail*
COMn_RTS	Programmable RTS lead/tail time	**comn_rts** *control,active,lead,tail*
CRESET	Configuration reset to factory default	**creset**
CSMOOTH	Sets carrier smoothing	**csmooth** *value*
DATUM	Choose a DATUM name type	**datum** *option*
USERDATUM	User defined DATUM	**userdatum** *semi-major,flattening,dx,dy,dz, rx,ry,rz, scale*
DGPSTIMEOUT	Sets maximum age of differential data to be accepted and ephemeris delay	**dgpstimeout** *value value*
DYNAMICS	Set receiver dynamics	**dynamics** *option*
ECUTOFF	Set elevation cutoff angle	**ecutoff** *angle*
FIX HEIGHT	Sets height for 2D navigation	**fix height** *height*
FIX POSITION	Set antenna coordinates for reference station	**fix position** *lat,lon,height [station id] [health]*
FIX VELOCITY	Accepts INS xyz (ECEF) input to aid in high velocity reacquisition of SVs	**fix velocity** *vx,vy,vz*
UNFIX	Remove all receiver FIX constraints	**unfix**
FREQUENCY_OUT	Variable frequency output (programmable)	**frequency_out** *n,k*
HELP or ?	On-line command help	**help** *option* or **?** *option*
LOCKOUT	Lock out satellite	**lockout** *prn*
UNLOCKOUT	Restore satellite	**unlockout** *prn*
UNLOCKOUTALL	Restore all satellites	**unlockoutall**
LOG	Choose data logging type	**log** *port,datatype,trigger,[period,offset]*
UNLOG	Kill a data log	**unlog** *port,data type*
UNLOGALL	Kill all data logs	**unlogall**
MAGVAR	Set magnetic variation correction	**magvar** *value*
MESSAGES	Disable error reporting from command interpreter	**messages** *port,option*
RESET	Performs a hardware reset (OEM only)	**reset**
RESETRT20	Performs a manual restart of RT20 mode	**resetrt20**
RTCM16T	Enter an ASCII text message	**rtcm16t** *ascii message*

Command	Description	Syntax
RTCMRULE	Set variations of the RTCM bit rule	**rtcmrule** *rule*
RTKMODE	Set up the RTK mode	**rrtkmode** *argument, data range*
SAVECONFIG	Save current configuration in flash memory (OEM only)	**saveconfig**
SEND	Send an ASCII message to any of the communications ports	**send** *port ascii-message*
SENDHEX	Sends non-printable characters in hexadecimal pairs	**sendhex** *port data*
SETCHAN	Sets maximum number of channels for tracking	**setchan** *option*
SETDGPSID	Enter in a reference station ID	**setdgpsid** *option*
SETHEALTH	Override PRN health	**sethealth** *prn,health*
RESETHEALTH	Reset PRN health	**resethealth** *prn*
RESETHEALTHALL	Reset all PRN health	**resethealthall**
SETNAV	Set a destination waypoint	**setnav** *from lat,from lon,to lat, to lon,track offset, from port,to port*
UNDULATION	Choose undulation	**undulation** *separation*
VERSION	Current software level	**version**

NOTES:

- Commands are not case sensitive (e.g. HELP or help)
- All commands and required entries can be separated by a space or a comma (*command*,*variable* OR *command variable*).
- A command or command string must be followed by pressing the Return key.
- Also refer to the Command/Log Functional Relationship chart, page 183, in Appendix F.

Table F-2 GPSCard Log Summary

Syntax: **log** *port,datatype,trigger,[period,offset]*

Log Name	Binary Log ID	Description	Log Name	Binary Log ID	Description
NovAtel Format Logs					
ALMA/B	18	Decoded Almanac	PRTKA/B		Computed Position
CDSA/B	39	Communication and Differential Decode Status	PXYA/B	26	Computed Cartesian Coordinate Position
CLKA/B	02	Receiver Clock Offset Data	RALA/B	15	Raw Almanac
COM1A/B	30	Log data from COM1	RCCA	N/A	Receiver Configuration
COM2A/B	31	Log data from COM2	RCSA/B	13	Receiver status incl. S/W version, # of working channels, CPU idle time, BISTs status, clock status
CONSOLEA/B	29	Log data from console	REPA/B	14	Raw Ephemeris
CTSA/B	19	Channel Tracking Status	RGEA/B/C/D	32,33	Channel Range Measurements
DCSA/B	09	Differential Corrections - NovAtel format	RT20A/B	35	Computed Position – Time Matched
DOPA/B	07	Dilution of Precision	RTCAA/B	38	RTCA format Differential Corrections with NovAtel headers
GGAB	27	Global Position System Fix Data - Binary Format	RTCMA/B	10	RTCM SC104 Differential Corrections with NovAtel headers
MKPA/B	05	Mark Position	RTCM16T	N/A	NovAtel ASCII Format – Special Message
MKTA/B	04	Time of Mark Input	RTKA/B		Computed Position – Time Matched
NAVA/B	08	Navigation Data	SATA/B	12	Satellite Specific Data
P20A/B	37	Computed Position – best available	SPHA/B	06	Speed and Direction Over Ground
PAVA/B		Positioning Averaging Status	SVDA/B	36	SV Position in ECEF XYZ Coordinates with Corrections
POSA/B	01	Computed Position	TM1A/B	03	Time of 1PPS
			VERA/B		Receiver Hardware and Software Version Numbers
			VLHA/B	34	Velocity, Latency, and Direction over Ground

Log Name	Binary Log ID	Description	Log Name	Binary Log ID	Description
NMEA Format Logs					
GPALM	N/A	NMEA Almanac Data	GPGSV	N/A	NMEA GPS Satellites in View
GPGGA	N/A	NMEA Global Position System Fix Data	GPRMB	N/A	NMEA Generic Navigation Information
GPGLL	N/A	NMEA Geographic Position - lat/lon	GPRMC	N/A	NMEA GPS Specific Information
GPGRS	N/A	GPS Range Residuals for Each Satellite	GPVTG	N/A	NMEA Track Made Good and Ground Speed
GPGSA	N/A	NMEA GPS DOP and Active Satellites	GPZDA	N/A	NMEA UTC Time and Date
GPGST	N/A	Pseudorange Measurement Noise Statistics	GPZTG		NMEA UTC & Time to Destination Waypoint
RTCA Format					
RTCAA/B	38	RTCA Differential Corrections			
RTCM Format					
RTCMA/B	10	RTCM SC104 Format, Type 1 – Differential Corrections			
RTCM3	N/A	RTCM Format Type 3 – Reference Station Precise Position Data			
RTCM16	N/A	RTCM Format, Type 16 – Special Message			
RTCM59	N/A	RTCM Type 59 Proprietary Message "N" – Pseudorange and Carrier Phase Observation Data			

N.B. A/B/C
A refers to GPSCard output logs in ASCII format.
B refers to GPSCard output logs in Binary format.
C refers to GPSCard output logs in Compressed binary format.

Table F-3Command/Log Relationships

The following table has been compiled to illustrate correlations among functions, commands & related logs.

COMMUNICATIONS, CONTROL AND STATUS			
Related Commands	**Descriptions**	**Related Logs**	**Descriptions**
COMn	COMn port configuration control	RCSA/B	Receiver self-test status
COMn_DTR	DTR handshaking control	CDSA/B	COM port communications status
COMn_RTS	RTS handshaking control	RTCM16T	NovAtel ASCII format special message
LOG	Logging control	RTCM16	RTCM format special message
RTCMRULE	Sets up RTCM bit rule	COMnA/B	Pass-through data logs
SEND	Sends ASCII message to COM port		
SENDHEX	Sends non-printable characters		
RTCM16T	Enters an ASCII message		

GENERAL RECEIVER CONTROL AND STATUS			
Related Commands	**Descriptions**	**Related Logs**	**Descriptions**
VERSION	Software/hardware information	RCCA	Receiver configuration status
CRESET	Reset receiver to factory default	RCSA/B	Version and self-test status
HELP	On-line command help	VERA/B	Receiver hardware and software version numbers
DYNAMICS	Set correlator tracking bandwidth		
$ALMA	Download almanac data file		
SAVECONFIG	Saves current configuration (OEM only)		

POSITION, PARAMETERS, AND SOLUTION FILTERING CONTROL			
Related Commands	**Descriptions**	**Related Logs**	**Descriptions**
DATUM	Select a standard datum	POSA/B	Position data
USERDATUM	User-customized datum	PXYA/B	Position (Cartesian x,y,z coordinates)
UNDULATION	Ellipsoid-geoid separation	GPGGA	NMEA, position data
FIX POSITION	Constrains to fixed lat, lon, height	GPGLL	NMEA, position data
FIX HEIGHT	Constrains to fixed height (2D mode)	DOPA/B	DOP of SVs currently tracking
FRESET	Clears all data which is stored in NVM	GPGSA	NMEA, DOP information
LOCKOUT	Deweights a satellite in solutions	MKPA/B	Position at time of mark
ECUTOFF	Satellite elevation cut-off for solutions	GPGRS	NMEA, range residuals
CSMOOTH	Sets amount of carrier smoothing	GPGST	NMEA, measurement noise statistics
RESETRT20	Manual reset of RT20 mode	P20A/B	Computed position – best available
$IONA	Download ionospheric correction data	RT20A/B	Computed position – time matched
RTKMODE	Set-up the RTK mode	GGAB	GPS fix data
		PRTKA/B	Computed position – best available
		RTKA/B	Computed position – time matched

SATELLITE TRACKING AND CHANNEL CONTROL			
Related Commands	**Descriptions**	**Related Logs**	**Descriptions**
ASSIGN	Satellite channel assignment	CTSA/B	Channel tracking status
DYNAMICS	Sets correlator tracking bandwidth	DOPA/B	DOP of SVs currently tracking
FIX VELOCITY	Aids high velocity reacquisition	ALMA/B	Current decoded almanac data
SETHEALTH	Overrides broadcast satellite health	RALA/B	Raw almanac data (hex)
$ALMA	Download almanac data file	RGEA/B/C/D	Satellite range measurements
		SATA/B	Satellite specific information
		SVDA/B	SV position (ECEF xyz)
		GPALM	NMEA, almanac data
		GPGSA	NMEA, SV DOP information
		GPGSV	NMEA, satellite-in-view information

WAYPOINT NAVIGATION			
Related Commands	**Descriptions**	**Related Logs**	**Descriptions**
SETNAV	Waypoint input	NAVA/B	Navigation waypoint status
MAGVAR	Magnetic variation correction	SPHA/B	Speed and course over ground
		VLHA/B	Velocity, latency & direction over ground
		POSA/B	Position data
		MKPA/B	Position at time of mark input
		GPRMB	NMEA, waypoint status
		GPRMC	NMEA, navigation information
		GPVTG	NMEA, track made good and speed
		GPZTG	NMEA, time to destination

DIFFERENTIAL REFERENCE STATION			
Related Commands	**Descriptions**	**Related Logs**	**Descriptions**
FIX POSITION	Constrain to fixed (reference)	RTCM	Transmits RTCM SC104 standard corrections
RTCMRULE	Selects RTCM bit rule	RTCMA/B	Transmits RTCM information in NovAtel ASCII/binary
LOG	Selects required differential-output log	RTCAA/B	Transmits RTCA differential corrections in NovAtel ASCII/bin
DGPSTIMEOUT	Sets ephemeris delay	DCSA/B	NovAtel format differential corrections
SETDGPSID	Set reference station ID	CDSA/B	COM port data transmission status
POSAVE	Implements position averaging for reference station	ALMA/B	Current almanac information
		RGEA/B	Channel range measurements
		SATA/B	Satellite specific information
		RTCM3	Reference position
		RTCM59	NovAtel format RT-20 observation data
		PAVA/B	Parameters being used in the position averaging process

DIFFERENTIAL REMOTE STATION			
Related Commands	**Descriptions**	**Related Logs**	**Descriptions**
ACCEPT	Accepts RTCM, RTCA, DCSB, or RT20 diff. inputs	GPGGA	NMEA, position fix data
RTCMRULE	Selects RTCM bit rule	GGAB	NovAtel binary version of GPGGA
$DCSA	NovAtel format differential correction input (ASCII)	POSA/B	Position information
$RTCM	RTCM differential correction input (ASCII)	CDSA/B	Differential decode status
$ALMA	Input almanac data	SATA/B	Satellite specific information
$RTCA	RTCA differential correction input (ASCII)	VLHA/B	Velocity, latency & direction over ground
DGPSTIMEOUT	Set maximum age of differential data accepted	SVDA/B	SV position in ECEF XYZ with corrections
RESETRT20	Manual reset of RT20 mode	P20A/B	Computed Position – best available
SETDGPSID	Select differential reference station ID to receive	RT20A/B	Computed Position – Time Matched
		CDSA/B	COM port data transmission status
		PRTKA/B	Computed Position – best available
		RTKA/B	Computed Position – Time Matched

POST PROCESSING DATA			
Related Commands	**Descriptions**	**Related Logs**	**Descriptions**
Depends on operating platform		RGEA/B/C/D	Satellite and ranging information
		REPA/B	Raw ephemeris information
		SATA/B	Satellite specific information
		SVDA/B	SV position in ECEF XYZ with corrections
		CLKA/B	Receiver clock offset information

CLOCK INFORMATION STATUS AND TIME			
Related Commands	**Descriptions**	**Related Logs**	**Descriptions**
CLOCKADJUST	Enable clock modeling & 1PPS adjust	CLKA/B	Receiver clock offset information
$UTCA	Download UTC data	TM1A/B	Time of 1PPS
		MKTA/B	Time of mark input
		GPZDA	NMEA, UTC time and date
		GPZTG	NMEA, UTC and time to waypoint

NAVIGATION DATA			
Related Commands	**Descriptions**	**Related Logs**	**Descriptions**
		FRMA/B	Framed raw navigation data
		FRWA/B	Framed raw navigation words

G SUMMARY OF STATUS TABLES

Table 5-1 GPSCard Channel Tracking States

State	Description
0	Idle
1	Sky searching
2	Wide band frequency pull-in
3	Narrow band frequency pull-in
4	Phase lock loop achieved
5	Reacquisition

Higher numbers are reserved for future use

Table 5-2 GPSCard Solution Status

Value	Description
0	Solution computed
1	Insufficient observations
2	No convergence
3	Singular AtPA Matrix
4	Covariance trace exceeds maximum (trace > 1000 m)
5	Test distance exceeded (maximum of 3 rej if distance > 10 km)
6	Not yet converged from cold start
7	Height or velocity limit exceeded. (In accordance with COCOM export licensing restrictions)

Higher numbers are reserved for future use

Table 5-3 Position Type

Type	Definition
0	No position
1	Single point position
2	Differential pseudorange position
3	RT-20 position
4	RT-2 position
5	WAAS position solution

Higher numbers are reserved for future use

Table 5-4 RTK Status for Position Type 3 (RT-20)

Status	Definition
0	Floating ambiguity solution (converged)
1	Floating ambiguity solution (not yet converged)
2	Modeling reference phase
3	Insufficient observations
4	Variance exceeds limit
5	Residuals too big
6	Delta position too big
7	Negative variance
8	RTK position not computed

Higher numbers are reserved for future use

Table 5-5 GPSCard Receiver Self-test Status Codes

N 7 | N 6 | N 5 | N 4 | N 3 | N 2 | N 1 | N 0 | <-<- Nibble Number

31 30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0

Bit	Description	Range Values	Hex Value
lsb = 0	ANTENNA	1 = good, 0 = bad	00000001
1	PRIMARY PLL	1 = good, 0 = bad	00000002
2	RAM	1 = good, 0 = bad	00000004
3	ROM	1 = good, 0 = bad	00000008
4	DSP	1 = good, 0 = bad	00000010
5	PRIMARY AGC	1 = good, 0 = bad	00000020
6	COM 1	1 = good, 0 = bad	00000040
7	COM 2	1 = good, 0 = bad	00000080
8	WEEK	1 = not set, 0 = set	00000100
9	NO COARSETIME	1 = not set, 0 = set	00000200
10	NO FINETIME	1 = not set, 0 = set	00000400
11	PRIMARY JAMMER	1 = present, 0 = normal	00000800
12	BUFFER COM 1	1 = overrun, 0 = normal	00001000
13	BUFFER COM 2	1 = overrun, 0 = normal	00002000
14	BUFFER CONSOLE	1 = overrun, 0 = normal	00004000
15	CPU OVERLOAD	1 = overload, 0 = normal	00008000
16	ALMANAC SAVED IN NVM	1 = yes, 0 = no	00010000
17	RESERVED		
18	RESERVED		
19	RESERVED		
20	RESERVED		
21	RESERVED		
22	RESERVED		
23	RESERVED		
24	RESERVED		
25	RESERVED		
26	RESERVED		
27	RESERVED		
28	RESERVED		
29	RESERVED		
30	RESERVED		
31	RESERVED		

Table 5-6 GPSCard Tracking Status

N 7 (bits 31–28) | N 6 (bits 27–24) | N 5 (bits 23–20) | N 4 (bits 19–16) | N 3 (bits 15–12) | N 2 (bits 11–8) | N 1 (bits 7–4) | N 0 (bits 3–0) <- <- Nibble Number

Bit	Description	Range Values	Hex.
lsb = 0	Tracking state	0 - 7 See below	1
1			2
2			4
3			8
4	Channel number	0 - n (0 = first, n = last) (n depends on GPSCard)	10
5			20
6			40
7			80
8			100
9	Phase lock flag	1 = Lock, 0 = Not locked	200
10	Parity known flag	1 = Known, 0 = Not known	400
11	Code locked flag	1 = Lock, 0 = Not locked	800
12	Reserved		1000
13			2000
14			4000
15	Reserved		8000
16			10000
17			20000
18	Reserved		40000
19	Grouping	1 = Grouped, 0 = Not grouped	80000
20	Frequency	1 = L2, 0 = L1	100000
21	Code type	0 = C/A 2 = P-codeless 1 = P 3 = Reserved	200000
22			400000
23	Reserved		800000
24 : 29	Reserved		
30	Reserved		
31	Reserved		

Table 5-7 GPSCard Range Reject-Codes

Value	Description
0	Observations good
1	Bad health
2	Old ephemeris
3	Eccentric anomaly error
4	True anomaly error
5	Satellite coordinate error
6	Elevation error
7	Misclosure too large
8	No Differential Correction
9	No Ephemeris
10	Invalid IODE
11	Locked Out

Table 5-8 GPSCard Velocity Status

Value	Description
0	Velocity computed from differentially corrected carrier phase data
1	Velocity computed from differentially corrected Doppler data
2	Old velocity from differentially corrected phase or Doppler (higher latency)
3	Velocity from single point computations
4	Old velocity from single point computations (higher latency)
5	Invalid velocity

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