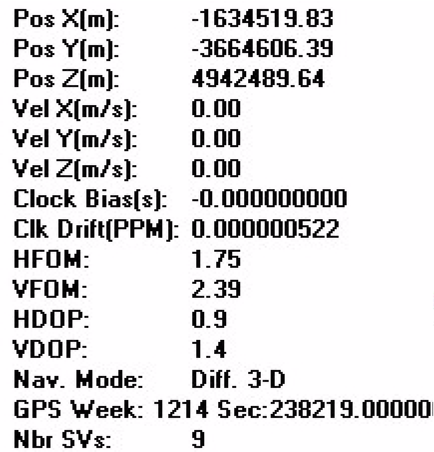

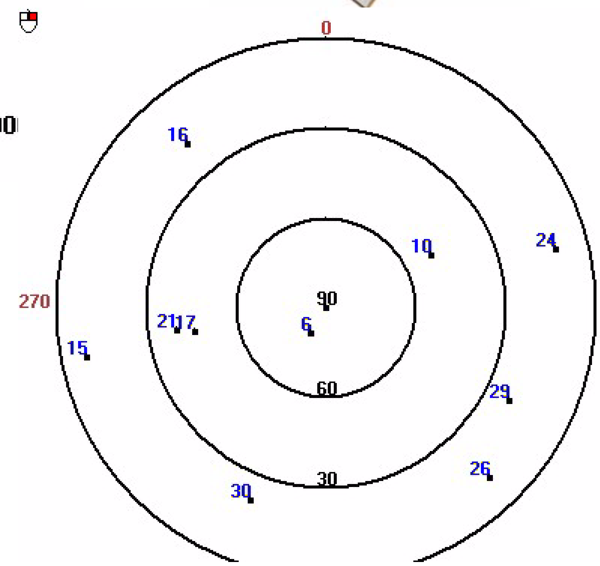

SUPERSTAR II Firmware

Reference Manual

SUPERSTAR II Firmware Reference Manual

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Proprietary Notice

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Customer Service

Contact Information

If you have any questions or concerns regarding your SUPERSTAR II-based receiver, please contact NovAtel Customer Service using any one of the following methods:

NovAtel GPS Hotline:	**1-800-NOVATEL** (Canada and the U.S.) 403-295-4900 (International)
Fax:	403-295-4901
E-mail:	support@novatel.ca
Website:	www.novatel.com
Write:	NovAtel Inc. Customer Service Dept. 1120 - 68 Avenue NE Calgary, Alberta, Canada T2E 8S5

✉ Before contacting NovAtel Customer Service regarding software concerns, please do the following:

1. Issue the NVM Reset command, *Message ID# 99* on *Page 55*, with value 0 to reset all NVM.
2. Log the following data requests to a file on your PC for 30 minutes

Receiver Status, Message ID# 49	one shot
Ephemeris Data, Message ID# 22	continuous
Measurement Block, Message ID# 23	1 Hz
HW/SW Identification, Message ID# 45	one shot

3. Send the file containing the log to NovAtel Customer Service, using either the NovAtel ftp site at ftp://ftp.novatel.ca/incoming or the support@novatel.ca e-mail address.

Firmware Updates

Firmware updates are firmware revisions to an existing model, which improve basic functionality of the GPS receiver. See also *Chapter 4, Firmware Updates* on *Page 130*.

Firmware upgrades are firmware releases, which increase basic functionality of the receiver from one model to a higher level model type. When available, upgrades may be purchased at a price, which is the difference between the two model types on the current NovAtel GPS Price List plus a nominal service charge.

If you need further information, please contact a NovAtel authorized dealer or NovAtel directly using one of the methods given above.

Foreword

Congratulations on purchasing a NovAtel product.

Whether you have bought a stand alone SUPERSTAR II card or a packaged receiver, the SUPERSTAR II User Manual, or SMART ANTENNA User Manual, will help you get the hardware operational. Afterwards, this text is your primary firmware command and logging reference.

Scope

This manual describes each message that the NovAtel SUPERSTAR II receivers are capable of accepting or generating.

A SMART ANTENNA contains a SUPERSTAR II card.

Sufficient detail is provided so that you should understand the purpose, syntax, and structure of each command or log and be able to effectively communicate with the receiver, thus enabling you 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 receiver.

There is also optional Satellite Based Augmentation System (SBAS) signal functionality in SUPERSTAR II-based products. Please see *Appendix A, SUPERSTAR II Card Models* on *Page 133* and *Appendix D, SBAS Positioning* on *Page 145* of this manual and the *Conventions* section below for more information.

This manual does not address any of the receiver hardware attributes or installation information. Please consult the appropriate hardware user manual for technical information on these topics, see *Table 1* on *Page 12*. Furthermore, should you encounter any functional, operational, or interfacing difficulties with the receiver, consult the same hardware manual for NovAtel warranty information. Customer support information may be found in this manual on *Page 10*.

What's New in Firmware Version 1.300 Since Version 1.200?

Version 1.300 of the firmware adds the following to this manual:

1. Support for 2-D mode, which is useful when there are only 3 satellites available for computing a solution
2. A fixed height mode command, Message ID# 87 to enable 2-D mode in 1. above, see *Page 46*
3. The NMEA Message Format and the NMEA Checksum Calculation, see *Section F.2, NMEA Format Data Messages* on *Page 150*
4. Non-SBAS models are now available, see *Appendix A, SUPERSTAR II Card Models* on *Page 133*
5. 5 Hz carrier phase (CP) models that are capable of 1, 2 or 5 Hz measurements, see *Table 19* on *Page 133*.

The most up-to-date version of this manual can be downloaded from our website at http://www.novatel.com/Downloads/docupdates.html.

If you are unfamiliar with any of the terms used in this manual, refer to the *GPS+ Reference Manual* available on our website at the address above.

Prerequisites

As this reference manual is focused on SUPERSTAR II commands and logging protocol, it is necessary to ensure that the receiver has been properly installed and powered up according to the instructions outlined in your product's companion hardware user manual before proceeding.

Conventions

This manual covers the full performance capabilities of NovAtel SUPERSTAR II-based receivers.

A list of models may be found in *Appendix A, SUPERSTAR II Card Models* on *Page 133*.

Simple conventions are:

H The number preceding H is a hexadecimal number
b The number preceding b is a binary number

In tables where values are missing they are reserved for future use.

Messages and status words are output as hexadecimal numbers and must be converted to binary format (and in some cases then also to decimal). Conversions and their binary or decimal results are always read from right to left.

Related Publications

The related publications are listed in *Table 1* below.

Table 1: Related Publications

PUBLICATION NAME	PUBLICATION NAME
[1] ICD-GPS-200 Rev. B	NAVSTAR GPS Space Segment/Navigation Interface
[2] RTCM-104 version 2.1 January 1994	Recommended Standards for Differential NAVSTAR GPS Radio Technical Commission for Maritime Services
[3] SAE J1211	SAE Recommended Environmental Practices for Electronic Equipment Design
[4] NMEA-0183 Rev 2.20	National Marine Electronics Association Standard for Interfacing
[5] STARVIEW User Manual	NovAtel Part Number OM-20000081 [a]
[6] SMART ANTENNA User Manual	NovAtel Part Number OM-20000078 [a]
[7] SUPERSTAR II User Manual	NovAtel Part Number OM-20000077 [a]

a. Adobe PDF versions of these manuals can be downloaded from our website at http://www.novatel.com/Downloads/docupdates.html.

Chapter 1 Messages

This section defines a serial data transfer protocol for the receiver. The serial data is sent in variable size message blocks, where the message block header defines the contents and size of all message blocks.

For discussion purposes, the PC is the controlling host computer, and the GPS receiver is a SUPERSTAR II-based product. *StarView* provides a graphical interface to control and monitor the operation of your NovAtel receiver. A *StarView* CD is supplied with development kits, otherwise *StarView* is available on our website at http://www.novatel.com/Downloads/fwswupdates.html.

Prior to entering the protocol, use *StarView* to set up both the PC and GPS receiver at the same baud rate and data setting. Upon entering the protocol, the PC and GPS receiver wait for message blocks. Refer also to the *StarView User Manual*, see *Table 1* on *Page 12*.

1.1 Physical Link Layer

The electrical signals used are those through the communication port. Only the receive and send lines are required. The serial port is asynchronous and should be set up with 1 start bit, 8 data bits, no parity bit, and one stop bit. Asynchronous data is generated at irregular intervals when the output has changed. A default baud rate of either 9600 or 19200 bps is used depending on your model. Both the PC and receiver are operating at the same rate and can be reset (see *Message ID# 110* on *Page 58*). See also *Appendix A, SUPERSTAR II Card Models,* starting on *Page 133*.

1.2 Data Link Layer

1.2.1 Bit Ordering

The ordering of data within message blocks is such that the least significant bit (LSB) is the first bit received and the most significant bit (MSB) is the last bit in the sequence.

	MSB							LSB
Order	7	6	5	4	3	2	1	0

This ordering is applied to all data formats, which include integer values, floating point values, and character strings.

1.2.2 Message Block Structure

Message blocks are used for communication between the GPS receiver and your PC. Each message block consists of a header and possibly data. The data portion of the block is of variable length depending on the message. The header has a fixed length of 4 bytes, consisting of a start-of-header character (SOH), block ID, block ID complement and message data length. Each block has a truncated 16-bit word containing the checksum associated with the complete content of the block. It is appended at the end of the data portion of the block.

The message block structure has the following form:

byte 1:	SOH
byte 2:	ID#
byte 3:	Complementary ID#
byte 4:	Message Data Length (0-255)
byte 5 .. n:	n-4 Data Bytes
byte n+1 .. n+2:	Checksum

where:

SOH

Start of header character (01H or decimal 1).

ID#

Byte containing the block ID numeric value. The block ID number field is used uniquely to identify the format of the data portion of the block. Since only 7 bits are needed for the ID#, the higher bit is used to identify if the message is sent in one shot (the message is output only once) or continuous (the message is output continuously at its message rate normally once per second) mode. This prevents an unnecessary increase in overhead by eliminating any extra bytes in the protocol. There are exceptions to this use of the higher bit as seen in example 2 below.

1. For example, Message ID# 50 with:

   ID = 32H; binary 0011 0010 where the msb = 0 for one shot
   01 32 CD 00 00 01

   or

   ID = B2H; binary 1011 0010 where the msb = 1 for continuous
   01 B2 4D 00 00 01

2. Take the case of Message ID#23, where setting the higher bit is used to identify if the message is to be logged in continuous mode or if the message is to be stopped.

   For example, Message ID# 23 with:

   ID# = 17H; binary 0001 0111 where the msb = 0 to stop output
   01 17 E8 00 01 01

   or

   ID# = 97H; binary 1001 0111 where the msb = 1 for continuous output
   01 97 68 01 00 01 01

For most messages, MSB = 0 is for one shot or to cancel continuous, MSB = 1 is for continuous unless specified otherwise. See byte 2 above and *Section 1.2.1, Bit Ordering*.

Complimentary ID#

1's complement of the ID# field. This can be calculated as:

Complimentary ID# = 255 - (Block ID#) or Cmpl ID# = (Block ID#) XOR 255

This field, in conjunction with the SOH, helps to synchronize the message blocks, since the SOH character can appear within the data, the Complimentary ID# field validates the header contents and thus confirms the start of the block.

Message Data Length

One byte containing the length of the data part of the message in bytes (excluding header and checksum).

Checksum

This fields contains the checksum value for the message blocks, which includes the header and data. The checksum calculation is discussed in *Checksum Calculation Rules* on *Page 19*.

1.2.3 Message Block Types

1.2.3.1 PC to GPS Receiver Message Types

There are 5 types of messages that can be sent from your PC to the GPS receiver:

Dummy Message (ID# 0):

Reserved

Initiate Link (ID# 63):

This is the first message sent by the PC upon entering the protocol. It informs the receiver that communication is desired. A password is encoded in the message. This message interrupts all receiver logs and waits for new data request messages.

Data Request (DR) Message:

Request the receiver to turn on/off broadcast data or to send data only once. The MSB of the ID# indicates the type of request with "1" to turn on broadcast, and "0" for once only or to turn off the broadcast.

Command Message (CM):

Request a particular receiver action other than a data request. The MSB of the ID# may be used to set the receiver to Normal mode (MSB=0) or to Special mode (MSB=1).

✉ For DR messages, Normal mode is for one shot output and Special mode is for continuous output. See also the *ID#* description on *Page 14.* However, for CMs, the Special mode has another meaning. *Table 2* on *Page 16* shows examples of Message ID#s where using Normal mode or Special mode does not send the message out in one shot or continuous mode.

Data Message (DM):

Any message containing data to be saved in receiver memory or processed by the receiver.

Table 2: Message Modes

Message ID#	Description	Normal Mode	Special Mode
2	Reset Receiver	Reset	N/A - The information does not change so this is unnecessary. To continuously reset the receiver is not recommended
23	Request Measurement Block Data	Off - Turns off continuous mode and does not give a one shot output	On (default)
30	Set Receiver Configuration	Set	N/A - Once set, the configuration does not need to be reset continuously
45	HW/SW ID Number	Identify	N/A - The information does not change unless you update your software
64	Set Channel Deselection	Set	N/A - Once set, channels do not need to be deselected continuously
69	Set Timing Parameters	Set	N/A - Once set, the timing parameters do not need to be updated continuously
77	Update Almanac	Update	N/A - Almanac data does not have to be renewed continuously
78	Common Almanac	Upload	N/A - Almanac data does not need to be reloaded continuously
79	Specific Almanac	Upload	N/A - Almanac data does not need to be reloaded continuously
80	Set Position/ Operating Mode	Set	N/A - Once set, the mode does not need to be reset continuously
81	Set Mask Angle	Set	N/A - Once set, the mask angle does not need to be reset continuously
83	Set DGPS Configuration	Set	N/A - Once set, the DGPS mode does not need to be reset continuously
84	Tropospheric/ Ionospheric Model	On (default)	Off - It is not recommended that you turn off the use of this model - for advanced users of GPS only
86	MSL Model	On	Off (default)
88	Datum to Use	Select/Define	N/A - Once set, the datum does not need to be updated continuously
90	Set Satellite Deselection	Set	N/A - Once set, a satellite does not need to be deselected continuously
91	Set DGPS Configuration	Set	N/A - Once set, the DGPS configuration does not need to be reset continuously
95	Particular Satellite	Request to track	N/A - Does not need to be re-requested
99	Erase NVM	Erase	N/A - Does not need to be re-erased
103	Set Date and Time	Set	N/A - Once set, the date and time do not need to be updated continuously
105	Set Default Binary Message List	Set	N/A - Once set, the message list does not need to be reset continuously
110	Configure COM1	Configure	N/A - The COM1 port does not need to be reconfigured continuously

1.2.3.2 GPS Receiver to PC Message Types

There are 6 types of messages that can be output from the GPS receiver to your PC (all data is sent in receiver internal format):

Dummy Message (ID# 0):

Reserved

Initiate Link (ID# 63):

This is the response to the PC initiate link message.

Acknowledge Message (ID# 126):

All messages are acknowledged by this message. It is sent as soon as possible if there is at least one message to acknowledge. The data field of this message contains 5 bytes which encode the ID#s of the messages acknowledged (4 messages per time interval and possibly a message from a previous time interval that was not completely decoded). A maximum of five messages may be acknowledged per message. Message ID# 0 indicates a dummy message and is discarded. Its purpose is only to fill the data field of the acknowledge message block. See also *Acknowledge Log ID# 126* on *Page 114*.

Link Overload Error Message (ID# 125):

Sent by the receiver only when at least one log caused an overload of the data link. This log is sent at a maximum rate of once per second. It encodes a bit map of all the Message ID#s (1-127), therefore indicating which ID#s caused the link overload. The log request that caused the overload is cancelled to prevent any further overload. See also *Link Overload Error Message ID# 125* on *Page 113*.

Data Message (DM):

Logs containing requested data.

Status Message (SM):

Informs the PC of the status of a file transfer performed using a command. The status is encoded in the MSB of the ID# field. If the MSB = 0, the command request is unsuccessful. If the MSB = 1, the command is successfully performed. This log is sent within 1 minute after the command. (This is currently only used for the almanac, see *Almanac Data Upload ID# 78* on *Page 39*).

1.3 Initiation

Upon receipt of an initiate link command block containing a valid password, the receiver sends a log block back to the PC with its own password.

This command also cancels all previous data request logs within 2 seconds.

The receiver responds to the initiate link command within 300 ms.

1.4 Data Link

In most cases the receiver is given commands for which it responds with one or several blocks of data. Typically the following sequence of events occur once the link is initiated.

The PC sends one or more command blocks to the receiver while keeping track of all commands that need to be acknowledged by the receiver. The receiver searches out each command sent by the PC and then compares its own checksum calculation with the value that was sent by the PC. If the values match, the receiver includes that particular ID# in the acknowledge log. If the checksums are different, the receiver does not include the ID#. Once all commands received during the last scheduled time interval are decoded, a new acknowledge log is built with all valid ID#s received. The acknowledge log is sent in the next available time slot.

For each individual log, the PC waits for its corresponding acknowledge log or produces a time-out error if not acknowledged within 300 ms.

The PC can send additional commands at any time. All command blocks are treated independently, therefore the PC does not wait for the acknowledge log before another command can be sent, except for file transfer commands. In this case the PC waits for the acknowledge log before continuing a file upload.

1.5 Error Recovery and Timing

Error detection and recovery are incorporated in this protocol. Some of the common error conditions are listed below:

1.5.1 Block ID Complement Error

If the block ID# in the header portion does not match the complementary block ID#, the block is discarded. This means that the data received is probably not a block.

1.5.2 Checksum Error

For the receiver, if the calculated checksum value on receipt of a block does not match the value in the block, the block is discarded and this command/log ID# is not included in the acknowledge log sent to the PC. For the PC, if it detects a checksum error then the block is discarded and a time-out occurs for the corresponding request.

1.5.3 Time-Out Errors

The PC waits for the reception of a command/log until the time of its data rate has elapsed. If a log is not received in this time, the time-out error is reported.

1.5.4 Frame Synchronization Errors

Extra characters can be generated when using asynchronous communications. To overcome this, synchronization is as follows:

1. If the character received when expecting the start of a block is not a SOH, then it ignores the character and continues to search for a SOH.
2. Once a SOH is found, the receiver assumes that the next two bytes are a valid block ID number and complement.
3. If they are complements, then it assumes that the packet has begun and the search for the next SOH starts after the checksum even if the checksum is invalid. If they are not complements, it continues to search for a SOH from the location of the block ID number.

1.6 Checksum Calculation Rules

The 16-bit checksum is defined as the 16-bit sum of all the unsigned 8-bit bytes starting at the beginning of the header, any overflow or carry over to the 16-bit sum is discarded immediately. Therefore, it adds unsigned bytes to produce a 16-bit result. For example, a valid configure COM1 port command can be:

```
SOH,ID#,CmplID#,Length,Baud and Mode,Cksum(LSB),Cksum(MSB)  (Syntax)

01, 110, 145, 01, 10, 11, 01  (DECIMAL)

01H,6EH,91H,01H,0AH,0BH,01H  (HEXADECIMAL)

00000001,01101110,10010001,00000001,00001010,00001011,00000001  (BINARY)
```

Where 10 decimal, 0A hexidecimal and 00001010 binary translates to:

0101 = 5 = 1500 bps

0 = NMEA

Please see *Message ID# 110* on *Page 58* for details. Checksum examples can be found throughout *Chapters 2 and 3* in the *Example Input* or *Example Output* following commands and logs.

1.7 Field Types

This section describes the data representation standards to be used in formulating the contents of data fields. The structures defined are:

1. Character Data
2. Integer Values
3. Floating Point Values

Character Data is stored in the block data field and is unsigned by default.

Integer values are represented in two's complement format.

Floating point values are stored in IEEE format to store data types that are larger than one byte. Words are stored in two consecutive bytes with the low-order byte at the lowest address and the high-order byte at the highest address.   The same convention applies for 32-bit and 64-bit values.

Table 3 on *Page 20* describes the field types used in the description of commands/logs.

Table 3: Field Types

Type	Binary Size (bytes)	Description
Char	1	The **char** type is an 8-bit integer in the range -128 to +127. This integer value may be the ASCII code corresponding to the specified character.
UChar	1	The **uchar** type is an 8-bit unsigned integer. Values are in the range from +0 to +255.
Short	2	The short type is 16-bit integer in the range -32768 to +32767.
UShort	2	The same as Short except that it is not signed. Values are in the range from +0 to +65535.
Long	4	The **long** type is 32-bit integer in the range -2147483648 to +2147483647.
ULong	4	The same as Long except that it is not signed. Values are in the range from +0 to +4294967295.
Double	8	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. This is IEEE 754.
Float	4	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. This is IEEE 754.
Enum	4	A 4-byte enumerated type beginning at zero (an unsigned long). In binary, the enumerated value is output.
Hex	n	Hex is a packed, fixed length (n) array of bytes in binary but in ASCII is converted into 2 character hexadecimal pairs.
String	n	String is a variable length array of bytes that is null-terminated in the binary case and additional bytes of padding are added to maintain 4 byte alignment. The maximum byte length for each String field is shown in their row in the log or command tables.

Following is the detail of the floating-point format:

Float (32 bits)

MSB (bit 31)	= Sign
Bit 30-23	= Exponent (exp)
Bit 22-00	= Mantissa
	= 2exp(-1*bit22) + 2 exp(-2*bit21)...
Value	= Sign * 1.mantissa * 2 exp(EXP-127)

Double (64 bits)

MSB (bit 63)	= Sign
Bit 62-52	= Exponent (exp)
Bit 51-00	= Mantissa
	= 2exp(-1*bit51) + 2 exp(-2*bit50)...
Value	= Sign * 1.mantissa * 2 exp(EXP-1023)

For example, Message ID# 6, bytes 11-14 (SNR value, float)

byte 11:	85
byte 12:	AC
byte 13:	41
byte 14:	42
float	= 4241AC85
Sign	= +
EXP	= 132
mantissa	= 0.5130773782
value	= 48.4

Chapter 2 Input Commands

2.1 Command Format

The receiver accepts commands in Binary format as described in *Chapter 1* or in NMEA format. In Binary format, the MSB of the Message ID# may be used to set the receiver to Normal mode (MSB=0) or to Special mode (MSB=1). See also the *ID#* description on *Page 14* and *Command Message* on *Page 15*.

Binary format messages include a checksum for error checking.

2.2 Command Settings

To determine the current command settings of the receiver, request a binary message list (see *Page 57*).

2.3 Commands by Function

Table 4 lists the commands by function while *Table 5* on *Page 24* lists commands in the order of their Message IDs. Please see *Section 2.5, Binary Protocol Command Reference* on *Page 25* for a more detailed description of individual commands which are listed in order of their Message IDs.

Table 4: Commands By Function Table

GENERAL RECEIVER CONTROL AND STATUS	
Message ID#	**Definition**
000	NMEA, Configure COM1 port
001	NMEA, Receiver initialization data
003	NMEA, Initiate BIT self test
005	NMEA, Set output configuration
007	NMEA, Erase non-volatile memory (NVM)
012	NMEA, Receiver configuration
30	Receiver configuration
45	Request hardware/software identification
49	Request receiver hardware levels
51	Initiate self-test
63	Initiate link
110	Configure the COM1 port
113	Request timing information
POSITION, PARAMETERS, AND SOLUTION FILTERING	
Message ID#	**Definition**
004	NMEA, Request log
008	NMEA, Set receiver parameters
8	Request current channel assignment data
20	Request navigation data (user coordinates)
21	Request navigation data (ECEF coordinates)

Continued on Page 22

POSITION, PARAMETERS, AND SOLUTION FILTERING	
Message ID#	**Definition**
22	Request ephemeris data
23	Request measurement block data
43	Request DGPS configuration
75	Request ionospheric and UTC time data
80	Set position/operating mode
81	Set mask angle
83	Set DGPS configuration
84	Set tropospheric/ionospheric model use
86	Set mean sea level model use
87	Set fixed height mode
CLOCK INFORMATION, STATUS, AND TIME	
Message ID#	**Definition**
75	Request ionospheric and UTC time data
113	Request timing information
DIFFERENTIAL BASE STATION	
Message ID#	**Definition**
33	Request satellite visibility, data and status
43	Request DGPS configuration
47	Request base station status
65	Request RTCM data message received
76	Request almanac data
DIFFERENTIAL ROVER STATION	
Message ID#	**Definition**
20	Request navigation data (user coordinates)
21	Request navigation data (ECEF coordinates)
23	Request measurement block data
43	Request DGPS configuration
48	Request differential message status
65	Request RTCM data message received
POST PROCESSING DATA	
Message ID#	**Definition**
22	Request ephemeris data
33	Request satellite visibility, data and status
75	Request ionospheric and UTC time data
113	Request timing information

Continued on Page 23

SATELLITE TRACKING AND CHANNEL CONTROL	
Message ID#	**Definition**
6	Request current channel assignment (1-6)
8	Request 2 channel measurement data
33	Request satellite visibility, data and status
50	Request satellite health summary
67	Request SBAS data
68	Request SBAS status message
76	Request almanac data
78	Almanac data upload
NMEA Format Commands	
Message ID#	**Definition**
000	Configure the COM1 port
001	Receiver initialization data
003	Initiate BIT self test
004	Request log
005	Set output configuration
007	Erase non-volatile memory (NVM)
008	Set receiver parameters
009	Define waypoint in MGRS format
010	Select active waypoint
WAYPOINT NAVIGATION	
Message ID	**Definition**
20	Request navigation data (user coordinates)
21	Request navigation data (ECEF coordinates)
009	NMEA, Define waypoint in MGRS format
010	NMEA, Select active waypoint

Table 5: SUPERSTAR II Binary Commands Summary

ID#	Definition	Message Type[a]
2	Reset receiver	CM
6	Request current channel assignment data	DR
20	Request navigation data (user coordinates)	DR
21	Request navigation data (ECEF coordinates)	DR
22	Request ephemeris data (ICD-GPS-200 format)	DR
23	Request measurement block data	DR
30	Set or Request receiver configuration	CM
33	Request satellite visibility, data and status	DR
43	Request DGPS configuration	DR
45	Request hardware/software identification	DR
47	Request base station status	DR
48	Request differential message status	DR
49	Request receiver status	DR
50	Request satellite health summary	DR
51	Initiate self-test	DR
63	Initiate Link	PM
64	Set channel deselection	CM
65	Request RTCM data message received	CM
67	Request SBAS data	DR
68	Request SBAS status message	DR
69	Set timing parameters	CM
75	Request ionospheric and UTC time data	DR
76	Request almanac data	DR
77	Update almanac	CM
78	Almanac data upload	CM
79	Specific almanac data upload	CM
80	Set position/operating mode	CM
81	Set mask angle	CM
83	Set DGPS configuration	CM
84	Set tropospheric/ionospheric model use	CM
86	Set mean sea level model use	CM
87	Set fixed height mode	CM
88	Select/define datum to use	CM
90	Set satellite deselection	CM
91	Set differential message configuration	CM
95	Request to track a particular satellite	CM
99	Erase NVM	CM

Continued on Page 25

ID#	Definition	Message Type[a]
103	Set date and time	CM
105	Set default binary message list	CM
110	Configure COM1 port mode	CM
113	Request timing Information	DR

a. CM = Command Message, PM = Protocol Message and DR = Data Request

2.4 Factory Defaults

When the receiver is first powered up, or after an *Erase NVM* command (*Message ID# 99* on *Page 55*), commands revert to their factory default settings. Also, there are settings that depend on the receiver model, for example, the baud rate at start-up.

2.5 Binary Protocol Command Reference

2.5.1 Reset Receiver ID# 2

This command performs a hardware reset if the password field (bytes 5-12) is valid.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5-12		Password: UGPS-000 In ASCII format, U character first.	N/A	Uchar[8]
13-14		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Transmitted: 14 Bytes , ID#2 *Reset*

01 02 FD 08 55 47 50 53 2D 30 30 30 04 03

2.5.2 Request Current Channel Assignment Data ID# 6

This command may be used to request current channel assignment data. See also *Message ID#s 6 and 7* output starting on *Page 77*.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5-6		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Transmitted: 6 Bytes , ID#6 (Continuous)

01 86 79 00 00 01

or:

Transmitted: 6 Bytes , ID#6 (One Shot)

01 06 F9 00 00 01

2.5.3 Request Navigation Data (User Coordinates) ID# 20

This command requests navigation data with position and velocity in user coordinates of latitude, longitude and height. See also *Message ID# 20* output on *Page 81*.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5-6		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Transmitted: 6 Bytes , ID#20 (Continuous)
01 94 6B 00 00 01

or:

Transmitted: 6 Bytes , ID#20 (One Shot)
01 14 EB 00 00 01

2.5.4 Request Navigation Data (ECEF Coordinates) ID# 21

This command requests navigation data with position and velocity in earth-centred-earth-fixed (ECEF) coordinates of X, Y and Z. See also *Message ID# 21* output on *Page 83*.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5-6		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Transmitted: 6 Bytes , ID#21 (Continuous)
01 95 6A 00 00 01

or:

Transmitted: 6 Bytes , ID#21 (One Shot)
01 15 EA 00 00 01

2.5.5 Request Ephemeris Data (ICD-GPS-200 Format) ID# 22

Each time a new request is sent, the receiver sends a complete set of ephemeris and SV clock data currently acquired. In continuous mode, the GPS receiver sends a complete set only on receipt of a new ephemeris. See also *Message ID# 22* output on *Page 86*.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5-6		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Transmitted: 6 Bytes , ID#22 (Continuous)

01 96 69 00 00 01

or:

Transmitted: 6 Bytes , ID#22 (One Shot)

01 16 E9 00 00 01

2.5.6 Request Measurement Block Data ID# 23

This command requests measurement block data for all tracked SVs. See also *Message ID# 23* output on *Page 87*. Sending this message in One Shot mode, turns it off and does not return any data. To start or to turn this message back on, send it in Continuous mode.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5	0-1	Message rate (see notebox below) 0: 1 Hz 1: 2 Hz 2: 5 Hz 3: Reserved	N/A	Uchar
	2-7	Reserved (set to 0)	N/A	
6-7		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

⌧ This command is not available unless your receiver has Carrier Phase Output (CP) capability. See also *Appendix A, SUPERSTAR II Card Models*, starting on *Page 133*.

The rate you choose must match that of your receiver. For example, if your receiver is capable of 1 Hz, choose 1 Hz in byte 5 above. If your receive is capable of 5 Hz then you can choose 1, 2 or 5 Hz.

Example Input:

Transmitted: 7 Bytes , ID#23 (Continuous)

01 97 68 01 00 01 01

2.5.7 Set Receiver Configuration ID# 30

Use this command to change the configuration of your receiver. The characteristic defined in *Table 6* on *Page 29* are not limits where the receiver stops functioning. They are rather limits within which the receiver performance and behavior are optimal for the application. Exceeding these limits causes receiver performance to degrade when used in the specified application.

See also *Message ID# 30* output on *Page 89*.

1. You must set the receiver configuration to match your application to get optimum performance.
2. You must reboot your receiver for a new navigation rate to take effect.

BYTE	BIT	DESCRIPTION	UNIT	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5	0-3	Configuration: 0: User configuration 1: Man 2: Tractor 3: Marine 4: Car 5: Plane 6: Rocket 7-14: Reserved 15: Unlimited	N/A	Uchar
	4-7	Reserved		
6	0-1	Navigation message[a] rate: 0: 1 Hz PVT 1: 2 Hz PVT 2: 5 Hz PVT 3: Reserved Change is effective at the next power-up.	N/A	Uchar
	2-7	Reserved		
7	0-1	Antenna type 0: Auto Detect [b] 1: Active 2: Passive	N/A	Uchar
	2-7	Reserved		
8		Reserved	N/A	Uchar
9-10		Maximum velocity - this field is only read when Byte 5 above is set to User configuration	m/s	Ushort
11	0-5	Maximum lateral acceleration in the range 0 to 40 m/s^2 - this field is only read when Byte 5 above is set to User configuration When 40 is set, the internal value is set to 39.2	m/s^2	Uchar
	6-7	Reserved		
12		Stand still threshold - this field is only read when Byte 5 above is set to User configuration	cm/s	Uchar

Continued on Page 29

13		Dead reckoning threshold Range 0-254 255: use current value	s	Uchar
14-20		Reserved	N/A	Uchar[7]
21-22		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

a. Navigation messages are NMEA GGA,GLL,GSA,RMC,VTG,906,907and Binary ID#s 20,21
b. Auto Detect starts up with a Passive setting, and auto switches to Active if an active antenna is detected.

Example Input:

Transmitted: 22 Bytes , ID#30 *Set*

01 1E E1 10 0A 1D E1 77 84 06 02 00 82 00 00 00 00 00 00 00
9D 03

Table 6: Preset Configurations

Preset Configuration	Maximum Velocity (m/s)	Maximum Acceleration (m/s^2)	Stand Still Threshold (m/s)
Man	10	3	0.2
Car	45	8	0.2
Tractor	20	7	0.2
Marine	20	7	0.1
Plane	100	20	0.2
Rocket	510	40	0.2

2.5.8 Request Receiver Configuration ID# 30

Use this command to obtain information on the configuration of your receiver. See also *Set Receiver Configuration* on *Page 28* and Message ID# 30 output on *Page 89*.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5-6		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Transmitted: 6 Bytes , ID#30 (One Shot)

01 1E E1 00 00 01

2.5.9 Request Satellite Visibility, Data and Status ID# 33

Use this command to request data and status information on satellites in view. See also *Message ID# 33* output on *Page 90*.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5-6		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Transmitted: 6 Bytes , ID#33 (Continuous)

01 A1 5E 00 00 01

or:

Transmitted: 6 Bytes , ID#33 (One Shot)

01 21 DE 00 00 01

2.5.10 Request DGPS Configuration ID# 43

Use this command to request information on the current DGPS configuration if your receiver is operating in differential mode. See also *Message ID# 43* output on *Page 92* and *Message ID# 83, Set DGPS Configuration* on *Page 44*.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5-6		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Transmitted: 6 Bytes , ID#43 (Continuous)

01 AB 54 00 00 01

or:

Transmitted: 6 Bytes , ID#43 (One Shot)

01 2B D4 00 00 01

2.5.11 Request Hardware/Software Identification ID# 45

Use this command to view your receiver’s software and hardware identification numbers and model. See also *Message ID# 45* output on *Page 93*.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5-6		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Transmitted: 6 Bytes , ID#45 (One Shot)

01 2D D2 00 00 01

2.5.12 Request Base Station Status ID# 47

This command allows you to request base station status information if your receiver is a BASE model and is operating in differential mode. See also *Message ID# 47* output on *Page 94* and *Appendix A, SUPERSTAR II Card Models* on *Page 133*.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5-6		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Transmitted: 6 Bytes , ID#47 (Continuous)

01 AF 50 00 00 01

or:

Transmitted: 6 Bytes , ID#47 (One Shot)

01 2F D0 00 00 01

2.5.13 Request Differential Message Status ID# 48

Use this command to view the status of your differential messages if your receiver is operating in differential mode. See also *Message ID# 48* on *Page 95*.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5-6		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Transmitted: 6 Bytes , ID#48 (Continuous)
01 B0 4F 00 00 01

or:

Transmitted: 6 Bytes , ID#48 (One Shot)
01 30 CF 00 00 01

2.5.14 Request Receiver Status ID# 49

Use this command to obtain information on the status of your receiver. See also *Message ID# 49* on *Page 97*.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5-6		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Transmitted: 6 Bytes , ID#49 (Continuous)
01 B1 4E 00 00 01

or:

Transmitted: 6 Bytes , ID#49 (One Shot)
01 31 CE 00 00 01

2.5.15 Request Satellite Health Summary ID# 50

Use this command to obtain satellite health information. See also *Message ID# 50* output on *Page 99*.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5-6		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Transmitted: 6 Bytes , ID#50 (Continuous)
01 B2 4D 00 00 01

or:

Transmitted: 6 Bytes , ID#50 (One Shot)

01 32 CD 00 00 01

2.5.16 Initiate Self-Test ID# 51

This command allows you to initiate, or output the results of, a built-in status test. See also *Message ID# 51* output on *Page 101*.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5	0-7	Built-in status test 0: Reserved 1: Initiate test 2: Output results	N/A	Uchar
6-7		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Transmitted: 7 Bytes , ID#51

01 33 CC 01 0A 0B 01

2.5.17 Initiate Link ID# 63

See *Section 1.3, Initiation* starting on *Page 17* for more on *Message ID# 63*.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5-12		Password (UGPS-000), in ASCII format, U character first	N/A	Uchar[8]
13-14		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Transmitted: 14 Bytes , ID#63 *Initiate link*

01 3F C0 08 55 47 50 53 2D 31 30 30 05 03

2.5.18 Set Channel Deselection ID# 64

This command allows you idle up to 12 channels if the password field (bytes 5-12) is valid. The channels to be disabled should be indicated in a bit map form. A 1 in the bit map specifies that the corresponding channel is disabled.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5-12		Password (UGPS-000), in ASCII format, U character first	N/A	Uchar[8]
13		bit map (bit 0: ch #1, bit 7: ch #8)	N/A	Uchar
14		bit map (bit 0: ch #9, bit 3: ch #12)	N/A	Uchar
15-16		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Transmitted: 16 Bytes , ID#64 *Set*

01 40 BF 0A 0A 1D E1 77 6A 02 51 00 82 00 C8 03

2.5.19 Request RTCM Data Message Received ID# 65

Use this command to request that the saved RTCM data processed by the receiver be output. See also *Section 3.3.16, RTCM Data Message Received ID# 65* starting on *Page 104*.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5-6		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Transmitted: 6 Bytes , ID#65 (Continuous)

01 C1 3E 00 00 01

or:

Transmitted: 6 Bytes , ID#65 (One Shot)

01 41 BE 00 00 01

2.5.20 Request SBAS Data ID# 67

Use this command to request SBAS data. See also *Message ID# 67* output on *Page 105*.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5-6		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

```
Transmitted: 6 Bytes , ID#67 (Continuous)
01 C3 3C 00 00 01
```

or:

```
Transmitted: 6 Bytes , ID#67 (One Shot)
01 43 BC 00 00 01
```

2.5.21 Request SBAS Status Message ID# 68

Use this command to request SBAS status information. See also *Message ID# 68* output on *Page 106*.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5-6		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

```
Transmitted: 6 Bytes , ID#68 (Continuous)
01 C4 3B 00 00 01
```

or:

```
Transmitted: 6 Bytes , ID#68 (One Shot)
01 44 BB 00 00 01
```

2.5.22 Set Timing Parameters ID# 69

This command allows you to set timing parameters for receivers with Precise Timing (T) capability. If all ones (F..Fh = 1111...1111) is entered in any field below, the corresponding value is not modified. See also *Message ID# 113, Time Status* on *Page 111* and *Appendix A, SUPERSTAR II Card Models* on *Page 133*.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5-8		Cable Delay Set the propagation delay that is induced by the antenna cable. This delay compensates the 1PPS output so it remains synchronized with the UTC time. Range from 0 to +1 ms	ns	Ulong
9-12		1PPS Offset Set the offset from the UTC time for the 1PPS signal to be output. The offset is in the range 0 to 900 ms in steps of 100 ms or it is not accepted.	ns	Ulong
13-16		1PPS Pulse Width Range from 0 to 65 ms	100 ns	Ulong
17	0	Timing Mode: Free-running	N/A	Uchar
	1	One Shot Alignment The receiver slews the 1PPS output to align it with GPS time once at power up. Afterwards, the 1PPS output is synchronized using the receiver's internal clock and therefore drifts. This mode is used for an externally controlled oscillator.		
	2	Continuous Alignment Keeps the 1PPS aligned on the GPS second boundary.		
18	0	1PPS output continuously. This is the default for models that do not have Precise Timing capability (T) and cannot be changed.	N/A	Uchar
	1	1PPS output only when using at least one satellite in navigation status		
	2	1PPS output only when acceptable conditions are met according to the residual		
	3	Conditions 1 and 2 above		
	4	There is no 1PPS output		
	5	1PPS output (only when the receiver has a position, for example, in Nav-3D or Diff-3D. This is the default for models that do have Precise Timing capability and can change.		
	6	Conditions 2 and 5 above		
19		Reserved	N/A	Uchar
20-21		Intrinsic delay (range from 0 to 65534 ns) 65535 ns indicates no changes	ns	Ushort

Continued on Page 37

22-31		Reserved	N/A	Uchar[10]
32-33		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Transmitted: 33 Bytes , ID#69 *Set*

01 45 BA 1B 0A 1D E1 77 6C 02 2D 00 82 00 00 00 00 00 00 00
00 00 00 00 C0 FB 12 00 CD AB BA B6 07

2.5.23 Request Ionospheric and UTC Time Data ID# 75

This command allows you to request ionospheric and UTC time information. See also *Message ID# 75* output on *Page 107*.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5-6		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Transmitted: 6 Bytes , ID#75 (Continuous)

01 CB 34 00 00 01

or:

Transmitted: 6 Bytes , ID#75 (One Shot)

01 4B B4 00 00 01

2.5.24 Request Almanac Data ID# 76

This command allows you to request almanac data. See also *Message ID# 76* output on *Page 108*.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5	0	Output almanac? (set to 1) 1: Yes, request an almanac	N/A	Uchar
	1-7	Reserved (set to 0)		
6-7		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Transmitted: 7 Bytes , ID#76 (One Shot)

01 4C B3 01 01 02 01

2.5.25 Update Almanac ID# 77

This command forces the decoding of a new almanac from SV subframe 4 and 5 data. See also *Message ID# 76* input on *Page 38* and output on *Page 108*.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5-6		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Transmitted: 6 Bytes , ID#77

01 4D B2 00 00 01

2.5.26 Almanac Data Upload ID# 78

This command provides an almanac for the receiver if the password field (bytes 5-12) is valid. The data field of the command is composed of a list of available SV#s (4 byte bit map) as well as the almanac data and week common to all SVs. This command is sent ahead of the specific almanac data upload command (*Message ID# 79* defined on *Page 40*). See also the *Message ID# 78* log on *Page 110*.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5-12		Password (UGPS-000), in ASCII format, U character first	N/A	Uchar[8]
13		bit map (bit 0: SV #1, bit 7: SV #8)	N/A	Uchar
14		bit map (bit 0: SV #9, bit 7: SV #16)	N/A	Uchar
15		bit map (bit 0: SV #17, bit 7: SV #24)	N/A	Uchar
16		bit map (bit 0: SV #25, bit 7: SV #32)	N/A	Uchar
17-18		Almanac week common to all SVs Range: 0 to 65535	weeks	Ushort
19		Time of almanac common to all SVs Range: 0 to 147 Resolution: 602112 / 4096	s	Uchar
20-21		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Transmitted: 21 Bytes , ID#78

01 4E B1 0F 0A 1D E1 77 6C 02 5A 00 82 00 00 00 00 00 00 D8
03

2.5.27 Specific Almanac Data Upload ID# 79

This command provides SV-specific almanac data (using the YUMA almanac format) to the receiver. The first data byte is the SV#. A complete series of these messages is sent in increasing SV# order, from 1 to 32, for the SVs specified in the common almanac SV bit map data message. It is important to note that each specific data message must be acknowledged (through *Message ID #126*, see *Page 114*) before sending the next specific data message.

✉ You must send Message ID# 78, see *Page 39*, before using this command.

If the GPS receiver does not receive all the SV specific almanac data messages specified in the common message within 55 seconds then a time-out error occurs. The GPS receiver then disregards all the data currently received and sends an unsuccessful status message to the PC. The PC resends the common message first, and then all the data messages.

The GPS receiver **always** sends back an almanac reception status log whether the full almanac upload is successful or not. The PC waits for this status log (or waits for the occurrence of a 60-second timeout period) before requesting another almanac upload. Otherwise, the previous almanac upload is cancelled and the new almanac upload request is ignored.

The almanac data specific to each SV is detailed below.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5	0-5	SV #	N/A	Uchar
	6-7	SV type 0: Reserved 1: GPS 2-3: Reserved		
6-13		Clock aging parameter, af0 Range: $-2.0^{10} - 2.0^{-20}$ to $(2.0^{10} - 1.0) - 2.0^{-20}$ Resolution: 2.0^{-20}	s	Double
14-21		Clock aging parameter, af1 Range: $-2.0^{10} - 2.0^{-38}$ to $(2.0^{10} - 1.0) - 2.0^{-38}$ Resolution: 2.0^{-38}	s/s	Double
22-29		Mean anomaly of reference time, M0 Range: $-2.0^{23} - 2.0^{-23} - \pi$ to $(2.0^{23} - 1.0) - 2.0^{-23} - \pi$ Resolution: $2.0^{-23} - \pi$	radians	Double
30-37		Argument of perigee, W Range: $-2.0^{23} - 2.0^{-23} - \pi$ to $(2.0^{23} - 1.0) - 2.0^{-23} - \pi$ Resolution: $2.0^{-23} - \pi$	radians	Double
38-45		Right ascension, Omega_0 Range: $-2.0^{23} - 2.0^{-23} - \pi$ to $(2.0^{23} - 1.0) - 2.0^{-23} - \pi$ Resolution: $2.0^{-23} - \pi$	radians	Double
46-53		Semi-major axis, Root_A Range: 2525.0 to $(2.0^{24} - 1.0) - 2.0^{-11}$ Resolution: 2.0^{-11}	$m^{1/2}$	Double

Continued on Page 41

54-61		Rate of right ascension, Omega_Dot Range: $-2.0^{15} - 2.0^{-38} - \pi$ to $(2.0^{15} - 1.0) - 2.0^{-38} - \pi$ Resolution: $2.0^{-38} - \pi$	radians/s	Double
62-69		Angle of Inclination relative to 0.30π, i range: $-2.0^{15} - 2.0^{-19} - \pi$ to $(2.0^{15} - 1.0) - 2.0^{-19} - \pi$ resolution: $2.0^{-19} - \pi$	radians	Double
70-77		Eccentricity, e Range: 0 to 0.03 Resolution: 2.0^{-21}	N/A	Double
78-79		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

```
Transmitted: 79 Bytes , ID#79

01 4F B0 49 0A 1D E1 77 6C 02 64 00 82 00 00 00 00 00 00 00
00 00 00 00 C0 FB 12 00 CD AB BA DC 1C FB 12 00 CC 2B E1 77
66 1F 49 00 6C 02 64 00 82 00 00 00 00 00 00 00 00 00 00 00
44 FB 12 00 84 2B E1 77 78 0E 5B 00 82 00 00 00 00 4C 13
```

2.5.28 Set Operating Mode ID# 80

This command allows you to set the receiver's operating mode. See also *Message ID# 47, Base Status* on *Page 94*.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13* MSB of Message ID# byte: 0: command is executed normally 1: receiver position is cleared (command parameters are ignored)			
5-12		Password (UGPS-XXX), in ASCII format, U character first, where the command field XXX is: 000: Fix position (see bytes 13-36 below) R00: Force to rover mode (position not saved) GSP: Get survey position B: Set base position and base information S: Force to survey mode If B or S above then YY where YY: bytes 11-12 (Station ID and Station Health): Bits 0-9: Station ID Bits 10-12: Station health (as per RTCM-104) Bits 13-15: Reserved	N/A	Uchar[8]
13-20		Interpretation depends on XXX in bytes 5-10 above 000 and BYY: Altitude ellipsoid SYY: Desired survey time R00 and GSP: N/A	m *or* hours	Double
21-28		Interpretation depends on XXX in bytes 5-10 above 000 and BYY: Latitude SYY, R00 and GSP: N/A	radians	Double
29-36		Interpretation depends on XXX in bytes 5-10 above 000 and BYY: Longitude SYY: Desired CEP R00 and GSP: N/A	radians *or* m	Double
37-38		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example:

You can fix the position by setting the following values:

Bytes	**Entry**
[5-12]	UGPS-BYY | Station ID | Station Health
[13-20]	Altitude
[21-28]	Latitude
[29-36]	Longitude

When the receiver decodes this command, the latitude, longitude and altitude are saved in its NVM and static mode is initiated immediately.

Self-Surveying Mode: You can end the surveying process by using the GSP command as indicated in the command specification above (bytes 5-12). When the receiver decodes this command, it uses the current averaged position and saves it to NVM without a station ID and Health Status. It then switches to static mode.

Example Input:

Receiver position is not cleared

Transmitted: 38 Bytes , ID#80

01 50 AF 20 0A 1D E1 77 4E 02 0A 00 82 00 00 00 00 00 00 00
00 00 00 00 C0 FB 12 00 CD AB BA DC 1C FB 12 00 7F 09

or:

Receiver position is cleared

Transmitted: 38 Bytes , ID#80

01 D0 2F 20 F0 1E E1 77 F6 03 2C 00 82 00 00 00 00 00 00 00
00 00 00 00 90 FB 12 00 CD AB BA DC EC FA 12 00 D0 0B

2.5.29 Set Mask Angle ID# 81

This command allows you to set the mask angle. This value is stored in NVM. See also *Message ID# 49, Receiver Status* on *Page 97*.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5-6		Mask angle (0 to $\pi/2$)	radians	Short
7-10		Reserved	N/A	Float
11-12		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Transmitted: 18 Bytes , ID#81

01 51 AE 0C 0A 1D E1 77 4E 02 16 00 82 00 00 00 73 03

2.5.30 Set DGPS Configuration ID# 83

This command allows you to set the DGPS configuration if your receiver is operating in differential mode.

See also *Message ID# 43, DGPS Status* on *Page 95*.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5	0	Enable 0 = Off (Use SBAS over DGPS corrections) 1 = On (Use DGPS over SBAS corrections)	N/A	Uchar
	1-3	Reserved, should be 1		
	4-6	Reserved, should be 0		
	7	Port 0 = COM1 1 = COM2		
6		Differential coast time	seconds	Uchar
7		Reserved	N/A	Uchar
8		COM2 port baud rate 1 = 300 . . 32 = 9600 . . 64 = 19200	300 baud	Uchar
9-16		Reserved	N/A	Uchar[4]
				Uchar[4]
17	0-1	Differential Mode 0 = No DGPS 1 = SBAS only 2 = DGPS only 3 = Select SBAS/DGPS automatically	N/A	Uchar
	2-7	Reserved	N/A	
18-25		Reserved	N/A	Uchar[8]
26-27		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Transmitted: 27 Bytes , ID#83 *Set*

```
01 53 AC 15 0A 1D E1 77 4E 02 26 00 82 00 00 00 00 00 00 00
00 00 00 00 C0 4C 04
```

2.5.31 Set Tropospheric/Ionospheric Model Use ID# 84

This command allows the receiver to use a tropospheric/ionospheric model correction if the password field (bytes 5-12) is valid. The correction is applied by default (see the Warning below).

Sending this command with the MSB of the message ID byte to 0 ensures that tropospheric/ionospheric model use is on. Setting the MSB of the message ID byte to 1 turns tropospheric/ionospheric model use off. See also *Message ID# 75, Ionospheric and UTC Data* on *Page 107*.

Warning!: This command is for advanced users of GPS only. It is not recommended that you turn off the tropospheric/ ionospheric model. The solution is seriously degraded with this model off.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13* MSB of Message ID# byte: 0: model is used 1: model is not used			
5-12		Password (UGPS-000), in ASCII format, U character first	N/A	Uchar[8]
13-14		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Tropospheric/Ionospheric model use is on

Transmitted: 14 Bytes , ID#84

01 54 AB 08 0A 1D E1 77 4E 02 32 00 09 03 |

2.5.32 Set Mean Sea Level Model Use ID# 86

This command allows you to use the mean sea level (MSL) model for your application if the password field (bytes 5-12) is valid. Its use is Off by default. When it is On, the undulation value is automatically added.

Sending this command in One Shot mode turns MSL model use on and in Continuous mode turns it off.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13* MSB of Message ID# byte: 0: model is used 1: model is not used			
5-12		Password (UGPS-000), in ASCII format, U character first	N/A	Uchar[8]
13-14		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Mean Sea Level model use is on

Transmitted: 14 Bytes , ID#86

01 56 A9 08 0A 1D E1 77 4E 02 48 00 1F 03

2.5.33 Set Fixed Height Mode ID# 87

This command is used to select a fixed mode. When NONE is selected, the receiver can not go in 2-D mode. When AUTO is selected, the receiver automatically tries to go in 2-D mode if only 3 satellites are available. This setting is stored in NVM.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5	0	Fixed Height Mode 0 = NONE (default) 1 = AUTO	N/A	Uchar
	1-7	Reserved		
6-13		Reserved	N/A	Double
14-15		Checksum	N/A	Ushort

Example Input:

Transmitted: 15 Bytes , ID#87 *Auto*

01 57 A8 09 01 00 00 00 00 00 00 00 00 0A 01

Transmitted: 15 Bytes , ID#87 *None*

01 57 A8 09 00 00 00 00 00 00 00 00 00 09 01

2.5.34 Select/Define Datum to Use ID# 88

Use this command to select the datum used to report the position or to define a user-defined datum.

When byte 5 is set to 0, byte 6 must be 0 or in the range from 3 to 63 (dx, dy, dz are preset for these datums). However, when byte 5 is set to 1 or 2, byte 6 must be 1 or 2 (user defined) and you must enter dx, dy, dz. See *Table 7* on *Page 48*.

The navigation data (user coordinates) *Message ID# 20*, see *Section 3.3.3, Navigation Data (User Coordinates) ID# 20* starting on *Page 81*, contains the datum currently in use.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5		Function 0: Select datum (bytes 7-36 are ignored) 1: Define a user-defined datum 2: Select and define a user-defined datum	N/A	Uchar
6		Datum number (from 0 to 63), see *Table 7* on *Page 48*	N/A	Uchar
7-8		dx	m	Short
9-10		dy	m	Short
11-12		dz	m	Short
13-20		A (semi-major)	m	Double
21-28		Inversed flattening (1/f)	N/A	Double
29-34		Reserved	N/A	Uchar[6]
35-36		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Transmitted: 36 Bytes , ID#88 *Select/define a datum*

```
01 58 A7 1E 0A 1D E1 77 30 03 0B 00 82 00 00 00 00 00 00 00
00 00 00 00 C0 FB 12 00 CD AB BA DC 1C FB 4F 09
```

Table 7: DATUM Description

#	NAME	ELLIPSE *Table 8 on Page 51*	DX	DY	DZ	COUNTRIES
0	WGS 1984	WGS-84	0	0	0	Global definition
1	User Defined 1					
2	User Defined 2					
3	Adindan	Clarke_1880	-161	-14	205	Sudan
4	Arc 1950	Clarke_1880	-143	-90	-294	Botswana, Lesotho, Malawi, etc.
5	Arc 1950	Clarke_1880	-169	-19	-278	Zaire
6	Arc 1960	Clarke_1880	-160	-6	-302	Kenya, Tanzania
7	Australian Geodetic 1984	Australian_National	-134	-48	149	Australia, Tasmania
8	Bogota Observatory	International	307	304	-318	Colombia
9	Campo Inchauspe	International	-148	136	90	Argentina
10	Cape	Clarke_1880	-136	-108	-292	South Africa
11	Carthage	Clarke_1880	-263	6	431	Tunisia
12	Chatham Island Astro 1971	International	175	-38	113	New Zealand (Chatham Island)
13	Chua Astro	International	-134	229	-29	Paraguay
14	Corrego Alegre	International	-206	172	-6	Brazil
15	European 1950	International	-87	-98	-121	Austria, Belgium, Denmark, Finland, France, West Germany, Gibraltar, Greece, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland
16	European 1950	International	-104	-101	-140	Cyprus
17	European 1950	International	-130	-117	-151	Egypt
18	European 1950	International	-86	-96	-120	England, Channel Islands, Ireland, Scotland, Shetland Islands
19	European 1950	International	-117	-132	-164	Iran
20	European 1950	International	-97	-88	-135	Italy (Sicily)
21	European 1979	International	-86	-98	-119	Austria, Finland, Netherlands, Norway, Spain, Sweden, Switzerland
22	Geodetic Datum 1949	International	84	-22	209	New Zealand
23	Hjorsey 1955	International	-73	46	-86	Iceland
24	Hong Kong 1963	International	-156	-271	-189	Hong Kong

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25	Hu-Tzu-Shan	International	-637	-549	-203	Taiwan
26	Indian 1954	Everest 1830	218	816	297	Thailand, Vietnam
27	Ireland 1965	Airy_modified	506	-122	611	Ireland
28	Kertau 1948	Everest 1948	-11	851	5	West Malaysia & Singapore
29	Liberia 1964	Clarke_1880	-90	40	88	Liberia
30	Luzon	Clarke_1866	-133	-77	-51	Philippines (Excluding Mindanao)
31	Massawa	Bessel_1841	639	405	60	Ethiopia (Eritrea)
32	Merchich	Clarke_1880	31	146	47	Morocco
33	Minna	Clarke_1880	-92	-93	122	Nigeria
34	Nahrwan	Clarke_1880	-247	-148	369	Oman (Masirah Island)
35	North American 1927	Clarke_1866	-5	135	172	Alaska
36	North American 1927	Clarke_1866	-3	142	183	Antigua, Barbados, Bermuda, Caicos Islands, Cuba, Dominican Republic, Grand Cayman, Jamaica, Turks Islands
37	North American 1927	Clarke_1866	-10	158	187	Canada
38	North American 1927	Clarke_1866	-7	162	188	Canada (Alberta, British Columbia)
39	North American 1927	Clarke_1866	-9	157	184	Canada (Manitoba, Ontario)
40	North American 1927	Clarke_1866	-22	160	190	Canada (New Brunswick, Newfoundland, Nova Scotia, Quebec)
41	North American 1927	Clarke_1866	4	159	188	Canada (Northwest Territories, Saskatchewan)
42	North American 1927	Clarke_1866	-7	139	181	Canada (Yukon)
43	North American 1927	Clarke_1866	0	125	201	Canal zone
44	North American 1927	Clarke_1866	0	125	194	Central America
45	North American 1927	Clarke_1866	-12	130	190	Mexico
46	North American 1983	GRS-80	0	0	0	Alaska, Canada, CONUS, Central America, Mexico
47	Old Egyptian 1907	Helmert_1906	-130	110	-13	Egypt
48	Old Hawaiian	Clarke_1866	61	-285	-181	Hawaii, Kauai, Maui, Oahu
49	Oman	Clarke_1880	-346	-1	224	Oman
50	Ord. Survey G. Britain 1936	Airy	375	-111	431	England, Isle of Man, Scotland, Shetland Islands, Wales
51	Pitcairn Astro 1967	International	185	165	42	Pitcairn Island

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52	Qatar National	International	-128	-283	22	Qatar
53	Qornoq	International	164	138	-189	Greenland (South)
54	Schwarzeck	Bessel_1841_in_ Namibia	616	97	-251	Namibia
55	South American 1969	South_America_ 1969	-57	1	-41	Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Trinidad & Tobago, Venezuela
56	South American 1969	South_America_ 1969	-60	-2	-41	Brazil
57	South American 1969	South_America_ 1969	-44	6	-36	Colombia
58	South American 1969	South_America_ 1969	-45	8	-33	Venezuela
59	South Asia	Modified Fisher 1960	7	-10	-26	Singapore
60	Tananarive Observatory 1925	International	-189	-242	-91	Madagasgar
61	Tokyo	Bessel_1841	-148	507	685	Japan
62	Tokyo	Bessel_1841	-128	481	664	Mean Value
63	WGS 1972	WGS-72	0	0	0	Global definition

Table 8: Ellipsoid Description Table

Ellipsoid name	Semi-major axis (a)	Inverse flattening (1/f)
Airy	6377563.3960	299.324964600
Airy_modified	6377340.1890	299.324964600
Australian_National	6378160.0000	298.250000000
Bessel 1841	6377397.1550	299.152812800
Bessel 1841 in Namibia	6377483.8650	299.152812800
Clarke 1866	6378206.4000	294.978698200
Clarke 1880	6378249.1450	293.465000000
Everest (Sabah & Sarawak)	6377298.5560	300.801700000
Everest 1830	6377276.3450	300.801700000
Everest 1948	6377304.0630	300.801700000
Everest 1956	6377301.2430	300.801700000
Everest_Modified	6377304.0630	300.801700000
GRS-80	6378137.0000	298.257222101
Helmert 1906	6378200.0000	298.300000000
Hough	6378270.0000	297.000000000
International	6378388.0000	297.000000000
Krassovsky	6378245.0000	298.300000000
Modified Fisher 1960	6378155.0000	298.300000000
SGS 85	6378136.0000	298.257000000
South America 1969	6378160.0000	298.250000000
WGS-72	6378135.0000	298.260000000
WGS-84	6378137.0000	298.257223563

2.5.35 Satellite Deselection ID# 90

This command allows you to deselect SVs that you no longer wish to track if the password field (bytes 5-12) is valid. The SVs are indicated in a bitmap form. A 1 in the bitmap specifies that the corresponding SV is deselected and is not tracked.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5-12		Password (UGPS-XXX), in ASCII format, U character first where XXX is: 000 - Deselect GPS SV 0G4 or 0G5 - Deselect SBAS SV	N/A	Uchar[8]
13		Dependant on XXX above XXX = 000 = GPS SV 0 = SV #1 : 7 = SV #8 XXX = 0G5 = SBAS SV (such as WAAS or EGNOS) 0 = SV #129 : 7 = SV #136	N/A	Uchar
14		Also, dependant on XXX in bytes 5-12 XXX = 000 = GPS SV 0 = SV #9 : 7 = SV #16 XXX = 0G5 = SBAS SV (such as WAAS or EGNOS) 0 = SV #137 1-6 = Reserved 7 = SV #138	N/A	Uchar
15		Also, dependant on XXX in bytes 5-12 XXX = 000 = GPS SV 0 = SV #17 : 7 = SV #24 XXX = 0G4 = SBAS SV (such as WAAS or EGNOS) 0-6 = Reserved 7 = SV #120	N/A	Uchar
16		Also, dependant on XXX in bytes 5-12 XXX = 000 = GPS SV 0 = SV #25 : 7 = SV #32 XXX = 0G4 = SBAS SV (such as WAAS or EGNOS) 0 = SV #121 : 7 = SV #128	N/A	Uchar
17-18		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

```
Transmitted: 18 Bytes , ID#90
01 5A A5 0C 0A 1D E1 77 30 03 1A 00 82 00 00 00 5A 03
```

2.5.36 Set Differential Message Configuration ID# 91

This command allows you to set the RTCM differential message type and rate if your receiver is a BASE model and is operating in differential mode.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5	0-5	Message 0 = Clear all messages 1 = RTCM1 4 = RTCM3	N/A	Uchar
	6-7	Type 0: RTCM 1-3: Reserved		
6		Rate 0: Stop transmitting 1-255: Rate in seconds	s	Uchar
7-8		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Transmitted: 8 Bytes , ID#91 *Set*

01 5B A4 02 F0 1E 10 02

2.5.37 Request to Track a Particular Satellite ID# 95

This command allows you to track an SV# on any available channel that is not currently tracking or that has not been deselected. It starts the search at a given Doppler frequency offset to the carrier (Doppler center frequency). The search window option is specified from 0 to 100 kHz in 1 kHz increments.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5	0-5	SV# (1 - 32) for GPS or SV# (33-51) for SBAS where 33 represents SV# 120 34 represents SV# 121 35 represents SV# 122 36 represents SV# 123 37 represents SV# 124 38 represents SV# 125 39 represents SV# 126 40 represents SV# 127 41 represents SV# 128 42 represents SV# 129 43 represents SV# 130 44 represents SV# 131 45 represents SV# 132 46 represents SV# 133 47 represents SV# 134 48 represents SV# 135 49 represents SV# 136 50 represents SV# 137 51 represents SV# 138	N/A	Uchar
	6-7	SV type 0: Reserved 1: GPS 2: SBAS such as WAAS and EGNOS		
6-9		Doppler center frequency: Range: -60 000 to +60 000	Hz	Long
10		Search window size: Range: 0 to +100 (1 kHz increments)	kHz	Uchar
11-14		Minimum C/No Range: 0.0 to +63.0	dB-Hz	Float
15-16		Doppler	Hz/s	Ushort
17		Track command 0: auto (assign only if not already tracking) 1: manual (force to track on an idle channel)	N/A	Uchar
18-19		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Track a particular satellite

Transmitted: 19 Bytes , ID#95

01 5F A0 0D 0A 1D E1 77 30 03 30 00 82 00 00 00 00 71 03

2.5.38 Erase NVM ID# 99

This command erases the data contained in the EEPROM if the password field (bytes 5-10) is valid. You must choose a value from *Table 9* below.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5-10		Password (UGPS-0), in ASCII format, U character first	N/A	Uchar[6]
11-12		Element to erase (00-20) in ASCII, see *Table 9*	N/A	Uchar[2]
13-14		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Table 9: Element to Erase

Characters	Element
00	All
01-04	Reserved
05	Almanac
06-08	Reserved
09	TCXO parameters
10	IONO and UTC parameters
11	Position
12	Time
13	DGPS configuration
14	Default NMEA message list
15	RS232 configuration and default binary message list
16-19	Reserved
20	Ephemeris

Example Input:

```
Transmitted: 14 Bytes , ID#99
01 63 9C 08 55 47 50 53 2D 30 30 30 04 03
```

2.5.39 Set Date and Time ID# 103

This command allows you to set the date and time (UTC) if the password field (bytes 5-12) is valid.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13* Bytes 2 and 3: Reserved in this command			
5-12		Password (UGPS-XXX), in ASCII format, U character first where XXX is: [000]: The date and time parameter is applied [100]: Requests a 1-shot 1PPS output and sets the system time to provide date and time if no SV is currently being tracked	Hex	Uchar[8]
13-15		UTC time Resolution: 1 s	h:min:s	Uchar:Uchar:Uchar
16-19		UTC date Resolution: 1 day	dy:mo:yr	Uchar:Uchar:Ushort
20-21		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

```
Transmitted: 21 Bytes , ID#103                    Set

01 67 98 0F 0A 1D E1 77 30 03 44 00 82 00 00 00 00 00 00 87
03
```

2.5.40 Set Default Binary Message List ID# 105

Use this command to set which logs to generate. Your selection is generated by default at start-up and comes out at the highest rate possible.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5	0	Reserved	N/A	Uchar
	1	Message ID# 1 flag 0: Do not transmit 1: Transmit		
	2	Message ID# 2 flag 0: Do not transmit 1: Transmit		
	3-7	Message ID# 3-7 flags: 0: Do not transmit 1: Transmit		
6		Message ID#s 8 to 15 flags: 0: Do not transmit 1: Transmit	N/A	Uchar
7 . . 20		As per Byte 6 for Message ID#s 16 to 23 . . As per Byte 6 for Message ID#s 120 to 127	N/A	Uchar . . Uchar
21-28		Reserved	N/A	Uchar[8]
29-30		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

Transmitted: 30 Bytes , ID#105

01 69 96 18 0A 1D E1 77 0E 05 0A 00 82 00 00 00 00 00 00 00
00 00 00 00 C0 FB 12 00 03 05

2.5.41 Configure COM1 Port Mode ID# 110

This command allows you to configure the baud rate and protocol of the COM1 port.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5	0-6	Baud rate in 300 baud units up to 19200 1: 300 . . 32: 9600 . . 64: 19200 (maximum)	N/A	Uchar
	7	Mode 0: NMEA 1: Binary		
6-7		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

✉ If you enter a rate other than 300, 600, 1200, 2400, 4800, 9600, or 19200, the rate is rounded to the nearest allowable baud rate by the receiver. For example, 0A = 1010 = 10 => 3000 is detected as 2400 by the receiver.

Example Input:

```
Transmitted: 7 Bytes , ID#110
01 6E 91 01 C0 C1 01
```

In this example, C0 = 1100 0000 => Binary mode and 64 => Binary mode at 19200 baud

2.5.42 Request Timing Information ID# 113

This command allows you to request the timing status of your receiver if it is a SUPERSTAR II-based product with Precise Timing (T) capability. See also *Message ID# 113* output on *Page 111* and *Appendix A, SUPERSTAR II Card Models* on *Page 133*.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*			
5-6		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort

Example Input:

```
Transmitted: 6 Bytes , ID#113 (Continuous)
01 F1 0E 00 00 01
```

or:

```
Transmitted: 6 Bytes , ID#113 (One Shot)
01 71 8E 00 00 01
```

2.6 NMEA Protocol Commands

Table 10 lists valid NMEA input sentences. An explanation of the supported NMEA protocol and field definitions is provided in *Appendix F, NMEA Format Data Messages* on *Page 150*. Individual NMEA commands and logs can be found in this chapter and *Chapter 3* respectively.

✉ The checksum is optional with NMEA commands.

For further details on the NMEA message structure and formats, please refer to NMEA 0183 specification.

The sentence type has the following meanings:

P-DR = Proprietary sentence issuing a data request

P-CM = Proprietary sentence issuing a command

Table 10: NMEA Input Commands

Identifier	Name	Type	Sentence Length (Max Characters)
000	Configure COM1 port	P-CM	17
001	Initialize time and position	P-CM	77
003	Initiate BIT self test	P-CM	15
004	Request log	P-DR	19
005	Set output configuration	P-CM	67
007	Erase non-volatile memory (NVM)	P-CM	18
008	Set receiver parameters	P-CM	60
009	Define waypoint in MGRS format	P-CM	57
010	Select active waypoint	P-CM	18
012	Receiver configuration	P-CM	65

2.6.1 $PMCAG, 000 Configure COM1 Port Command

This command allows you to configure the baud rate and protocol (from NMEA to binary) of the COM1 port. Use *Message ID# 110* to switch back (from binary to NMEA), see *Page 58*. On power-up COM1 stays in the same mode.

```
HEADER       |  CONTENTS OF DATA FIELDS

$PMCAG,000  |
             |  ,x*hh<CR><LF>
             |   |
             |   Baud Rate Selection, see Table 11 below
```

Table 11: Baud Rate Selection

Character	Baud Rate
0	19200
1	300
2	600
3	1200
4	2400
5	4800
6	9600
7	19200

Example:

Configure COM1 to binary mode at 19200.

```
$PMCAG,000,0*58<CR><LF>
```

2.6.2 $PMCAG, 001 Initialize Time and Position

This command initializes the receiver with reference UTC date, UTC time and user position.

```
HEADER      | CONTENTS OF DATA FIELDS

$PMCAG,001 |
,xx,xx,xxxx,xx,xx,xx,±xx,xx,±llll.ll,a,yyyyy.yy,a,±x.xx*hh<CR><LF>
 |  |  |    |   |  |   |  |  |        | |        |  |
 |  |  |    |   |  |   |  |  |        | |        |  |
 |  |  |    |   |  |   |  |  |        | |        |  altitude1
 |  |  |    |   |  |   |  |  |        | ---------- longitude-E/W2
 |  |  |    |   |  |   |  |  ---------- latitude-N/S3
 |  |  |    |   |  |   |  reserved4
 |  |  |    |   |  |  reserved5
 |  |  |    -------- time6
 ------- date7
```

Example:

$PMCAG,001,08,07,1993,16,37,21,00,00,5301.97,N,00133.48,E,35.35*40<CR><LF>

Date	08/07/1993
Time	16:37:21
Reserved	Must be 00
Reserved	Must be 00
Latitude	53° 01.97' North
Longitude	1° 33.48' East
Altitude	35.35 m above mean sea level

1. Altitude in meters above (or below) mean sea level (resolution: 0.01 m)
2. Longitude - E/W with respect to WGS-84
3. Latitude - N/S with respect to WGS-84
4. Reserved, must be 00
5. Reserved, must be 00
6. UTC Time (Hour 0-23, Minutes 0-59, Seconds 0-59)
7. UTC Date (Day 1-31, Month 1-12, Year 1980-2079)

2.6.3 $PMCAG, 003 Initiate Self-Test

This command requests a complete self-test of the receiver. Results of the self-test are automatically output (see *$PMCAG, 902 Self-Test Results* starting on *Page 117*) on COM1 at completion of the BIT self-test sequence.

HEADER	CONTENTS OF DATA FIELDS
$PMCAG,003	*hh<CR><LF>

Example:

```
$PMCAG,003*47<CR><LF>
```

2.6.4 $PMCAG, 004 Request Log Command

This message requests only one transmission of the NMEA log you specify. See also *Section 3.4, NMEA Protocol Logs* starting on *Page 115* for a list of available NMEA logs.

```
HEADER       |  CONTENTS OF DATA FIELDS

$PMCAG,004   |
             |
             |  ,ccc*hh<CR><LF>
             |   |
             |   Sentence Identifier[1]
```

Example:

Request a GPGGA log.

`$PMCAG,004,GGA*2D<CR><LF>`

1. Valid sentence identifiers are those listed in *Section 3.4, NMEA Protocol Logs* starting on *Page 115*

2.6.5 $PMCAG, 005 Set Output Configuration Command

Use this command to configure the output of the COM1 port. It contains the input/output COM1 baud rate and the list of Message IDs, see table below, with their minimum time interval between consecutive transmissions.

ID	Description
900	Navigation Status
906	Bearing, Distance and Delta-Elevation to Waypoint
907	User Position in MGRS Format
GGA	Global Positioning System Fix Data
GLL	Geographic Position - Latitude/Longitude
GSA	GPS DOP and Active Satellites
GSV	GPS Satellites in View
RMC	Recommended Minimum Specific GPS Data
VTG	Track Made Good and Ground Speed
ZDA	UTC Time and Date

```
HEADER      |  CONTENTS OF DATA FIELDS
________________________________________________________________

$PMCAG,005  |
            |  ,x.x,ccc,xxx,...,ccc,xxxx*hh<CR><LF>
            |   |   |   |       |   |
            |   |   |   |       ------ nth message block1
            |   |   ------ first message block1
            |   baud rate2
```

Example:

`$PMCAG,005,4.8,GGA,010,RMC,001,VTG,001,ZDA,010*48<CR><LF>`

Logs: GGA and ZDA transmitted every 10 s, RMC and VTG transmitted every 1 s @4800 bps

`$PMCAG,005,1,GLL,001*2A<CR><LF>`

Logs: GGA and ZDA transmitted every 10 s, GLL, RMC and VTG transmitted every 1 s @4800 bps and stored in NVM: GLL,001 @ 4800 (overwrites all previous NVM messages)

1. If the receiver is capable of navigating at a rate > 1Hz, enabling an NMEA message with a rate value of 999 will request that message at the fastest rate possible provided that:
   - the fastest rate has been set by Binary message 30 or NVM elements have been cleared
   - the NMEA message is capable of the fastest rate. These include GGA, GLL, GSA, RMC, VTG, 906 and 907.

   See also *Table 19, SUPERSTAR II Software Models* on *Page 133*.
2. Messages can be stopped by entering a rate value of 0.

1. Each message block includes:
   ccc: message identifier
   xxx: time interval between consecutive transmissions (001to 999 s) where 000 stops the transmission
2. Valid baud rates: 0.3, 0.6, 1.2, 2.4, 4.8, 9.6, 19.2 (in KBaud units)
   0: Keep same baud rate (no effect) and update message list with new update rate values
   1: Save the included list in NVM and overwrite the previous one

2.6.6 $PMCAG, 007 Erase Non-Volatile Memory Command

```
HEADER       |  CONTENTS OF DATA FIELDS

$PMCAG,007  |
            |
            |  ,xx*hh&lt;CR&gt;&lt;LF&gt;
            |   |
            |   element¹
            |
```

Table 12: PMCAG, 007 Elements

Characters	Element
00	ALL [a]
01-04	RESERVED
05	ALMANAC
06-08	RESERVED
09	TCXO PARAMETERS
10	IONO & UTC PARAMETERS
11	POSITION
12	TIME
13	DGPS CONFIGURATION
14	DEFAULT NMEA MSG LIST
15	RS232 CONFIGURATION [a]
W00 – W49	WAYPOINT ID
WXX	ALL WAYPOINTS

a. These commands force the receiver to go into the default mode and baud rate (dependant on your receiver model) at the next power-up.

Example:

```
$PMCAG,007,15*6B<CR><LF>
```

1. NVM element to erase: configuration of COM1 and binary message list sent by default after each power-up. See also *Table 12* above.

2.6.7 $PMCAG, 008 Set Receiver Parameter Command

This command allows you to configure the parameters of your receiver.

```
HEADER       |  CONTENTS OF DATA FIELDS

$PMCAG,008   |
             |
             |  ,15,a,a,a,x.x,x,a,x,x.x,,x,x,,,,*hh<CR><LF>
             |   |  | | |  |  | | |  | | | |
             |   |  | | |  |  | | |  | | | UTC Time Resolution 1 2
             |   |  | | |  |  | | |  | | Lat/Long Resolution 1 3
             |   |  | | |  |  | | |  | Reserved 4
             |   |  | | |  |  | | |  COM2 Port Baud Rate 5
             |   |  | | |  |  | | Differential Coast Time 1 6
             |   |  | | |  |  | DGPS Mode (E/D/W/B) 1
             |   |  | | |  |  Datum Number 7
             |   |  | | |  Mask Angle 1 8
             |   |  | | Tropospheric/Ionospheric Model Use (E/D)
             |   |  | MSL Model Use (E/D)
             |   |  Reserved
             |   Number of Elements 9
```

Each of the parameters (except the number of elements) may be NULL, the associated receiver parameters are left unchanged. The last four fields are reserved future use and are therefore also NULL.

Example:

1. Stored in NVM
   DGPS mode: E = enable, D = disable, W = SBAS only, B = DGPS only
2. This parameter controls the number of digits from the fraction part of the UTC Time data in all NMEA messages. The default value is 2 and the range is 0 to 9.
3. This parameter controls the number of digits from the fraction part of the latitude and longitude data in all NMEA messages. The default value is 4 and the range is 0 to 5.
4. Reserved field, null
5. Valid baud rates: 0.3, 0.6, 1.2, 2.4, 4.8, 9.6, 19.2 (in KBaud units)
6. 0 - 255 seconds
7. This parameter is used to specify the datum that is used to express the position. See *Table 7* on *Page 48*.
8. Value between 0.0 to 90.0°
9. This number indicates how many parameters are listed in the messages (15)

```
$PMCAG,008,15,E,E,,10.5,0,E,45,9.6,,,,,,,*37<CR><LF>
```

DGPS and MSL modes

Does not affect current Tropospheric/Ionospheric model status

Mask Angle: 10.5 °

Datum 0 - WGS 1984

DGPS Coast time: 45 seconds

DGPS Baud Rate: 9600 (COM2 port)

Does not affect present resolution on Latitude\Longitude and UTC time data

2.6.8 $PMCAG, 009 Define Waypoint in MGRS Format

Define the position of a waypoint in Military Grid Reference System (MGRS) format. Refer to http://earth-info.nga.mil/GandG/grids/grids1.htm for more information on MGRS zone numbers.

```
HEADER        |  CONTENTS OF DATA FIELDS
              |
---------------------------------------------------------------------------
$PMCAG,009    |
              |
              |  ,xx,a,a,a,xxxxx,xxxxx,±xxxxx.x,c--c,xx*hh<CR><LF>
              |    |  | | |   |     |      |      |    |
              |    |  | | |   |     |      |      | Waypoint number (00 - 49)
              |    |  | | |   |     |      |     Waypoint name (max 8 char)
              |    |  | | |   |     |     Altitude above MSL (m)
              |    |  | | |   |    Grid northing
              |    |  | | |  Grid easting
              |    |  | | Square row
              |    |  | Square column
              |    | Zone letter
              |   Zone number
```

Example:

```
$PMCAG,009,18,T,X,R,02090,38779,100.5,POINTA,03*79<CR><LF>
```

Zone number	18 [1]
Zone letter	T
Square column	X
Square row	R
Grid easting	02090
Grid northing	38779
Altitude	100.5
Waypoint name	POINTA
Waypoint ID	03

1. If the Square Column field (latitude band) is X, then the Zone number field should not be set to 32, 34 or 36. These zones were incorporated into other zone numbers and do not exist, see *Figure 1* following.

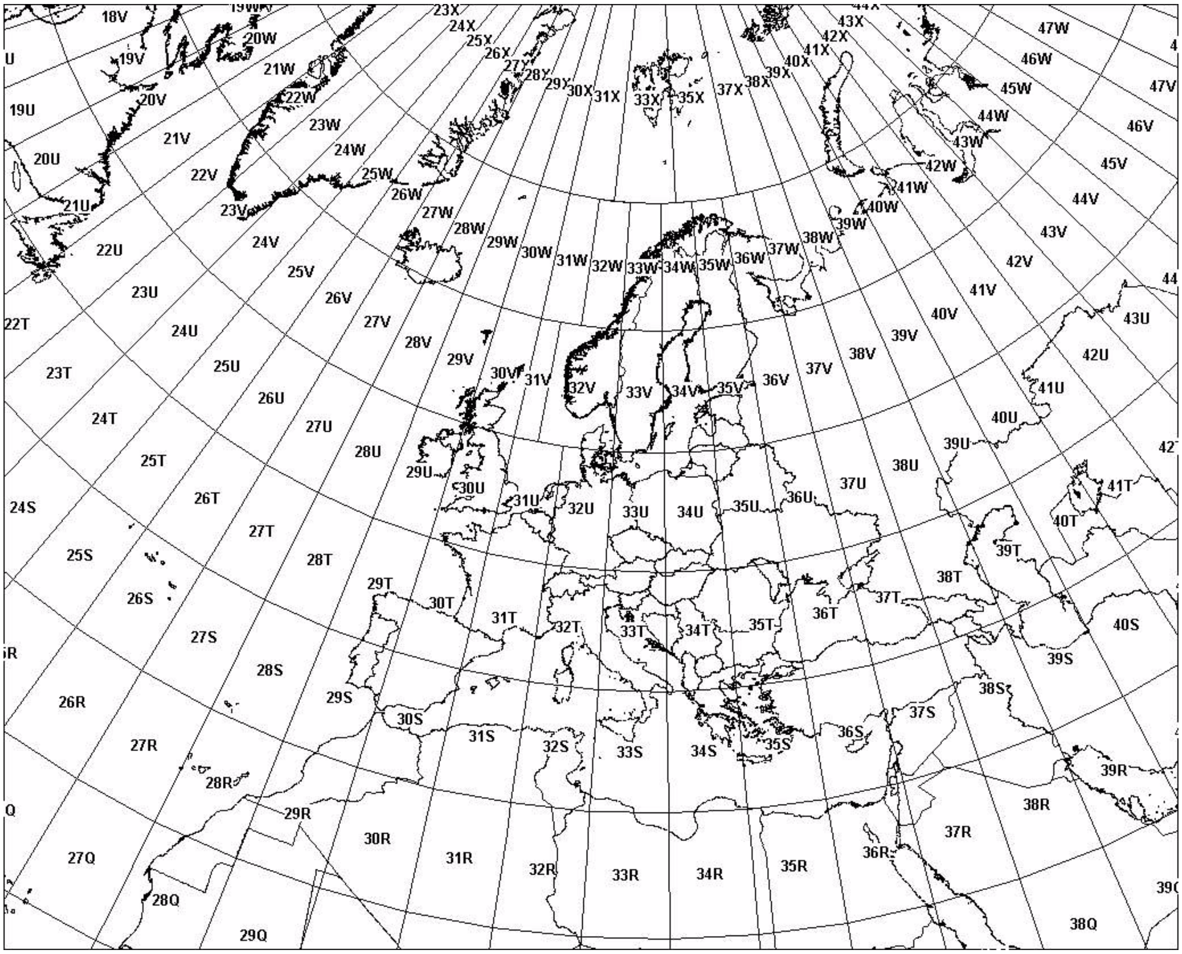

Figure 1: Example of Part of the MGRS Grid

2.6.9 $PMCAG, 010 Select Active Waypoint

Selects the active waypoint to be used in subsequent requests to $PMCAG, 906, see *Page 118*.

```
               |
HEADER         |   CONTENTS OF DATA FIELDS
               |

$PMCAG,010     |
               |
               |   ,xx*hh<CR><LF>
               |     |
               |    Waypoint ID (00-49)
               |
```

Example:

```
$PMCAG,010,03*47<CR><LF>
```

2.6.10 $PCMAG, 012 Receiver Configuration

This message is used to configure the receiver for the following modes.

```
HEADER        |  CONTENTS OF DATA FIELDS
              |
$PMCAG,012    |  ,x,a,a,a,xxx,xx,x.xx,xxx,xxx,xxx,,,,,,,,*hh<CR><LF>
              |   | | | |  |  |   |    |   |   |
              |   | | | |  |  |   |    |   |   Filtering period in
              |   | | | |  |  |   |    |   |   dynamic mode [1]
              |   | | | |  |  |   |    |   |
              |   | | | |  |  |   |    |   Filtering period in
              |   | | | |  |  |   |    |   static mode [2]
              |   | | | |  |  |   |    Dead reckoning threshold (s) [3]
              |   | | | |  |  |   |
              |   | | | |  |  |   Stand still threshold [3,4]
              |   | | | |  |  |
              |   | | | |  |  Maximum accelaration (m/s^2) [4,5]
              |   | | | |  Maximum speed (m/s) [4]
              |   | | | Motion detector [6]
              |   | | Phase measurement type [7]
              |   | Antenna type (P/A/F) [8]
              |   Predefined configuration [9]
```

1. 5..1270 seconds where 1275 sets the value to the predefined receiver parameters
2. 0.0 to 2.50 m/s
3. 0.0 to 2.55 m/s
4. This field is read only when User Configuration is chosen
5. 0 to 40
6. A: Automatic
   S: Static
   M: Motion
7. F: False
   T: True
8. P: Auto Detect (starts with passive and switches to active if an active antenna in detected)
   A: Active
   F: Passive
9. 0: User Configuration
   1: Man
   2: Tractor
   3: Marine
   4: Car
   5: Plane
   6: Rocket
   7-14: Reserved
   15: Unlimited

Example 1:

$PMCAG,012,4,P,F,A,45,8,0.20,255,300,300,,,,,,,,*33<CR><LF>

Example 1 shows the default inputs in StarView.

Example 2:

$PMCAG,012,5,A,F,A,100,20,0.20,255,300,300,,,,,,,,*29<CR><LF>

In *Example 2*, the Antenna Type is Active and the Predefined Configuration is Plane.

Example 3:

$PMCAG,012,1,P,F,A,10,3,0.20,255,300,300,,,,,,,,*3D<CR><LF>

In *Example 3*, the Predefined Configuration is set to Man.

Chapter 3 Output Logs

3.1 Logs

The receiver sends commands in Binary format as described in *Chapter 1* or in NMEA format. In Binary format, the MSB of the Message ID# may be used to set the receiver to Normal mode (MSB=0) or to Special mode (MSB=1). See also the *ID#* description on *Page 14* and *Command Message* on *Page 15*.

Binary format messages include a checksum for error checking.

3.1.1 Message Latencies

Message latency is the delay after a 1PPS mark and is an indication of when to expect a specific message to be output. It refers to the time difference between the 1PPS and the time of transmission of the first byte of the message. Message latencies for SSII are given in *Table 13*.

Table 13: Message Vs. Latency

Message ID#	Definition	Mean Latency (ms)	Standard Deviation (ms)
20	Navigation data (user coordinates)	552.3	8.1
21	Navigation data (ECEF coordinates)	551.9	2.2
23	Measurement block data	155.1	3.5
33	Satellite visibility, data and status	751.6	2.2.1
113	Timing status	553.0	0.2
GGA	Global Positioning System fix data	550.4	0.2
GLL	Geographic position (lat/lon)	549.9	14.4
GSA	GPS DOP and active satellites	549.8	16.0
GSV	GPS satellites in view	50.5	2.6
VTG	Track made good and ground speed	550.5	0.2
ZDA	UTC time and date	150.8	0.7

3.2 Logs by Function

Table 14 lists the logs by function while *Table 15 on Page 76* is a listing of logs in order of their Message IDs.

Table 14: Logs By Function Table

GENERAL RECEIVER CONTROL AND STATUS	
Message	**Definition**
30	Receiver configuration
45	Hardware/software identification
49	Receiver status
51	Self-test results
113	Timing status

Continued on Page 73

POSITION, PARAMETERS, AND SOLUTION FILTERING	
Message ID#	**Definition**
20	Navigation data (user coordinates)
21	Navigation data (ECEF coordinates)
22	Ephemeris data
23	Measurement block data
43	DGPS configuration
75	Ionospheric and UTC time data
GPGGA	NMEA, fix data, position data and undulation
GPGLL	NMEA, position data
GPGRS	NMEA, range residuals
GPGSA	NMEA, DOP information
CLOCK INFORMATION, STATUS, AND TIME	
Message ID#	**Definition**
75	Ionospheric and UTC time data
113	Timing status
DIFFERENTIAL BASE STATION	
Message ID#	**Definition**
33	Satellite data
43	DGPS configuration
47	Base station status
65	RTCM data message received
76	Almanac data
DIFFERENTIAL ROVER STATION	
Message ID#	**Definition**
20	Navigation data (user coordinates)
21	Navigation data (ECEF coordinates)
23	Measurement block data
43	DGPS configuration
48	Differential message status
65	RTCM data message received
POST PROCESSING DATA	
Message ID#	**Definition**
22	Ephemeris data
33	Satellite data
75	Ionospheric and UTC time data
113	Timing status

Continued on Page 75

SATELLITE TRACKING AND CHANNEL CONTROL	
Message ID#	**Definition**
6	Current channel assignment (1-6)
7	Current channel assignment (7-12)
GPGSA	NMEA, SV DOP information
GPGSV	NMEA, satellite-in-view information
33	Satellite visibility, data and status
50	Satellite health summary
67	SBAS data
68	SBAS status message
76	Almanac data
78	Almanac reception status
NMEA Format Messages	
Message ID#	**Definition**
900	Navigation status
902	Self-test results
906	Bearing, distance and delta-elevation to waypoint
907	User position - MGRS format
908	Receiver parameter status
912	Receiver configuration
GGA	GPS fix data and undulation
GLL	Geographic position - latitude/longitude
GSA	GPS DOP and active satellites
GSV	GPS satellites in view
RMC	GPS specific information
VTG	Track made good and ground speed
ZDA	UTC time and date information
WAYPOINT NAVIGATION	
Message ID	**Definition**
20	Navigation data (user coordinates)
21	Navigation data (ECEF coordinates)
900	Navigation status
906	Bearing, distance and delta-elevation to waypoint
907	User position - MGRS format

Table 15: SUPERSTAR II Log Summary

ID#	Definition	Message Type [a]
6	Current channel assignment data (1-6)	UR/FR
7	Current channel assignment data (7-12)	UR/FR
20	Navigation data (user coordinates) [b]	UR/FR
21	Navigation data (ECEF coordinates) [b]	UR/FR
22	Ephemeris data (ICD-GPS-200 format) [c]	UR/FR
23	Measurement block data	UR/FR
30	Receiver configuration	DR/DM
33	Satellite visibility, data and status [b]	UR/FR
43	DGPS configuration	UR
45	Hardware/software identification	UR
47	Base station status data	DR/DM
48	Differential message status data	DR/DM
49	Receiver status data	DR/DM
50	Satellite health summary	UR/FR
51	Self-test results	DR/DM
65	RTCM data message received	FR
67	SBAS data	DR/DM
68	SBAS status message	DR/DM
75	Ionospheric and UTC time data	DR/DM
76	Almanac data	DR/DM
78	Almanac reception status	SM[d]
113	Timing status	DR/DM
125	Link overload error log	PM[d]
126	Acknowledge log	PM[d]

a. DM = Data Message, DR = Data Request, FR = First Request, PM = Protocol Message, SM = Status Message and UR = Update Request
b. Twice per second when in 2 Hz PVT mode
c. On first request and then on new ephemeris reception
d. PMs and SMs are output once per second or per 100 ms

3.3 Binary Protocol Logs

3.3.1 Current Channel Assignment Data (1-6) ID# 6

Structure: **Message ID#: 6**
Rate (seconds): 1

This log shows you the current satellites assigned to channels 1 through 6.

BYTE	BIT	DESCRIPTION	UNIT	TYPE	OFFSET
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*				0
5		Reserved	N/A	Uchar	4
6	0-4	SV # (0-31)	N/A	Uchar	5
	5	SV type 0: GPS SV, SV = bit 0-4 +1 1: SBAS SV, SV = bit 0-4 + 120	N/A		
	6-7	Reserved	N/A		
7-10		Carrier frequency resolution	cycles	Ulong	6
11-14		Serial to Noise ratio (SNR)	dB-Hz	Float	10
15-18		Reserved	N/A	Uchar[4]	14
19	0-1	Tracking state 0: not ready 1: bits ready 2: measurement ready 3: failed	N/A	Uchar	18
	2-3	Allocation state 0: idle 1: locating 2: tracking	N/A		
	4	Channel mode 1: automatic 0: manual	N/A		
	5	SNR level 0: old SNR levels 1: new SNR levels	N/A		
	6-7	Reserved	N/A		
20-33		Channel 2 assignment data	As per Channel 1		19
34-47		Channel 3 assignment data			33
48-61		Channel 4 assignment data			47
62-75		Channel 5 assignment data			61
76-89		Channel 6 assignment data			75
90-91		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort	89

Example Output:

```
00000000 00000000 00160201 06F95501
177F2602 008D0E31 42000000 001A18FC
24020000 00000000 00000010 1C1D2402
00744F26 42000000 001A0994 250200E3
D3554200 0000001A 0F202402 00AB421F
42000000 001A0C10 260200CB 2E1E4200
0000001A C90C012B D4158347 78532D30
```

Example header translated to decimal: 01 06 249 85

3.3.2 Current Channel Assignment Data (7-12) ID#7

Structure: **Message ID#: 7**
Rate (seconds): 1

This log shows you the current satellites assigned to channels 7 through 12.

BYTE	BIT	DESCRIPTION	UNIT	TYPE	OFFSET
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*				0
5		Reserved	N/A	Uchar	4
6	0-4	SV # (0-31)	N/A	Uchar	5
	5	SV type 0: GPS SV, SV = bit 0-4 +1 1: SBAS SV, SV = bit 0-4 + 120	N/A		
	6-7	Reserved	N/A		
7-10		Carrier frequency resolution	cycles	Ulong	6
11-14		SNR	dB-Hz	Float	10
15-18		Reserved	N/A	Uchar[4]	14
19	0-1	Tracking state 0: not ready 1: bits ready 2: measurement ready 3: failed	N/A	Uchar	18
	2-3	Allocation state 0: idle 1: locating 2: tracking	N/A		
	4	Channel mode 1: automatic 0: manual	N/A		
	5	SNR level 0: old SNR levels 1: new SNR levels	N/A		
	6-7	Reserved	N/A		
20-33		Channel 8 assignment data	As per Channel 7		19
34-47		Channel 9 assignment data			33
48-61		Channel 10 assignment data			47
62-75		Channel 11 assignment data			61
76-89		Channel 12 assignment data			75
90-91		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort	89

Example Output:

```
00000034 9A0F0107 F855000D 15260200
F0D52542 00000000 3A138724 0200ACC3
3F420000 00003A02 A1240200 00000000
00000000 340F7F23 0200E2A1 13420100
00003A22 D3240200 CEF72242 F8FF0000
3A2ED324 0200760C 15420000 00003A61
120131CE 2803660C 050C0500 00000000
```

Example header translated to decimal: 01 07 248 85

3.3.3 Navigation Data (User Coordinates) ID# 20

Structure: **Message ID#: 20**
Rate (seconds): 1, 0.2 or 0.5 [1]

This log contains the best position (latitude, longitude and altitude coordinates) and velocity (m/s) computed by the receiver. In addition, it reports height and velocity Figures of Merit (FOMs) and a Dilution of Precision value (DOP), which are quality indicators. For more information on the FOM and DOP, refer to the *Glossary* in the *GPS+ Reference Manual* available on our website at http://www.novatel.com/Downloads/docupdates.html.

BYTE	BIT	DESCRIPTION	UNITS	TYPE	OFFSET
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*				0
5	0-4	UTC time: hours	hours	Uchar	4
	5	Time not corrected by UTC parameters: 1 = True 0 = False	N/A		
	6-7	Reserved	N/A		
6		UTC time: minutes	minutes	Uchar	5
7-14		UTC time: seconds	s	Double	6
15		UTC date: day	day	Uchar	14
16		UTC date: month	month	Uchar	15
17-18		UTC date: year	year	Ushort	16
19-26		Latitude Range: $-\pi/2$ to $\pi/2$	radians	Double	18
27-34		Longitude Range: $-\pi$ to π	radians	Double	26
35-38		Altitude	m	Float	34
39-42		Ground speed	m/s	Float	38
43-46		Track angle Range: $-\pi$ to π	radians	Float	42
47-50		North velocity	m/s	Float	46
51-54		East velocity	m/s	Float	50
55-58		Vertical velocity	m/s	Float	54
59-62		HFOM	m	Float	58
63-66		VFOM	m	Float	62
67-68		HDOP Resolution: 0.1 units	N/A	Ushort	64

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1. SUPERSTAR II-based receivers are capable of a navigation rate of 1 Hz. If you have a model with 5 Hz PVT, you can alternatively select 5 Hz (0.2) or 2 Hz (0.5). See a list of models on *Page 133*.

69-70		VDOP Resolution: 0.1 units	N/A	Ushort	68
71	0-4	NAV Mode 0: Initialization required 1: Initialized 2: NAV 3-D 3: Altitude hold (NAV 2-D) 4: Differential 3-D 5: Differential 2-D 6: Dead reckoning With Base Station Mode only: 8: Base station	N/A	Uchar	70
	5	Solution confidence level 0: Normal (NAV solution from < 5 SVs) 1: High (NAV solution from ≥ 5 SVs)			
	6	Differential source selection 0: SBAS 1: DGPS			
	7	Reserved			
72	0-3	Number of SVs used to compute this solution	N/A	Uchar	71
	4-7	Coordinate system (lowest nibble) Datum number b3,b2,b1,b0			
73	0-3	System mode 0: Self test 1: Initialization 2: Acquisition 3: Navigation 4: Fault	N/A	Uchar	72
	4-5	Coordinate system (highest nibble) Datum number b5,b4			
	6	Satellite tracking mode 0: All SVs in view (based on current almanac, position and time) 1: Sky search			
	7	Coordinate system (highest nibble) Datum number b6 (b7 = 0)			
74		Elapsed time since power up (hours)	hours	Uchar	73
75		Reserved		Uchar	74
76-77		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort	75

Example Output:

```
C00000D8 010114EB 47131600 00000000
8049400E 04D30786 79A09A7D 8CEC3FDB
F869D772 D8FFBF3A 45834448 D947B5F2
0C0F3F00 00000000 00000000 00000087
0536413D FF694100 861848A2 0903BE04
DB170115 EA4F1202 0000C010 0341BE04
```

Example header translated to decimal: 01 20 235 71

3.3.4 Navigation Data (ECEF Coordinates) ID# 21

Structure: **Message ID#: 21**
Rate (seconds): 1, 0.2 or 0.5 [1]

This log contains the receiver's best available position and velocity in earth-centered-earth-fixed (ECEF) coordinates (see *Figure 2* on *Page 85*). In addition, it reports height and velocity Figures of Merit (FOMs) and Dilution of Precision (DOP) values, which are quality indicators. For more information on the FOM and DOP, refer to the *Glossary* in the *GPS+ Reference Manual* available on our website at http://www.novatel.com/Downloads/docupdates.html.

BYTE	BIT	DESCRIPTION	UNITS	TYPE	OFFSET
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*				0
5-12		GPS Time Range: 0.0 to 604800.0	s	Double	4
13-14		Week	weeks	Short	12
15-22		X coordinate position	m	Double	14
23-30		Y coordinate position	m	Double	22
31-38		Z coordinate position	m	Double	30
39-42		Velocity vector along X-axis	m/s	Float	38
43-46		Velocity vector along Y-axis	m/s	Float	42
47-50		Velocity vector along Z-axis	m/s	Float	46
51-58		Clock bias	s	Double	50
59-66		Clock drift	s/s	Double	58
67-70		HFOM	m	Float	66
71-74		VFOM	m	Float	70
75-76		HDOP Resolution: 0.1 units	N/A	Ushort	74
77-78		VDOP Resolution: 0.1 units	N/A	Ushort	76

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1. SUPERSTAR II-based receivers are capable of a navigation rate of 1 Hz. If you have a model with 5 Hz PVT, you can alternatively select 5 Hz (0.2) or 2 Hz (0.5). See a list of models on *Page 133*.

79	0-4	NAV Mode 0: Initialization required 1: Initialized 2: NAV 3-D 3: Altitude hold (NAV 2-D) 4: Differential 3-D 5: Differential 2-D 6: Dead reckoning For BASE model units: 8: Base Station	N/A	Uchar	78
	5	Solution Confidence Level 0: Normal (NAV solution from < 5 SVs) 1: High (NAV solution from ≥ 5 SVs)			
	6	Differential source selection 0: SBAS 1: DGPS			
	7	Reserved			
80	0-3	Number of SVs used to compute this solution	N/A	Uchar	79
	4-7	Reserved			
81-83		Reserved	N/A	Uchar[3]	80
84-85		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort	84

Example Output:

```
0115EA4F FCF6FFFF 67150341 BE0480BC
B172E0F0 38C1D045 BD1674F5 4BC1B661
068BA9DA 52410000 00000000 00000000
00000839 647553AD 0FBEB0CA FCEAFEBF
A23EB7C5 3B41F6E1 70410800 0C00A209
00000027 220155AA 10000000 00000000
```

Example header translated to decimal: 01 21 234 79

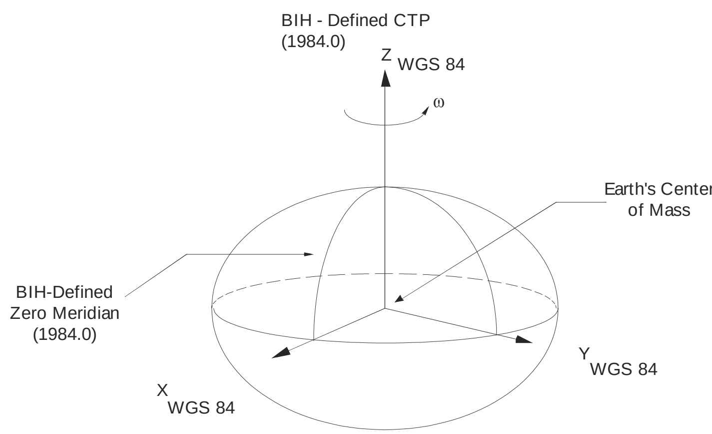
- Definitions - *

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, 90° East of the X-Axis.



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

Figure 2: ECEF Coordinate System

3.3.5 Ephemeris Data ID# 22

Structure: **Message ID#: 22**
Rate (seconds): 1

This log contains ephemeris data for one satellite at a rate of one log per second until the ephemeris data list is complete, and then only if there is new ephemeris data. Please refer to the NAVSTAR GPS Space Segment/ Navigation Interface document ICD-GPS-200 Rev. B for specifics on the format of the ephemeris data. See *Table 1* on *Page 12* for contact information.

BYTE	BIT	DESCRIPTION	UNITS	TYPE	OFFSET
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*				0
5	0-4	SV# (0-31)	N/A	Uchar	4
	5-7	Reserved	N/A		
6-77		Ephemeris sub-frame 1-3/words 3-10 MSB of byte 6 is Bit 61 of subframe 1	as per NAVSTAR [a]		5
78-79		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort	77

a. See Reference [1] on *Page 12*

Example Output:

```
0000002D 00000000 28040116 E9490C2F
90005402 533040F1 5E6365DB 09E86226
AC00FFFB FC99DD62 0936309F 401A21FF
07EE0107 C6670A19 A10D06B1 26AC5BFF
E7A233AE 77FFF127 D4C99F24 F9125659
D9FFA578 620E2716 220131CE 280366BE
```

Example header translated to decimal: 01 22 233 73

3.3.6 Measurement Block Data ID# 23

Structure: **Message ID#: 23**
Rate (seconds): 1, 0.2 or 0.5 [1]

This log contains raw data carrier phase and code phase data. If measurement blocks exist, the total length of the log is:

15 + 11*N Measurement Block + 2

Otherwise, the total length of the log is 6 bytes (the header plus the checksum only).

1. Please also read the *Measurements* appendix starting on *Page 138* of this manual for more details on raw code phase measurements and raw carrier phase measurements.
2. This log is only available on GPS receiver models that have Carrier Phase Output (CP) capability. See also *Appendix A*, *SUPERSTAR II Card Models*, starting on *Page 133*.

BYTE	BIT	DESCRIPTION	UNITS	TYPE	OFFSET
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*				0
5		Time slew value	175ns	Uchar	4
6	0-2	Time Status 0: Unknown 1: Not Set 2: Coarse (25 x 10^{-6} s Variance) 3: Fine (1 x 10^{-14} s Variance)	N/A	Uchar	5
	3-7	Reserved			
7		Number of measurement blocks	N/A	Uchar	6
8-15		Predicted GPS time This is the time when the measurement samples have been taken at the receiver (not the transmission time).	s	Double	7
16	0-5	SV# (0-31)	N/A	Uchar	15
	6	Reserved			
	7	Toggle at each ephemeris transmission			
17		Signal-to-Noise ratio (SNR). For example, a value of 160 translates to 40.0 dB/Hz	0.25 dB/Hz	Uchar	16

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1. SUPERSTAR II-based receivers with a carrier phase (CP) option are capable of 1 Hz output. If you have a 5 Hz CP model, you can also select 5 Hz (0.2) or 2 Hz (0.5). See a list of models on *Page 133*.

18-21		Code phase The correlator aligns the locally generated satellite C/A with the received signal using a precision of 1/1024 of a half chip. A chip lasts for 1/1023 ms Therefore, the code phase precision is 1/1023 ms/2/1024. Range: 0 to 2095103999	1/1024 half chip	Ulong	17
22-25	0-1	Carrier Phase 0: Ready 1: Phase Ambiguous 2: Phase Unlock 3: Not Ready For most applications, use measurements only when both bits 0 and 1 are clear. See *Section C.4, Carrier Phase In Message ID# 23* starting on *Page 141*.	N/A	Uchar[4]	21
	2-11	Carrier Phase Range: 0-1023	cycles		
	12-31	Integrated number of cycles Range: Natural roll over	cycles		
26		Cycle_Slip Counter. Raw data and tracking loop slips are observable in the measurement. The carrier tracking loop has a 180° ambiguity so it is possible to slip by a full cycle or a half cycle. The half cycles are detected and signalled through the measurements qualifiers (least significant 2 bits of the carrier phase). Cycle_Slip Counter Increments by 1 every time a cycle slip is detected during a 10 ms period Range: natural roll over Range for BASE model units: loss of carrier continuity and number of GPS data parity errors	N/A	Uchar	25
27...	Measurement block #2 . . Measurement block #N Next SV offset = 15 + (#SVs x 11)		As per Measurement Block #1 (bytes 16-26 above)		
28-29		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort	variable

Example Output:

```
43022B00 19284401 00000000 D2060117
E86E0900 090E0100 00402103 4105D66A
A1627424 E1AE2801 89D4BA56 2A749487
D3B00110 B97CF97E 73008B9B BA0114BB
C42C6473 A002BD16 011DB925 A5717304
B0EFD401 17AB3E5B DD7234B3 6D23011C
9FFAB9C5 7210EAF0 95010F9D EA29B172
303349C9 01049FAE 8E6C7274 FF615B01
1A2E012D D25F3136 392D3631 34323837
```

Example Header Translated to Decimal: 01 23 232 110

3.3.7 Receiver Configuration ID# 30

Structure: **Message ID#: 30**
Rate (seconds): 1

Use this log to view the receiver configuration parameters. See also *Page 28* to set the configuration.

BYTE	BIT	DESCRIPTION	UNITS	TYPE	OFFSET
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*				0
5	0-3	Predefined configuration: 0: User configuration 1: Man 2: Tractor 3: Marine 4: Car 5: Plane 6: Rocket 7-14: Reserved 15: Unlimited	N/A	Uchar	4
	4-7	Reserved	N/A		
6	0-1	Navigation message[a] rate: 0: 1 Hz PVT 1: 2 Hz PVT 2: 5 Hz PVT 3: Reserved	N/A	Uchar	5
	2-7	Reserved	N/A		
7	0-1	Antenna type 0: Auto Detect [b] 1: Active 2: Passive	N/A	Uchar	6
	2-7	Reserved			
8		Reserved		Uchar	7
9-10		Maximum speed	m/s	Ushort	8
11	0-5	Maximum acceleration in the range 0 to 40 m/s When 40 is received, the internal value is set to 39.2	m/s^2	Uchar	10
	6-7	Reserved			
12		Standstill threshold	cm/s	Uchar	11
13		Dead reckoning threshold in the range 0 to 254	s	Uchar	12
14-20		Reserved		Uchar[7]	13
21-22		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort	variable

a. Navigation messages are NMEA GGA, GLL, GSA, RMC, VTG and Binary ID#s 20 and 21
b. Auto Detect starts up with a Passive setting, and auto switches to Active if an active antenna is detected.

Example Output:

```
01 1E E1 10 0A 1D E1 77 84 06 02 00 82 00 00 00 00 00 00 00
9D 03
```

Example Header Translated to Decimal: 01 30 225 16

3.3.8 Satellite Visibility Data and Status ID# 33

Structure: **Message ID#: 33**
Rate (seconds): 1

Data transmission of up to 12 satellites in view listed in decreasing elevation order.

BYTE	BIT	DESCRIPTION	UNITS	TYPE	OFFSET
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*				0
5	0-3	Total number of satellites in view	N/A	Uchar	4
	4-7	Reserved	N/A		
6	0-4	SV# (0 - 31) for GPS If this value is 0 and Byte 9, bits 1-7 are non-zero, see Byte 9 below for the SBAS SV# If Byte 9, bits 1-7 are zero, add 1 to the SV# to get the PRN	N/A	Uchar	5
	5-6	SV status 0 = In view 1 = Tracking 2 = Measurement ready 3 = Used by navigation	N/A		
	7	Differential corrections available 0 = Off 1 = On	N/A		
7		Elevation Range: -90 to +90	degree	Char	6
8	0-7	Azimuth Range: 0 to 360 The azimuth value is from bits 0 to 7 of byte 8 and bit 0 of byte 9	degree	Char	7
9	0			Char	8
	1-7	Non-zero = SBAS SV (33-51) Add this value to 87 to get the true SBAS SV# For example, 33 represents SBAS SV# 120 (Byte 6, bits 0-4 above will be zero in this case)	N/A		
10		SNR Range: 0 to 90	dB	Uchar	9
11-15		Satellite visibility data of the 2nd SV	as per SV1	as per SV1	10
16-20		Satellite visibility data of the 3rd SV	as per SV1	as per SV1	15
21-25		Satellite visibility data of the 4th SV	as per SV1	as per SV1	20
26-30		Satellite visibility data of the 5th SV	as per SV1	as per SV1	25
31-35		Satellite visibility data of the 6th SV	as per SV1	as per SV1	30
36-40		Satellite visibility data of the 7th SV	as per SV1	as per SV1	35
41-45		Satellite visibility data of the 8th SV	as per SV1	as per SV1	40
46-50		Satellite visibility data of the 9th SV	as per SV1	as per SV1	45

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51-55		Satellite visibility data of the 10th SV	as per SV1	as per SV1	50
56-60		Satellite visibility data of the 11th SV	as per SV1	as per SV1	55
61-65		Satellite visibility data of the 12th SV	as per SV1	as per SV1	60
66-67		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort	65

Example Output:

```
00000000 00000010 010121DE 3D0A6550
05013669 394B0035 7027FD00 2F742100
012F7D1D CD002E77 1248002B 7C0F7B00
276F0E45 01276407 B700272C 030D0024
00000000 00000000 0000330C 0133CC24
```

Example Header Translated to Decimal: 01 33 222 61

3.3.9 DGPS Configuration ID# 43

Structure: **Message ID#: 43**
Rate (seconds): 1

This log outputs the current DGPS configuration if your receiver is operating in differential mode.

BYTE	BIT	DESCRIPTION	UNITS	TYPE	OFFSET
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*				0
5	0	Enable 0 = Off (Use SBAS over DGPS corrections) 1 = On (Use DGPS over SBAS corrections)	N/A	Uchar	4
	1-3	Mode 0 = No DGPS 1 = SBAS only 2 = DGPS only 3 = DGPS/SBAS automatically			
	4-6	Reserved: must be 0			
	7	Port 0: COM1 1: COM2			
6		Differential coast time	seconds	Uchar	5
7		Reserved	N/A	Uchar	6
8		Baud rate (1=300, ... 32=9600, ... 64=19200)	bauds	Uchar	7
9-25		Reserved	N/A	Uchar[8]	8
			N/A	Uchar[8]	16
26-27		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort	25

Example Output:

```
00001AE2 0C012BD4 15834778 532D3030
300A0288 00000000 002D0000 00002804
```

Example Header Translated to Decimal: 01 43 212 21

3.3.10 Hardware/Software Identification ID# 45

Structure: **Message ID#: 45**
Rate: one shot

This log provides software identification information.

BYTE	BIT	DESCRIPTION	UNITS	TYPE	OFFSET
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*				0
5-18		Operational software part number	N/A	Uchar[14]	4
19-32		Model part number, for example: 169-613955-XXX where XXX is the Configuration Block Number, see also *Appendix A, SUPERSTAR II Card Models*, starting on *Page 133*.	N/A	Uchar[14]	18
33-36		Model checksum	N/A	Uchar[4]	32
37-50		Boot S/W part number	N/A	Uchar[14]	36
51-73		Reserved	N/A	Uchar[22]	50
74-86		Product serial number (PSN)	N/A	Uchar[13]	73
87-90		Reserved	N/A	Uchar[4]	86
91-94		Boot checksum	Hex	Short	90
95-98		Operational checksum	Hex	Short	94
99	0-2	System type 0 - 2 = Reserved 3 = SUPERSTAR II	N/A	Uchar	98
	3-7	Reserved			
100-101		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort	99

Example Output:

```
1A2E012D D25F3136 392D3631 34323837
2D303032 3136392D 36313339 35352D34
30307C01 54953136 392D3631 33393134
2D303037 01000000 00000000 00000000
00000000 00000000 00000000 00000000
00000000 00000000 00000000 B525FB7A
5ACD1A7D 002F0F01 CE310000 010130CF
18000000 00000000 00000000 00000000
```

Example Header Translated to Decimal: 01 45 210 95

3.3.11 Base Station Status Data ID# 47

Structure: **Message ID#: 47**
Rate (seconds): 1

This log contains the position of the base station as received through RTCM messages if your receiver is a BASE model and is operating in differential mode. It also has a time tag, the status of the base station, and the RTCM messages in use and their rates. This information is set at the base station using *Message ID# 80, Set Operating Mode* and *Message ID# 91, Differential Message Status*. See *Page 42* and *Page 53* respectively for details on these commands.

BYTE	BIT	DESCRIPTION	UNITS	TYPE	OFFSET
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*				0
5	0-1	Base Status 0: Not in base 1: Position not initialized 2: Base initialized 3: Reserved	N/A	Uchar	4
	2-4	Baud Rate 0: 300 1: 600 2: 1200 3: 2400 4: 4800 5: 9600 6: 19200	N/A		
	5-7	Reserved	N/A		
6-13		Time remaining in survey	hours	Double	5
14-17		Base station position CEP	meters	Float	13
18-25		Base station position latitude	radians	Double	17
26-33		Base station position longitude	radians	Double	25
34-41		Base station position height	meters	Double	33
42-45		Reserved	N/A	Uchar[4]	41
46	0-4	Number of differential messages to follow	N/A	Uchar	45
	5-7	Reserved	N/A		
47		Message type	N/A	Uchar	46
48		Message rate	s	Uchar	47
Next message					Variable
variable		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort	Variable

Example Output:

```
24020011 F8134200 0000003A F313012F
D02A1600 00000000 00000078 4EDB3E4B
F0F19EF1 7EEC3FDD 8E4CC4A0 0300C02A
DB5738DF 60904000 00000000 04100131
```

Example Header Translated to Decimal: 01 47 208 42

3.3.12 Differential Message Status ID# 48

Structure: **Message ID#: 48**
Rate (seconds): 1

This log outputs the status of the differential message requested by *Message ID# 48* if your receiver is a BASE model or is operating as a rover in differential mode. See also *Appendix A, SUPERSTAR II Card Models*, starting on *Page 133*.

If the unit is in rover mode the fields in *Table 16* are used. However, if the unit is in base mode, the fields in *Table 17* on *Page 96* are used. Set the operating mode using *Message ID# 80, Set Operating Mode*, see *Page 42*.

Table 16: Rover Message ID# 48

BYTE	BIT	DESCRIPTION	UNITS	TYPE	OFFSET
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*				0
5		Station identification number	N/A	Uchar	4
6	0-1	Reserved	N/A	Uchar	5
	2-4	Station health	N/A		
	5-6	Station identification bit	N/A		
	7	Reserved	N/A		
7-10		Message received bitmap 0 = RTCM1 1 = RTCM2 2 = RTCM3 3-7 = Reserved 8 = RTCM9	=	Uchar[4]	6
11-14		Reserved	N/A	Uchar[4]	10
15-16		Differential data link - valid word count	N/A	Uchar[2]	14
17-18		Differential data link - parity error count	N/A	Uchar[2]	16
19-24		Reserved	N/A	Uchar[6]	18
25-26	0-12	Receiver mode bits 0-12: ZCount of last message 1, 2, or 9	N/A	Uchar[2]	24
	13-15	DGPS Status 0: DGPS disabled 1: Initialization/synchronization 2: Correcting 3: Bad GDOP 4: Old corrections 5: Station unhealthy 6: Too few SVs 7: Reserved	N/A		
27-28		Reserved	N/A	Uchar[2]	26
29-30		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort	28

Table 17: Base Message ID# 48

BYTE	BIT	DESCRIPTION	UNITS	TYPE	OFFSET
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*				0
5		Station identification number (bits 0-7)	N/A	Uchar	4
6	0-1	Reserved	N/A	Uchar	5
	2-4	Station health	N/A		
	5-6	Station identification bit	N/A		
	7	Reserved	N/A		
7-10		Message received bitmap 0 = RTCM1 1 = Reserved 2 = RTCM3	N/A	Uchar[4]	6
11-24		Reserved	N/A	Uchar[14]	10
25-26	0-12	ZCount of last message 1, 2, or 9	N/A	Ushort	24
27-28		Reserved	N/A	Uchar[2]	26
29-30		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort	28

Example Output:

```
BC520175 270130CF 18011801 00000000
00000031 0D000000 00000000 00794500
002E0201 55AA1000 00000000 00000000
```

Example Header Translated to Decimal: 01 48 207 24

3.3.13 Receiver Status ID# 49

Structure: **Message ID#: 49**
Rate (seconds): 1

This log provides information on the configuration of your GPS receiver.

BYTE	BIT	DESCRIPTION	UNITS	TYPE	OFFSET
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*				0
5	0-3	System mode 0: Self test 1: Initialization 2: Acquisition 3: Navigation 4: Fault	N/A	Uchar	4
	4-5	Reset source	N/A		
	6	Satellite tracking mode 0: All SVs in view (based on current almanac, position and time) 1: Sky search	N/A		
	7	NVM controller state 0: Idle (no process in progress) 1: Busy (erase and/or store data process in progress)	N/A		
6	0	Tropospheric model 0: Enabled 1: Disabled	N/A	Uchar	5
	1	MSL model 0: Enabled 1: Disabled	N/A		
	2-3	Last power-up modes 0: Cold start (invalid almanac, time or position) 1: Initialized start (valid almanac, time and position) only with battery backup RAM	N/A		
	4	Reserved	N/A		
	5-7	Time source 0: Initialization required 1: External 2: SV without NAV mode 3: SV with NAV mode	N/A		
7-8		Almanac week of collection	N/A	Ushort	6
9-10		Week number	N/A	Ushort	8

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11-14	0-31	SV deselect bitmap Byte 11: bit 0 = SV1 . . . Byte 14: bit 7 = SV32	N/A	Uchar[4]	10
15-16	0-11	Channel deselection bitmap Byte 15: bit 0 = Ch1 . . . Byte 16: bit 7 = Ch12	N/A	Uchar[2]	14
17		Reserved	N/A	Uchar	16
18-21		SBAS SV disable bit 0 = SV120 and so on	N/A	Uchar[4]	17
22		Minimum idle time	%	Uchar	21
23		Idle time	%	Uchar	22
24-25		Mask angle	0.01°	Short	23
26	0-5	Discretes 0: DISC_IP1 1: DISC_IP2 2: DISC_IP3 3: DISC_IO1 4: DISC_IO2 (position valid output only pin) 5: DISC_IO3	N/A	Uchar	25
	6-7	Reserved	N/A		
27-33		Reserved	N/A	Uchar[7]	26
34		NAV mode 0: Initialization required 1: Initialized 2: NAV 3-D 3: Altitude hold (2-D) 4: Differential 3-D 5: Differential 2-D 6: Dead reckoning 7: Reserved 8: Base station	N/A	Uchar	33
35-40		Reserved	N/A	Uchar[6]	34
41-42		Differential word count	N/A	Ushort	40
43-44		Parity error count	N/A	Ushort	42
45-46		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort	44

Example Output:

```
00000000 28040131 CE280366 BE04BE04
00000000 00000000 00000000 00F30106
700300C3 A3884302 3600204F 0CFF0000
00006508 0117E879 09000A18 05000028
```

Example Header Translated to Decimal: 01 49 206 40

3.3.14 Satellite Health Summary ID# 50

Structure: **Message ID#: 50**
Rate (seconds): 30

This log indicates the health of each GPS satellite.

BYTE	BIT	DESCRIPTION	UNITS	TYPE	OFFSET
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*				0
5	0-1	SV #1 0: Healthy 1: Unhealthy	N/A	Uchar	4
	6-7	SV #4 0: Healthy 1: Unhealthy	N/A		
6	0-1	SV #5 0: Healthy 1: Unhealthy	N/A	Uchar	5
	6-7	SV #8 0: Healthy 1: Unhealthy	N/A		
7	0-1	SV #9 0: Healthy 1: Unhealthy	N/A	Uchar	6
	6-7	SV #12 0: Healthy 1: Unhealthy	N/A		
8	0-1	SV #13 0: Healthy 1: Unhealthful	N/A	Uchar	7
	6-7	SV #16 0: Healthy 1: Unhealthy	N/A		
9	0-1	SV #17 0: Healthy 1: Unhealthy	N/A	Uchar	8
	6-7	SV #20 0: Healthy 1: Unhealthy	N/A		
10	0-1	SV #21 0: Healthy 1: Unhealthy	N/A	Uchar	9
	6-7	SV #24 0: Healthy 1: Unhealthy	N/A		

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11	0-1	SV #25 0: Healthy 1: Unhealthy	N/A	Uchar	10
	6-7	SV #28 0: Healthy 1: Unhealthy	N/A		
12	0-1	SV #29 0: Healthy 1: Unhealthy	N/A	Uchar	11
	6-7	SV #32 0: Healthy 1: Unhealthy	N/A		
13-14		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort	44

Example Output:

```
0132CD08 2880E008 B82CA0E0 FC040131
```

Example Header Translated to Decimal: 01 50 205 08

3.3.15 Self-Test Results ID# 51

Structure: **Message ID#: 51**
Rate (seconds): 1

This log outputs the results of an initiated built-in test (BIT) request.

BYTE	BIT	DESCRIPTION	UNITS	TYPE	OFFSET
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*				0
5		Bit copy of the initiated BIT request message 0: Reserved 1: Initiated BIT result 2: Power up BIT result	N/A	Uchar	4
6	0	RAM 0: Fail 1: Pass	N/A	Uchar	5
	1	Flash 0: Fail 1: Pass			
	2	EEPROM 0: Fail 1: Pass			
	3	UART 0: Fail 1: Pass			
	4	Real time clock 0: Fail 1: Pass			
	5	Correlator and RF 0: Fail 1: Pass			
	6-7	Reserved			
7-9		Reserved	N/A	Uchar[3]	6
10	0	Boot software checksum 0: Pass 1: Fail	N/A	Uchar	9
	1	Operation software checksum 0: Pass 1: Fail			
	2-4	Flash error code. If different from 000, the receiver cannot be reset. 0: Pass 1: Fail			
	5-6	Flash ID			
	7	Flash size OK and software supported 0: Flash OK 1: Flash bad			

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11	0	EEPROM status link error 0: Pass 1: Fail	N/A	Uchar	10
	1	Memory location error 0: Pass 1: Fail			
	2-7	Reserved			
12	0	COM1 port (UART) serial link 0: Pass 1: Not ready or busy	N/A	Uchar	11
	1	TX flag 0: Full 1: Not full			
	2	Internal loop tests data 0: Received 1: Not received			
	3	Framing or parity 0: Pass 1: Fail			
	4	RX flag 0: Full 1: Not full			
	5	Overrun test 0: Pass 1: Fail			
	6-7	Reserved			
13		COM2 port (UART) results (see the byte 12 description above)	Hex	Uchar	12
14	0-2	bit 0: Link timeout 0: Pass 1: Error bit 1: Clock date error 0: Pass 1: Error bit 2: Clock time error 0: Pass 1: Error	N/A	Uchar	13
	3-4	Scratch pad error bit 3: 0: Pass 1: Error bit 4: Reserved			
	5-7	Reserved			

Continued on Page 103

15	0	RF MAG LO limit 0: Pass 1: Error	N/A	Uchar	14
	1	RF MAG HI limit 0: Pass 1: Error			
	2	RF SIGN LO limit 0: Pass 1: Error			
	3	RF SIGN HI limit 0: Pass 1: Error			
	4	RF I and Q test 0: Pass 1: Error			
	5	RF PLL 0: Locked 1: Not Locked			
	6-7	Reserved			
16		Global correlator test results #1 Bit 0: Channel 0 error in I and Q test . . Bit 7: Channel 7 error in I and Q test	N/A	Uchar	15
17		Global correlator test results #2 Bit 0: Channel 0 error in I and Q test . . Bit 7: Channel 7 error in I and Q test	N/A	Uchar	16
18		Global correlator test results #3 Bit 0: Channel 9 error in I and Q test Bit 1: Channel 10 error in I and Q test Bit 2: Channel 11 error in I and Q test Bit 3: Channel 12 error in I and Q test Bit 4: Channel 9 error in Measurement test Bit 5: Channel 10 error in Measurement test Bit 6: Channel 11 error in Measurement test Bit 7: Channel 12 error in Measurement test	N/A	Uchar	17
19-40		Reserved	N/A	Uchar[22]	18
41-42		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort	40

Example Output:

```
00000000 00000000 00002F0C 0133CC24
023F0000 00803100 00000000 00000000
00000000 00000000 00000000 00000000
00000000 16020106 F9550117 8A260200
```

Example Header Translated to Decimal: 01 51 204 36

3.3.16 RTCM Data Message Received ID# 65

Structure: **Message ID#: 65**
Rate (seconds): 1

This message shows the saved RTCM data processed by the receiver. The RTCM Frame in this log is the same RTCM frame that the rover received, see Reference [2] on *Page 12* for the interface rules.

BYTE	BIT	DESCRIPTION	UNITS	TYPE	OFFSET
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*				
5		Control fixed at 0x00	N/A	Uchar	4
6 - n		RTCM frame data	N/A	String	Variable
variable (n+1, n+2)		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort	Variable

Example Output:

```
00000000 6E0C0141 BE3A0059 7E7D5F43
4A7E615A 68677F77 4F6E4F67 7E57677F
6D707F47 65434240 7C494154 41437841
405A4E6F 4748646A 4068724F 4C67427E
6F7E4642 0F160114 EB47101A 00000000
```

Example Header Translated to Decimal: 01 65 190 58

3.3.17 SBAS Data ID# 67

Structure: **Message ID#: 67**
Rate (seconds): 1

Bytes 21 - 52 of this log provide the 250-bit SBAS message. The 250-bit message is packed into a 32-byte frame. See also *Section D.2.1, SBAS Messages* starting on *Page 146* and *Appendix A, SUPERSTAR II Card Models*, starting on *Page 133*.

BYTE	BIT	DESCRIPTION	UNITS	TYPE	OFFSET
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*				
5-8		Week number	N/A	Ulong	4
9-16		GPS time range: 0.0 to 604800.0	s	Double	8
17-20		SV ID	N/A	Ulong	16
21-52		SBAS message data field	N/A	Uchar [32]	20
53-54		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort	52

Example Output:

```
00C00000 D7020143 BC30DE04 00000000
00007475 19412200 0000C60D 401DFFDF
FFFE9FFD FFDFFDFF DFFDFFDF FFFFFFFF
BBB3BBBB BB9D456A C3409C1B 0144BB07
```

Example Header Translated to Decimal: 01 67 188 48

3.3.18 SBAS Status Message ID# 68

Structure: **Message ID#: 68**
Rate (seconds): 1

This log provides the status of the SBAS (for example WAAS and EGNOS) message.

BYTE	BIT	DESCRIPTION	UNITS	TYPE	OFFSET
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*				0
5-6		Message count	N/A	Ushort	2
7		SV ID	N/A	Uchar	6
8		SBAS message number	N/A	Uchar	7
9		Correction age	seconds	Uchar	8
10-11		Reserved	N/A	Uchar[2]	9
12-13		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort	11

Example Output:

```
5C008910 0144BB07 3D007A1A 000000D8
010114EB 47143700 20250000 0043400C
```

Example Header Translated to Decimal: 01 68 187 07

3.3.19 Ionospheric and UTC Time Data ID# 75

Structure: **Message ID#: 75**
Rate (seconds): 1

This log outputs Ionospheric Model parameters and UTC Time parameters.

BYTE	BIT	DESCRIPTION	UNITS	TYPE	OFFSET
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*				0
5		a0: Alpha parameter constant term		Char	4
6		a1: Alpha parameter 1st order term		Char	5
7		a2: Alpha parameter 2nd order term		Char	6
8		a3: Alpha parameter 3rd order term		Char	7
9		a0: Beta parameter constant term		Char	8
10		a1: Beta parameter 1st order term		Char	9
11		a2: Beta parameter 2nd order term		Char	10
12		a3: Beta parameter 3rd order term		Char	11
13		Is the Ionospheric data valid? 0 = Not valid 1 = Valid		Uchar	12
14		a0: 2nd alpha parameter constant term		Ulong	13
15		a1: 2nd alpha parameter 1st order term		Ulong	14
16		DTLS: delta time due to leap seconds		Char	15
17		TOT: reference time of UTC parameters		Uchar	16
18		WNT: UTC reference week number		Uchar	17
19		WNLSF: Future week number		Uchar	18
20		DN: Day number		Uchar	19
21		DTLSF: Future delta time due to leap seconds		Char	20
22		Is the UTC data valid? 0 = Not valid 1 = Valid		Uchar	21
23-38		Reserved		Uchar[16]	22
39-40		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort	38

Example Output:

```
005492E3 FE000000 00DE0901 4BB42812
FFFE023B F9FC0801 09000000 09000000
0D90DCDE 050D0100 00000000 00000000
00000000 000000EE 070108F7 120A2CFD
```

Example Header Translated to Decimal: 01 75 180 40

3.3.20 Almanac Data ID# 76

Structure: **Message ID#: 76**
Rate (seconds): 1

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. For more information on Almanac data, refer to the GPS SPS Signal Specification (Reference [1] on *Page 12*).

The SUPERSTAR II family of receivers automatically saves almanac information in their non-volatile memory (NVM), therefore creating an almanac boot file is not necessary.

BYTE	BIT	DESCRIPTION	UNITS	TYPE	OFFSET
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*				
5	0-5	SV# (1 -31)	N/A	Uchar	4
	6-7	SV type 0: Reserved 1: GPS 2: Reserved			
6-9		Almanac reference time, TOA	s	Ulong	5
10-13		Clock aging parameter, af0 Range: $-2.0^{10} - 2.0^{-20}$ to $(2.0^{10} - 1.0) - 2.0^{-20}$ Resolution: 2.0^{-20}	s	Ulong	9
14-21		Clock aging parameter, af1 Range: $-2.0^{10} - 2.0^{-38}$ to $(2.0^{10} - 1.0) - 2.0^{-38}$ Resolution: 2.0^{-38}	s/s	Double	13
22-29		Mean anomaly of reference time, M0 Range: $-2.0^{23} - 2.0^{-23} - \pi$ to $(2.0^{23} - 1.0) - 2.0^{-23} - \pi$ Resolution: $2.0^{-23} - \pi$	radians	Double	21
30-37		Argument of perigee, W Range: $-2.0^{23} - 2.0^{-23} - \pi$ to $(2.0^{23} - 1.0) - 2.0^{-23} - \pi$ Resolution: $2.0^{-23} - \pi$	radians	Double	29
38-45		Right ascension, Omega_0 Range: $-2.0^{23} - 2.0^{-23} - \pi$ to $(2.0^{23} - 1.0) - 2.0^{-23} - \pi$ Resolution: $2.0^{-23} - \pi$	radians	Double	37
46-53		Semi-major axis, Root_A Range: 2525.0 to $(2.0^{24} - 1.0) - 2.0^{-11}$ Resolution: 2.0^{-11}	$m^{1/2}$	Double	45

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54-61		Rate of right ascension, Omega_Dot Range: $-2.0^{15} - 2.0^{-38} - \pi$ to $(2.0^{15} - 1.0) - 2.0^{-38} - \pi$ Resolution: $2.0^{-38} - \pi$	radians/s	Double	53
62-69		Angle of Inclination relative to 0.30π, i range: $-2.0^{15} - 2.0^{-19} - \pi$ to $(2.0^{15} - 1.0) - 2.0^{-19} - \pi$ resolution: $2.0^{-19} - \pi$	radians	Double	61
70-77		Eccentricity, e Range: 0 to 0.03 Resolution: 2.0^{-21}	N/A	Double	69
78-79		Almanac week common to all SVs Range: 0 to 65535	weeks	Short	77
80...		Next satellite block			variable
variable		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort	variable

Example Output:

```
00000000 00000000 000000EE 07014CB3
4F4100E0 04000000 000000A0 343F0000
00000000 903D52DD CE0A1E59 03C0BD17
D315F29D FBBFFB06 86479FE5 CE3F0000
00009A21 B4401C02 257C2F39 40BE0D34
56FBE695 A13F0000 00008094 753FDC04
621B0108 F7120A55 AF001C79 3595081D
```

Example Header Translated to Decimal: 01 76 179 79

3.3.21 Almanac Reception Status ID# 78

Structure: **Message ID#: 78**
Rate (seconds): 1

This log informs the PC of the status of the almanac upload.

This log is sent once after a new almanac data transfer (which includes one *Message ID# 78* and multiple *Message ID# 79*s, see *Page 40*) to confirm successful almanac upload. There are no data bytes.

BYTE	BIT	DESCRIPTION	UNITS	TYPE	OFFSET
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13* The MSB of the ID# field encodes the status as follows: 0 = Unsuccessful 1 = Successful				0
5-6		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort	4

Example Output:

```
20725C9B 409E0128 3E014EB1 00000101
```

Example Header Translated to Decimal: 01 78 177 00

3.3.22 Timing Status ID# 113

Structure: **Message ID#: 113**
Rate (seconds): 1

This log allows you to view precise timing information if your receiver is a model with Precise Timing (T) capability. See also *Appendix A, SUPERSTAR II Card Models*, starting on *Page 133*.

The clock bias and drift parameters are computed using the pseudorange measurements and the predicted true range (using the known user position). A Time Figure Of Merit (TFOM) for the clock errors is derived using the residuals of the least-square time solution. When using GPS measurements only, the TFOM does not take into account any bias in the residuals that may be induced by the atmospheric errors. Therefore it provides a relative accuracy estimate. When the SBAS channel is available, the clock bias estimate is virtually free of systematic errors and the computed TFOM approximates an absolute accuracy of the 1PPS output by the receiver.

BYTE	BIT	DESCRIPTION	UNITS	TYPE	OFFSET
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*				0
5-8		Cable delay value Propagation delay induced by the antenna cable that has been entered using *Message ID# 69*, *Set Timing Parameters*, see *Page 36*	ns	Ulong	4
9-12		1PPS offset Delay between the edge of the UTC second and the rising edge of the 1PPS signal that has been entered using the *Set Timing Parameters* command *ID# 69*	ns	Ulong	8
13-16		1PPS pulse length Length of the 1PPS pulse that has been entered using the *Set Timing Parameters* command *ID# 69*	100 ns	Ulong	12
17		Number of observations Number of satellites used to compute the clock error	N/A	Uchar	16
18-19		Mask angle Elevation angle below which satellite measurements are not used	0.01°	Ushort	17
20		Leap second change Indicates the change to the leap second value applicable at the end of the current day (at midnight) Zero indicates no leap second change This value reverts to 0 after midnight, when the new leap second value has been applied to the UTC time	s	Char	19
21		Leap second value Offset between the GPS time and the UTC time It contains only the leap second number and NOT the fractional part transmitted in the *GPS Navigation Message ID# 21*, see *Page 83*	s	Char	20
22-29		Clock bias Bias between the predicted time and the actual time at the time of the solution	ns	Double	21
30-37		Clock drift Frequency drift of the TCXO at the time of the solution	ppm	Double	29

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38-41		UTC date of the 1PPS output	dy: mo: yr	Char: Char: Short	37
42-51		UTC time of the 1PPS output	hr: min: s	Char: Char: Double	41
52-55		1PPS residual Residual computed from the expected 1PPS output time and the actual 1PPS output time, within the resolution period of ±50 ns To be used for systems with feedback or for post-processing	ns	Long	51
56	0-1	Timing operating mode 0: Standard 1: One shot alignment 2: Constant alignment		Uchar	55
	2-3	Residual status 0: All residuals acceptable 1: One residual rejected 2: More than one residual rejected 3: Not tested			
	4-5	Time estimator status 0: Successful 1: Warning (residual cannot run) 2: Not ready (no measurements) 3: Alarm (raised by residual)			
	6	SBAS processing 0: Inactive 1: Active			
	7	Static operation 0: Inactive 1: Active			
57-60		TFOM(1Φ) clock bias	ns	Long	56
61		Reserved	N/A	Uchar	60
62-63		Intrinsic delay	ns	Ushort	61
64-65		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort	63

Example Output:

```
0A030200 1E120171 8E3B0000 00000000
00001027 00000AC2 01000D63 D5CB83A4
C808C05C 765F2A6F 92D0BF0F 0AD40711
010060FE FFFF7F44 40000000 00C20400
0000646C 07F31101 06F95500 17BA2402
```

Example Header Translated to Decimal: 01 113 142 59

3.3.23 Link Overload Error Message ID# 125

Sent by the receiver only when at least one log caused an overload of the data link. This log is sent at a maximum rate of once per second. This log encodes a bit map of all the Message ID#s (1 to 127), therefore indicating which ID#s caused the link overload. The request of the message that caused the overload is cancelled to prevent any further overload.

Structure: **Message ID#: 125**
Rate (seconds): 1

BYTE	BIT	DESCRIPTION	UNITS	TYPE	OFFSET
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*				0
5-20		Message ID#s bitmap (marked 1 not 0) 0 = ID# 1 : 126 = ID# 127	N/A	Uchar[16]	4
21-22		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort	20

Example Output:

```
020A0054 92E3FE00 000000AC 09017D82
10000000 00000000 00000800 00000000
00180101 08F7120A F872001C 763D9508
```

Example Header Translated to Decimal: 01 125 130 16

3.3.24 Acknowledge Log ID# 126

The receiver generates this log to acknowledge all messages. It is sent as soon as possible if there is at least one message to acknowledge. The data field of this log contains 5 bytes that encode the IDs of the messages acknowledged (4 messages per time interval and possibly a message from a previous time interval that was not completely decoded). A maximum of five messages may be acknowledged per log. *Message ID# 0* indicates a dummy message and is discarded. Its purpose is only to fill the data field of the acknowledge log.

Structure: **Message ID#: 126**
Rate (seconds): 0.1

BYTE	BIT	DESCRIPTION	UNITS	TYPE	OFFSET
1-4	Header, see *Section 1.2.2, Message Block Structure* starting on *Page 13*				0
5		ID of first message acknowledged	N/A	Uchar	4
6		ID of second message acknowledged	N/A	Uchar	5
7		ID of third message acknowledged	N/A	Uchar	6
8		ID of fourth message acknowledged	N/A	Uchar	7
9		ID of fifth message acknowledged	N/A	Uchar	8
10-11		Checksum, see *Section 1.6, Checksum Calculation Rules* starting on *Page 19*	N/A	Ushort	9

Example Output:

```
017E8105 14151600 00440101 2DD25F31
```

Example Header Translated to Decimal: 01 126 129 05

3.4 NMEA Protocol Logs

Table 18 lists a set of supported NMEA logs. An explanation of the supported NMEA protocol and field definitions is provided in *Appendix F*, *NMEA Format Data Messages* on *Page 150*. Individual NMEA commands and logs can be found in *Chapter 2* and this chapter respectively.

For further details on the NMEA message structure and formats, please refer to NMEA 0183 specification.

Table 18: List of NMEA Logs

Message ID#	Name
900	Navigation Status
902	Self-Test Results
906	Bearing, distance and delta-elevation to waypoint [a b]
907	User position - MGRS format
908	Receiver Parameter Status
912	Receiver Configuration
GGA	Global Positioning System Fix Data [a b]
GLL	Geographic Position - Latitude/Longitude [a b]
GSA	GPS DOP and Active Satellites [a b]
GSV	GPS Satellites in View
RMC	Recommended Minimum Specific GPS Data [a b]
VTG	Track Made Good and Ground Speed [a b]
ZDA	UTC Time & Date

a. This message is sent at twice the requested update rate if the 2Hz PVT mode is active

b. This message is sent at five times the requested update rate if the 5Hz PVT mode is active

3.4.1 $PMCAG, 900 Navigation Status

This log provides the current navigation mode and GPS fix quality indicator.

```
HEADER       |  CONTENTS OF DATA FIELDS

$PMCAG,900  |
            |
            | ,ccc,c*hh<CR><LF>
            |  |   |
            |  |   GPS Fix Quality Indicator¹
            |  |
            |  Navigation mode²
```

Example:

`$PMCAG,900,3-D,H*5F<CR><LF>`

Navigation Mode:	3-D fix
GPS Fix Quality:	Obtained from at least 5 SVs

1. GPS Fix Quality Indicator:

L (Low):	Navigation solution is obtained from less than 5 satellite measurements
H (High):	Navigation solution is obtained from at least 5 satellite measurements

2. Navigation modes:

3DD	3-D fix with differential aiding
3-D	3-D fix
2DD	2-D fix (constant altitude) with differential aiding
2-D	2-D fix (constant altitude)
D-R	Dead-Reckoning
INI	Initialized (last good fix or external initialization)
NCD	No Computed Data. Fix data is not valid and should be ignored The receiver does not have a valid time and/or a valid position (from last good fix or external initialization)

3.4.2 $PMCAG, 902 Self-Test Results

Result of a receiver self-test. This log is automatically output in response to an initiated BIT self-test request (see NMEA command 003 on *Page 62*). This log can also be requested through NMEA command 004 to retrieve the current status of the engine without initiating a self-test sequence, see *Page 63*.

```
HEADER       |  CONTENTS OF DATA FIELDS

$PMCAG,902 |
           |
           | ,x.xxx,xxx,a,aaaa,xx,xx*hh<CR><LF>
           |  |      |   | |    |  |
           |  |      |   | |    |  Faults identifier
           |  |      |   | |    Number of active faults
           |  |      |   | Engine self-test result1
           |  |      |   SW revision letter
           |  |      SW variation number
           |  SW part number (root number)
```

Faults identifier description (must be converted in HEX format):

General Results (0=fail, 1=Pass):

bit 0:	RAM
bit 1:	Flash
bit 2:	EEPROM
bit 3:	UART
bit 4:	Real time clock
bit 5:	Correlator and RF
bit 6-7:	Reserved

Examples:

`$PMCAG,902,1.2000,000,R,PASS,00,63`

`$PMCAG,902,1.2000,000,R,FAIL,03,49`

Faults in Flash, EEPROM and UART sections (49 = 31H)

1. Engine self test result from the last initiated BIT (PASS, FAIL). See also the opening paragraph above.

3.4.3 $PMCAG, 906 Bearing, Distance and Delta-Elevation to Waypoint

Bearing, distance and delta-elevation to, and location of, a specified waypoint from the present position. The distance is calculated along the great circle path.

```
HEADER      | CONTENTS OF DATA FIELDS

$PMCAG,906 |

,xx,a,a,a,xxxxx,xxxxx,±xxxxx.x,cc,xx,xxx.x,xxxxxxxx.xxx,xxxxx.x,a*hh
 |  | | |   |     |      |      |  |   |          |        |    |
 |  | | |   |     |      |      |  |   |          |        |  Status 1
 |  | | |   |     |      |      |  |   |          | Delta-altitude (m)
 |  | | |   |     |      |      |  |   |         Distance (m)
 |  | | |   |     |      |      |  |  True bearing (degrees)
 |  | | |   |     |      |      | Waypoint number (00 - 49)
 |  | | |   |     |      |     Waypoint name (max 8 char)
 |  | | |   |     |     Altitude above MSL (m)
 |  | | |   |    Grid northing
 |  | | |  Grid easting
 |  | | Square row
 |  | Square column
 | Zone letter
Zone number

<CR><LF>
```

Example:

```
$PMCAG,906,18,T,X,R,02069,38914,100.5,HILL,03,355.8,143.772,70.6,A*6E
<CR><LF>
```

Zone number	18
Zone letter	T
Square column	X
Square row	R
Grid easting	02090
Grid northing	38914
Altitude	100.5
Waypoint name	HILL
Waypoint number	03
Bearing	355.8 degrees
Distance	143.772 m
Delta-altitude	70.6 m
Status	Data Valid

1. Status: A = Data Valid
   B, V = Data Invalid

3.4.4 $PMCAG, 907 User Position in MGRS Format

Current position in MGRS format and UTC time of position.

```
HEADER       |  CONTENTS OF DATA FIELDS
             |
$PMCAG,907   |
             |
             |  ,xx,a,a,a,xxxxx,xxxxx,±xxxxx.x,hhmmss.ss,A*hh<CR><LF>
             |   |  | | |   |     |       |        |       |
             |   |  | | |   |     |       |        |      Status1
             |   |  | | |   |     |       |       UTC time of position
             |   |  | | |   |     |      Altitude above MSL (m)
             |   |  | | |   |    Grid northing
             |   |  | | |  Grid easting
             |   |  | | Square row
             |   |  | Square column
             |   | Zone letter
             |  Zone number
```

✉ The position references the receiver's active datum.

Example:

$PMCAG,907,18,T,X,R,02090,38779,100.5,141105,A*79<CR><LF>

Zone number	18
Zone letter	T
Square column	X
Square row	R
Grid easting	02090
Grid northing	38779
Altitude	100.5
UTC time	14:11:05
Status	Valid Data

1. Status: A = Data Valid - Navigation Mode
B, V = Data Invalid

3.4.5 $PMCAG, 908 Receiver Parameter Status

```
HEADER       |  CONTENTS OF DATA FIELDS

$PMCAG,908 |
           |
           |  ,15,a,a,a,x.x,,a,x,x.x,,x,x,,,,*hh<CR><LF>
           |   |  | | |  | | | |  |   | |
           |   |  | | |  | | | |  |   | UTC time resolution
           |   |  | | |  | | | |  |   Lat/Long resolution
           |   |  | | |  | | | |  COM2 port baud rate 1
           |   |  | | |  | | | Differential coast time 2
           |   |  | | |  | | DGPS mode 3
           |   |  | | |  |Datum number 4
           |   |  | | |  Mask angle
           |   |  | | Tropospheric model use (E/D)
           |   |  | MSL model use (E/D)
           |   |  Reserved
           |  Number of elements 5
```

Example:

$PMCAG,908,15,D,E,E,8,35,E,45,9.6,,5,6,,,,*5B<CR><LF>

Enable:	DGPS, tropospheric and MSL modes
Mask angle:	8.0°
Used datum:	35 - North American 1927 (Canada)
DGPS coast time:	45 seconds
DGPS baud rate:	9600 (COM2 port)
Lat/Long resolution:	0.00001 of minutes
UTC time resolution:	1µs

1. Valid baud rates: 0.3, 0.6, 1.2, 2.4, 4.8, 9.6, 19.2 (in KBaud units)
2. 0 to 255 seconds
3. DGPS Mode: D = Disable
   E = Automatic
   W = SBAS only
   B = DGPS only
4. This parameter reports the number of the datum that is currently used to report the position. Refer to the supported datum list on *Page 48*.
5. Indicates the number of elements that follow

3.4.6 $PMCAG, 912 Receiver Configuration

This log gives the current receiver configuration.

```
HEADER       | CONTENTS OF DATA FIELDS

$PMCAG,912   |
             |,x,a,a,a,xxx,xx,x.xx,xxx,xxx,xxx,,,,,,,,*hh<CR><LF>
             | | | | |   |  |    |   |   |   |
             | | | | |   |  |    |   |   |   Filtering period in
             | | | | |   |  |    |   |   |   dynamic mode (s)1
             | | | | |   |  |    |   |   |
             | | | | |   |  |    |   |   Filtering period in
             | | | | |   |  |    |   |   static mode (s)1
             | | | | |   |  |    |   |
             | | | | |   |  |    |   Dead reckoning threshold (s)
             | | | | |   |  |    |
             | | | | |   |  |    Stand still threshold (m/s)
             | | | | |   |  Maximum acceleration (m/s2)
             | | | | |   Maximum speed (m/s)
             | | | | Reserved
             | | | Reserved
             | | Antenna type (P/A) 2
             | Predefined configuration 3
```

Example:

$PMCAG,912,4,P,,,00045,08,0.20,130,,,,,,,,,,*3D<CR><LF>

---

1. An empty field means that the default value set by NovAtel is used
2. P: Auto Detect (starts with passive and switches to active if an active antenna in detected)
   A: Active
   F: Passive
3. 0: User configuration
   1: Man
   2: Tractor
   3: Marine
   4: Car
   5: Plane
   6: Rocket
   7-14: Reserved
   15: Unlimited

3.4.7 $GPGGA Global Positioning System Fix Data

Time, position and fix related data. It is sent at twice the requested update rate if the 2Hz PVT mode is active.

```
HEADER       |  CONTENTS OF DATA FIELDS

$GPGGA       |
             |
             |  ,hhmmss.ss,llll.lll,a,yyyyy.yyyy,a,x,xx,xx.x,
             |   |         |         | |          | | |  |
             |   |         |         | |          | | |  HDOP
             |   |         |         | |          | | SVs in use1
             |   |         |         | |          | Quality indicator2
             |   |         |         | |          E/W - East or West
             |   |         |         | Longitude3
             |   |         |        N/S - North or South
             |   |        Latitude4
             |   UTC of position
             |
             |   ±xxxxx.x,M,xxxx,M,xxxx,xxxx*hh<CR><LF>
             |   |        | |     | |     |
             |   |        | |     | |   Differential base station
             |   |        | |     | |   ID(0000-1023)
             |   |        | |     | Age of differential GPS data5
             |   |        | |    Units of geoidal separation, meters
             |   |        | Geoidal separation6
             |   |       Units of antenna altitude, meters
             |   Altitude7
```

Example:

```
$GPGGA,012338.61,5619.2837,N,17235.8964,E,1,05,2.3,34.2,M,-17.5,M,,
```

UTC	01:23:38.61
Latitude	56° 19.2837' North
Longitude	172° 35.8964' East
Quality	GPS fix
SVs used	5
HDOP	2.3
Altitude	34.2 m above mean sea level
Geoidal Separation	-17.5 m

1. May be different from number in view
2. GPS Quality indicator:
   0 = fix not available or invalid
   1 = GPS fix
   2 = Differential GPS fix
3. Longitude with respect to WGS-84.(3-digit degrees, 2-digit minutes, 4-digit decimal fraction minutes)
4. Latitude with respect to WGS-84. (2-digit degrees, 2-digit minutes, 4-digit decimal fraction minutes)
5. Time in seconds since last SC104 Type 1 or 9 update, empty field when DGPS is not used
6. Geoidal separation: the difference between the WGS-84 earth ellipsoid and mean-sea-level (geoid)
7. Geoidal height is added to the altitude if you selected to add geoidal separation in either NMEA Message 008, see *Page 66*, or Binary Message ID# 86, see *Page 46*

3.4.8 $GPGLL Geographic Position Latitude/Longitude

Latitude and longitude of present position, time of position and status.

```
HEADER        |   CONTENTS OF DATA FIELDS

$GPGLL        |
              |
              |  ,llll.llll,a,yyyyy.yyyy,a,hhmmss.ss,A*hh<CR><LF>
              |   |         | |          | |         |
              |   |         | |          | |         |
              |   |         | |          | |        Status1
              |   |         | |          | UTC of position
              |   |         | |         E/W - East or West
              |   |         | Longitude2
              |   |        N/S - North or South
              |  Latitude3
              |
```

Example:

```
$GPGLL,5619.2837,N,17235.8964,E,012338.61,A*0C<CR><LF>
```

Latitude	56° 19.2837' North
Longitude	172° 35.8964' East
UTC	01:23:38.61
Status	Valid Data

1. Status: A = Data Valid
   V = Data Invalid
2. Longitude with respect to WGS-84 (3-digit degrees, 2-digit minutes, 4-digit decimal fraction minutes)
3. Latitude with respect to WGS-84 (2-digit degrees, 2-digit minutes, 4-digit decimal fraction minutes)

3.4.9 $GPGSA GPS DOP and Active Satellites

Operating mode, satellites used for navigation and DOP values.

```
HEADER        |  CONTENTS OF DATA FIELDS

$GPGSA        |
              |
              | ,a,x,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx.x,xx.x,
              |  | | |  |  |  |  |  |  |  |  |  |  |  |  |    |
              |  | | |  |  |  |  |  |  |  |  |  |  |  |  |    HDOP
              |  | | |  |  |  |  |  |  |  |  |  |  |  |  PDOP
              |  | |                                    PRNs of SVs used[1]
              |  | Mode[2]
              |  |
              |  Mode[3]
              |
              |  xx.x*hh<CR><LF>
              |  |
              |  VDOP
              |
```

This log is sent at twice the requested update rate if the 2 Hz PVT mode is active.

Example:
$GPGSA,A,3,14,22,03,09,08,29,17,,,,,,2.7,2.2,1.6*3A<CR><LF>

Mode	3 = 3-D
SVs used	PRNs 14, 22, 03, 09, 08, 29 and 17
PDOP	2.7
HDOP	2.2
VDOP	1.6

1. PRN numbers of satellites used in solution (null for unused fields)
2. Mode: 1 = Fix not available
   2 = 2-D
   3 = 3-D
3. Mode: M = Manual, forced to operate in 2-D or 3-D mode
   A = Automatic, allowed to automatically switch between 2-D and 3-D mode

3.4.10 $GPGSV GPS Satellites In View

Number of SVs in view, PRN numbers, elevation, azimuth and SNR values. Four satellites maximum per transmission. Additional satellite data is sent in the second or third sentence.

```
HEADER      |  CONTENTS OF DATA FIELDS

$GPGSV      |
            |
            | ,x,x,xx,xx,xx,xxx,xx..........,xx,xx,xxx,xx.x*hh<CR><LF>
            |  | | |  |  |  |   | |         | |             |
            |  | | |  |  |  |   | |         | --------------4th SV
            |  | | |  |  |  |   | ----------2nd - 3rd SV
            |  | | |  |  |  |   SNR[1]
            |  | | |  |  |  Azimuth, degrees[2]
            |  | | |  |  Elevation, degrees[3]
            |  | | |  Satellite PRN number
            |  | | Total number of satellites in view
            |  | Message number[4]
            |  Total number of messages[5]
            |
```

Example:

```
$GPGSV,2,1,06,03,12,238,06,07,82,008,15,11,04,053,,27,43,178,12*7F<CR><LF
>
```

Number of Messages	2
Message Number	1
SV Visible	6
PRN	03
Elevation	12°
Azimuth	238°
SNR	6 dB
PRN	07
Elevation	82°
Azimuth	8°
SNR	15 dB
PRN	11
Elevation	4°
Azimuth	53°
SNR	Not tracked
PRN	27
Elevation	43°
Azimuth	178°
SNR	12 dB

1. SNR 00-99 dB, null when not tracking
2. Azimuth, range 000 to 359°
3. Elevation, range 00 to 90°
4. Message number, 1 to 9
5. Total number of messages, 1 to 9

Example:

```
$GPGSV,2,2,06,15,23,187,08,17,35,323,11,,,,,,,,*4E<CR><LF>
```

Messages	2
Message number	2
SV visible	6
PRN	15
Elevation	23°
Azimuth	187°
SNR	8 dB
PRN	17
Elevation	35°
Azimuth	323°
SNR	11 dB

3.4.11 $GPRMC Recommended Minimum Specific GPS Data

Time, date, position, course and data.

```
HEADER      |  CONTENTS OF DATA FIELDS

$GPRMC      |
            |
            | ,hhmmss.ss,A,llll.llll,a,yyyyy.yyyy,a,xxx.x,xxx.x,
            |  |         | |         | |          | |     |
            |  |         | |         | |          | |     Track1
            |  |         | |         | |          | Speed, knots
            |  |         | |         | |         E/W - East or West
            |  |         | |         | Longitude2
            |  |         | |        N/S - North or South
            |  |         | Latitude3
            |  |        Status4
            |  UTC of position fix
            |
            |  xxxxxx,,*hh<CR><LF>
            |  |
            |  Date5
            |
```

Example:
`$GPRMC,152119.00,A,5101.3000,N,11441.5834,W,0.0,0.0,211004,,*25`

UTC	15:21:19.00
Status	A
Latitude	51° 01.3000' North
Longitude	114° 41.5834' West
Speed	0.0 knots
Heading	0.0° from North
Date	21/10/2004

1. The track made good, measured clockwise from North at the current position. Range 0-360°
2. Longitude with respect to WGS-84 (3-digit degrees, 2-digit minutes, 4-digit decimal fraction minutes)
3. Latitude with respect to WGS-84 (2-digit degrees, 2-digit minutes, 4-digit decimal fraction minutes)
4. Status: A: Data Valid
   V: NAV Receiver Warning
5. Date: 2-digit day, 2-digit month and 2 digit-year (ddmmyy)

3.4.12 $GPVTG Track Made Good and Ground Speed

Actual track made good and speed relative to the ground. See the *Glossary of Terms* appendix in this manual.

```
HEADER       |  CONTENTS OF DATA FIELDS

$GPVTG       |
             |
             | ,xxx.x,T,,,xxx.x,N,xxx.x,K*hh<CR><LF>
             |  |     |   |     | |     |
             |  |     |   |     | Speed, km/h
             |  |     |   Speed, knots
             |  Track, degrees true
```

This log is sent at twice the requested update rate if the 2 Hz PVT mode is active

Example:
`$GPVTG,234.6,T,,,075.3,N,139.5,K*21<CR><LF>`

Track	234.6° from North
Speed	75.3 knots
Speed	139.5 km/h

3.4.13 $GPZDA Time and Date

UTC time and date.

```
HEADER       |  CONTENTS OF DATA FIELDS

$GPZDA       |
             |
             | ,hhmmss.ss,xx,xx,xxxx,xx,xx*hh<CR><LF>
             |  |         |  |  |    |  |
             |  |         |  |  |    |  Reserved
             |  |         |  |  |    Reserved
             |  |         |  |  Year
             |  |         |  Month
             |  |         Day
             |  UTC
             |
```

Example:
`$GPZDA,151701.00,21,10,2004,,*61<CR><LF>`

UTC	15:17:01.00
Date	21 October 2004

Chapter 4 Firmware Updates

The software update utility is designed to provide an easy way to update your SUPERSTAR II receiver software and model. The software package includes the following items:

- An update utility, usually called update.exe (may be named otherwise)
- An activation key
- An application note containing the instructions as they are in this appendix

4.1 System Requirements

Before you use the update utility, make sure your computer is IBM PC-compatible with the following minimum system requirements:

- Intel-compatible 486DX-66 MHz PC or higher
- One standard serial port
- Windows 95 operating system or higher

4.2 Utility Installation

Follow the steps below to install the Update utility:

1. Create a folder on the PC and name it “Update” for the Update utility installation. The folder name is not critical, but avoid names that are over 8 characters long.
2. Copy the Update utility executable file (update.exe for this example) into the newly created folder.
3. Select *Run* from the *Start* menu and press the *Browse* button to locate update.exe in the Update folder. Select update.exe, press the *Open* button and then *OK*.

   Alternatively, you can create a shortcut to the update.exe program on your desktop.

4.3 Registration Key

Figure 3: Update Registration Window in DOS

Contact NovAtel Inc. with the number that appears on your screen to obtain your registration key, see *Figure 3* above. Contact information can be found on *Page 10.* Follow the steps below to enter the registration key:

1. Copy and paste the registration key from a text file or the Customer Service e-mail. Right-click on the left corner of the DOS window, and select *Edit | Paste*, see *Figure 4* on *Page 131*. The registration key can also be entered manually.
2. Press <Enter>.

✉ The registration key contains your computer information. Only the computer that originally generated the ID number that you sent to NovAtel, is able to run the update.exe program. If you have multiple updates or upgrades, you must do them all from this one computer.

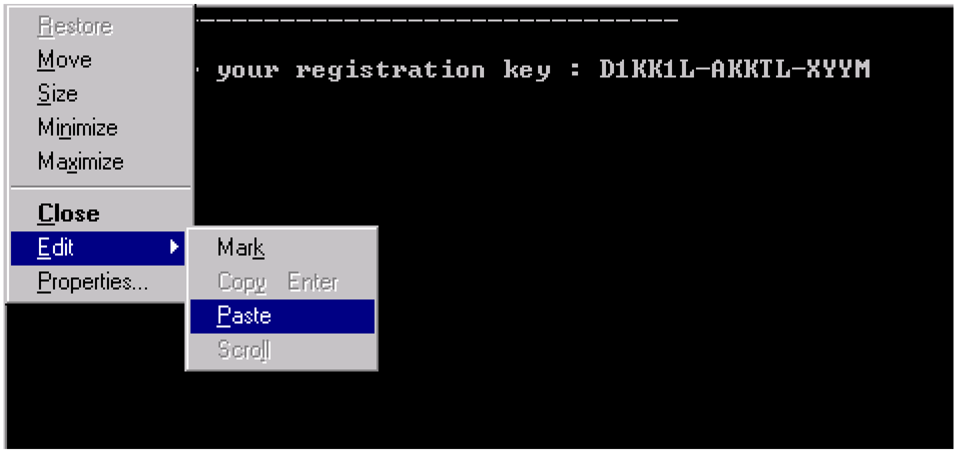

Figure 4: Paste the Registration Key into the DOS Window

4.4 Registration Key Accepted

A message confirms the Update software utility activation once the key has been entered, see *Figure 5* below. Press any key, for example <Enter>, to exit.

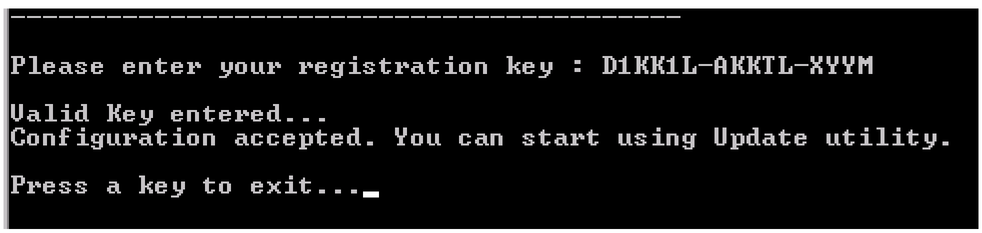

Figure 5: Configuration Accepted

4.5 Starting Software and Options Update

Once activated, the Update utility works until the date or session counter expires. Simply follow the instructions on the screen. The Update utility prompts you to remove or apply power to the GPS receiver. The sessions counter decrements every time a programming session is successfully executed. An example is shown in *Figure 6* below.

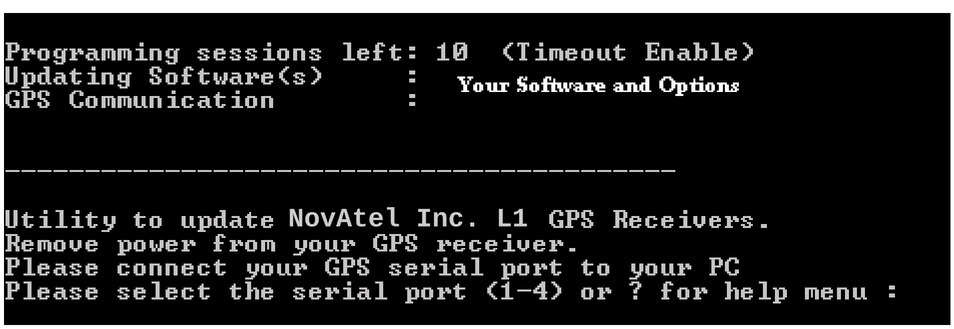

Figure 6: Update Utility Activation

4.5.1 Programming Success

The Update utility confirms programming success at the end of the programming session, see *Figure 7* below. At this point, remove power from your GPS receiver.

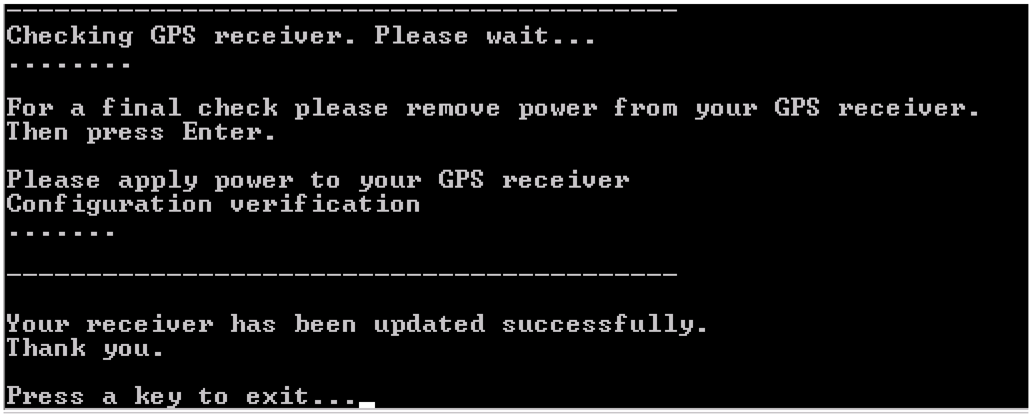

Figure 7: End of Programming Session

Appendix A SUPERSTAR II Card Models

Consult *Table 19* below for details on the SUPERSTAR II-based models available and their capabilities.

See also *Section 3.3.10, Hardware/Software Identification ID# 45, Message ID# 45* on *Page 93*.

Table 19: SUPERSTAR II Software Models

Model Name	Config Block Number	1Hz Carrier Phase (1CP)	5Hz Carrier Phase (5CP)	5Hz PVT (5HZ)	DGPS Base Station (BASE)	Timing (T)	SBAS [(N) if No SBAS]	Unlimited Altitude and Velocity (H)	Start Up At 19200 (-19)	Way-points
STD	200						✓			✓
1CPT	201	✓				✓	✓			✓
1CPT-19	202	✓				✓	✓		✓	✓
5CP-19	213	✓	✓				✓		✓	✓
5HZ	204			✓			✓			✓
BASE	205	✓			✓		✓			✓
1CPH	206	✓					✓	✓		✓
STDN	207									✓
1CPN	208	✓								✓
1CPN-19	209	✓							✓	✓
5CPN-19	214	✓	✓						✓	✓
5HZN	211			✓						✓
BASEN	212	✓			✓					✓

Appendix B Precise Timing

This appendix familiarizes you with the features of Precise Timing, which is available on the SUPERSTAR II board (stand-alone, in a FlexPak enclosure or in a SMART ANTENNA). This timing engine enables the output of a precise 1PPS signal aligned to UTC time, along with related timing data. Verify that your receiver model has Precise Timing (T), see *Section A, SUPERSTAR II Card Models* on *Page 133* for more details on models and their capabilities.

This appendix details the performance specifications, functional descriptions, and I/O messages to use the timing engine.

SBAS (for example WAAS and EGNOS) is an option available on SUPERSTAR II-based products. The SBAS and T features are independent from one another, but together yield a more accurate 1PPS alignment and enhanced timing integrity. See also *Appendix D, SBAS Positioning*, starting on *Page 145*.

B.1 The SUPERSTAR II Timing Engine

The SUPERSTAR II timing engine provides an accurate 1PPS timing pulse aligned to UTC for use in precise network synchronization applications. Several timing parameters are configurable and are detailed further. As an option, the receiver can make use of the SBAS signal to enhance the availability, integrity and accuracy of the timing pulse.

The receiver can operate as a standard SUPERSTAR II receiver, that is, provide position, velocity and time information in real-time under any given dynamics, or it can operate in static mode and provide an accurate timing signal. You can set the receiver to operate in either static or dynamic mode using *Section 2.5.28, Set Operating Mode ID# 80* on *Page 42*. The receiver is also capable of self-surveying its position.

The accuracy of the 1PPS signal, that is, the alignment of the leading edge of the 1PPS with respect to the UTC second boundary, is as follows:

±50 ns (typical)

B.2 Definitions

This section gives definitions to some fundamental timing elements presented in this appendix.

The 1PPS output time represents the predicted time, in UTC units, at which the 1PPS signal has been output. This predicted time is based on a propagation of the receiver's previously computed system time including clock bias and clock drift.

The 1PPS residual is the difference between the 1PPS output time and the desired output time. For example, if the desired output time is 12:00:00.000000000 and the computed 1PPS Output Time is 12:00:00.000000025, then the 1PPS Residual is 0.000000025.

The clock bias represents the estimated error in the previous predicted time. This value is computed at the standard receiver solution update rate and is based on the GPS measurements and the known receiver position. The clock bias values are typically filtered to remove the intrinsic measurement noise (thermal noise, atmospheric corrections mis-modeling, and so on). The intent is to have the clock bias represent the true oscillator phase error as accurately as possible. The clock bias does not represent the absolute error of the time misalignment. For example, if there is a 10-ns offset in all pseudorange measurements, the filter tracks the best estimate along that constant offset.

The clock drift represents the oscillator frequency error. This value is typically computed using GPS carrier phase measurements.

B.3 Precise Timing Features

In static mode, the receiver uses a known position with observed measurements (pseudo-ranges and delta-ranges) to derive accurate clock information, that is, clock bias and clock drift. Fix the position using command *Message ID# 80* (see *Set Operating Mode ID# 80* on *Page 42*), in which the exact position of the receiver antenna must be entered.

The 1PPS output can be set to be offset from the UTC second by a fixed value ranging from 0 to 1 s, in increments of 100 ms (see *Message ID# 69* on *Page 36*). The offset is a positive number only, where the rising edge of the 1PPS is delayed with respect to the UTC second boundary by the desired amount of ms. You can also set the pulse width using this command.

If you know the delay induced on the 1PPS signal due to:

- the cable length between the GPS antenna and the receiver, since the time solution is computed for the antenna location
- and the cable length from the receiver's 1PPS output to the host application,

then the sum of these values can be set in the receiver in order to compensate for the signal delays induced by the cables. A reasonable estimate of the total delay would be the total cable length divided by the speed of light.

If you know by calibration the delay induced on the 1PPS signal through the receiver circuitry prior to its actual output, you can program this value in the receiver to compensate for the delay. The default value for the intrinsic delay is set to 1900 ns.

You may specify a 1PPS output control parameter via a command. This parameter indicates under which conditions the 1PPS output should be inhibited.

See *Section 2.5.22, Set Timing Parameters ID# 69* on *Page 36* for more details.

B.3.1 1PPS Alignment Modes

The receiver can operate in three different 1PPS alignment modes:

- Constant Alignment: Keeps the 1PPS signal aligned on the UTC second boundary.
- One Shot Alignment: This mode is used only when the receiver is using an externally controlled oscillator. The receiver slews the 1PPS output to align it with UTC time once at power up. Afterwards, the receiver assumes a perfect 10 MHz input reference frequency and outputs the 1PPS signal accordingly. You can request the receiver to redo its one-shot alignment using command *Message ID #103*. See *Section B.6, Use of One Shot Alignment Mode* on *Page 136* for more information on this mode.
- Standard Alignment (Free-Running): This is the default mode for receivers without the Precise Timing model.

B.4 Receiver Self-Surveying

You can request the receiver to initiate a self-survey using *Message ID# 80* on *Page 42*. In this case, the current position is averaged out and a Figure-Of-Merit (FOM) reflecting the accuracy of the averaged position is computed. This process continues until the desired surveying period has been reached. For more information on the FOM, see the *Glossary* in this manual.

When the survey process is complete, the associated data is stored in Non-Volatile Memory (NVM). The receiver then automatically switches to static mode using the last surveyed position, which becomes the active known position.

✉ If you move the antenna, the self-survey process must be re-initiated.

B.5 Residual Monitor

The receiver implements a residual algorithm.

In order to interpret correctly the status of the time solution, two separate status indicators must be taken into account: the residual solution status (RSS) and the Time Estimator status (TES). These are provided in *Message ID# 113, Section 3.3.22, Timing Status ID# 113* on *Page 111*.

The Time Estimator status may take one of the values in *Table 20*:

Table 20: Time Estimator Status Conditions

Time Estimator Status (TES)	Condition
Successful	Time Estimator Status is set to OK
Warning	Time Estimator Status is set to WARNING **or** [Time Estimator Status is set to FAULT DETECTED
Not ready	Default value at power up

The residual provides either one of the status indicators in *Table 21* to you at a given time:

Table 21: Residual Solution Status Conditions

Residual Solution Status (RSS)
Acceptable
One residual rejected
More than one residual rejected
Insufficient observations

Here is an example of how you can interpret the current setting of both status indicators:

> If TES is set to Successful and RSS is set to One residual detected, it indicates that a faulty satellite has been detected but is still below an acceptable limit. This may occur when there is a slow drift building up in the measurements.

Furthermore, the 1PPS output can be set to disabled by the residual in order to enhance timing integrity.

B.6 Use of One Shot Alignment Mode

The purpose of this section is to present the use and behavior of the Timing Engine when it is in One Shot Alignment Mode.

The current oscillator’s phase offset is represented by the clock bias. This value is constantly being computed by the receiver and subsequently ‘consumed’ by realigning the system time based on this offset. You should not incorporate the clock bias in the external oscillator steering algorithm. Instead, nullify the clock drift in order to drive the 1PPS within 50 ns. The predicted time used to output the 1PPS assumes a perfect 10 MHz frequency. This means that the 1PPS drifts according to the current clock drift. The 1PPS residual represents the error between the 1PPS output time and the time at which it should have been output. For example, if the receiver is set to output the 1PPS aligned on the second edge, using *Message ID# 69*, then the 1PPS residual is in fact a fraction of the 1PPS output time.

Once the external oscillator stabilizes at a perfect 10 MHz frequency, the 1PPS Residual remains constant. It represents the actual phase offset. To remove this constant phase offset, redo the receiver’s one-shot alignment using command *Message ID #103*. It removes this offset from the 1PPS and is reflected in the reported 1PPS residual, which is a constant within ±50 ns. To generate a 1PPS aligned on a true zero error, a 1PPS can either be regenerated with external equipment using the receiver 1PPS signal and the 1PPS Residual, or removed from the reported phase offset from the external oscillator.

Appendix C Measurements

This appendix explains in detail, for advanced users, the processing of the raw carrier and code phase measurements of the SUPERSTAR II. These GPS receivers provide raw measurements: raw code phase measurements and, if your receiver is a model with Carrier Phase (CP) capability, raw carrier phase measurements. Before being used in an algorithm, the raw measurements must be manipulated in order to provide a meaning to you, perhaps as a system integrator. Both raw measurements are taken and latched simultaneously at the measurement mark.

Raw measurements are provided in *Message ID# 23*. The structure of this message is provided in *Chapter 3* on *Page 87*. Details on the integrated carrier phase output by this message is given in *Section C.4* on *Page 141*.

See also *Appendix A, SUPERSTAR II Card Models*, starting on *Page 133*.

C.1 Measurements Concepts

C.1.1 Time Aligned Concept

The clock steering is performed as follows. The receiver steers the measurement mark of the receiver. The steering is performed in such a way that the measurements are taken at the one second epoch (i.e. every second x.000000, x+1.00000 in the case of 1 Hz measurements). To achieve the fractional seconds of the time tag, the clock bias and the clock drift are used to steer the measurement mark so that it occurs at the one second epoch. This way, receivers take their measurements simultaneously. The steering occurs at each second.

The carrier phase and code phase measurements are taken at the same time.

C.1.2 Doppler Concept

The GPS data is modulated by a 1.57542 GHz carrier, see *Figure 8* and *Figure 9* on *Page 139*. The effect of the relative velocity of the satellite and the receiver (Doppler effect) is to shift this signal in frequency. A carrier tracking Phase Lock Loop (PLL) regenerates the carrier frequency shifted by the induced Doppler. To determine the Doppler from the measurements, the nominal number of cycles has to be subtracted for the measured number of cycles (which is composed of the nominal + Doppler).

The carrier measurement output is the integrated carrier in the 1024th cycle from which the IF frequency ramp is removed. What remains in the carrier phase measurement is therefore the satellite clock drift, the Doppler, an IF neglected fractional component and the part of IF corresponding to the correction to the clock due to the clock drift.

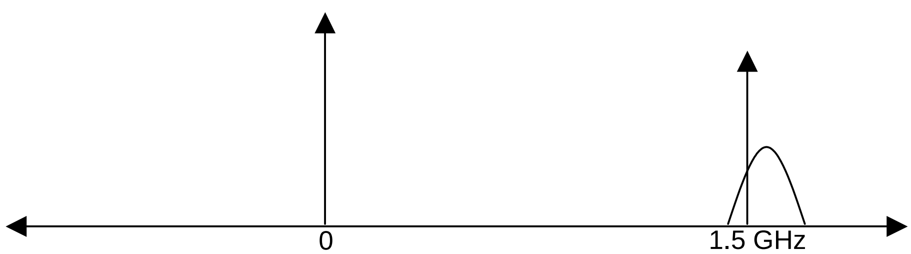

Figure 8: Modulated GPS Data (Doppler Present)

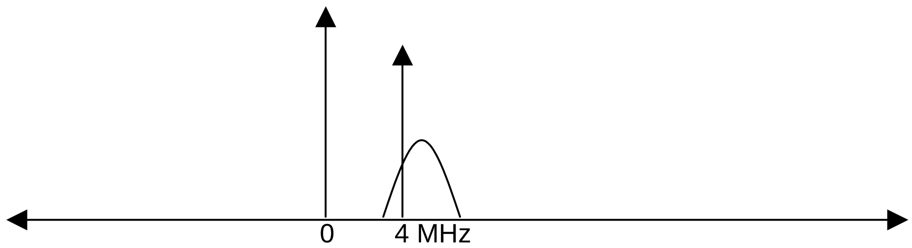

Figure 9: Demodulated GPS Data (Doppler Present)

Because of the Doppler shift, the reconstructed carrier is shifted in frequency. We reconstitute a frequency of Fnom + FDoppler.

The carrier phase (Integrated Carrier Phase) that we generate is:

```
ICP = INTEGRATED MEASURED PHASE – INTEGRATED NOMINAL PHASE
```

The Integrated Carrier Phase (ICP) represents the Doppler shift frequency measured by the receiver and integrated over time. To retrieve the instantaneous Doppler value from the ICP measurements, compute the derivative of the ICP measurements. For example, the average Doppler value over a period of one second can be computed by dividing the difference between two consecutive ICP measurements by the measurement period:

$$(ICP(i)-ICP(i-1))/0.999999$$

for a measurement period of 0.999999.

The ICP are accumulated for 1 s. The nominal number of cycles is computed for 1 s - 1 µs so if the TCXO does not drift, ICP = integrated cycles due to Doppler plus a nominal error. If the TCXO drifts, the measurement period is not affected by the clock drift but the ICP contains the clock drift value.

C.1.3 Clock Drift Concept

A clock drift influences the duration of the measurements mark by reaching the mark count in advance or with a delay depending on the drift direction. Time alignment compensates this effect by delaying or advancing the occurrence of the mark interrupt based on the predicted clock drift. In this way, the measurement period is increased or decreased.

Because the measurement mark time base is the same as the carrier DCO clock, the clock drift has an impact on the carrier cycles measurements. The number of cycles measured is directly affected by the clock drift. This effect is fully compensated by changing the measurements period.

Table 22 summarizes the effect of the clock drift on the measurement period (time) and the code and carrier phases.

Table 22: Clock Drift (CD) Effects

Measurement	Time Aligned
Time	The measurement period varies in the range [1 s – 175 ns, 1 s + 175 ns]. This is due to the time correction granularity of 175 ns. The clock drift has little impact on the measurement period since it influences only the fraction of 175 ns offset from 1 s.
Code	CD has only little effect.
Carrier	The ICP needs to be corrected to account for the measurement period which varies between epochs. The ICP contains the clock drift.

C.2 Code Phase Measurements

Raw Code phase measurements are punctual measurements. They can be used to derive pseudorange measurements. Raw phase measurements are basically transmitted time (time of transmission in 1/1024 chip) latched at the time mark. The time tag (identification of the Measurement mark) of that mark is reported in *Message ID# 23*, see *Page 87*. The pseudoranges are computed using the following relation:

$$\rho_i = [PredictedTime_i - Floor(PredictedTime_i)] - (CodePhase_i) \diagup (CodePhaseUnitPeriod)$$

if $\rho_i < 0$

$$\rho_i += 1$$

$$\rho_i = \rho_i \times C$$

Equation 1

Floor : Round towards minus infinity. The CodePhaseUnitPeriod is 1/1024 half chip.

CodePhaseUnitPeriod = 1023000*2048 where 1023000 = C/A code chip rate and 2048 is 2 * 1024.

C is the speed of light.

So to convert the code phase to time units, the code phase must be divided by the chip rate and multiplied by the resolution.

The time of applicability of the measurements is the predicted time. This tag is said to be predicted since it refers to a predicted time that is based on the previous estimate clock bias and clock drift. Therefore, the predicted time is in error only by the second derivative of the clock bias. The receiver steers the measurement mark continuously.

C.3 Carrier Phase Measurements

Raw carrier phase measurements (ϕ) are output as ICP. The 32 bits carrier phase measurement is composed of the 30 bits ICP in 1/1024 cycles at the L1 frequency and a 2-bit status. When read as an unsigned number, ICP wraps at value 2^30 (1/1024) cycles. This is done to reduce the bandwidth requirements in *Message ID# 23*. To unwrap raw carrier phase measurements, we use this process :

RAWICP = MSG23ICP / 1024

IF (ABSOLUTE(DICP) > 2^{19})

IF ((RAWICP $_{I+1}$ - RAWICP $_I$) > 0)

RAWICP $_{I+1}$ AND ALL SUBSEQUENT RAWICP ARE DECREASED BY 2^{20}

ELSE (EQ.-2)

RAWICP $_{I+1}$ AND ALL SUBSEQUENT RAWICP ARE INCREASED BY 2^{20}

Equation 2

Unwrapped raw carrier phase measurements are used to derive a quantity ICP. The ICP is computed using the relation below:

$$ICP_k(cycles) = RawICP_0 + \sum_{i=1}^{k}(\Delta ICP_i + 4.5803)$$
$$\Delta ICP = (RawICP_i - RawICP_{i-1})$$

Equation 3

When removing the nominal cycles, the measurement generator truncates the IF frequency to 1405400 Hz. A correction of 4.5803 is applied on the RawICP to correct for this.

Correction to apply for the truncated IF:

$$TrunkCorrection = 1405400 - F_{IF} * .999999 = 4.5804$$
$$where$$
$$F_{IF} = 1405396.825 Hz$$

Equation 4

C.4 Carrier Phase In Message ID# 23

In *Message ID# 23*, the carrier phase measurement information bits are sent by the GPS receiver. The systems use different detectors to set those 2 bits, which provide information about the whole cycle counter and cycle fraction. See *Table 23* below.

Table 23: Measurement Bits

Bit 0	Bit 1
Whole cycle bit (WC)	Fraction bit (FR)

The WC bit is used to qualify the status of whole cycle counter. Each time a channel is initialized the WC bit is set. Because of the nature of GPS navigation data message (bi-phase modulation), the receiver must adjust the carrier phase measurement for a half-cycle count. When the software has detected the initial polarity of phase tracking (0 or 180 degree boundary), the receiver adjusts the initial phase measurements. The WC counter bit is clear. Then, the receiver starts and continues the accumulation of cycles until loss of power has been detected. The bit can be asserted when the receiver has detected a parity error while demodulating and assembling the GPS word. This status is latched over a 1 second period.

The FR bit is used to qualify the status of the carrier phase measurement fraction. The receiver monitors the stability of the phase tracking loop. A steady tracking is characterized by a very stable phase error in the phase detector. When the phase error motion is determined to have exceeded a threshold in the one-second interval, the FR bit of the measurement status is asserted.

The WC and FR bits are both set on two distinctive events:

- The phase lock is lost. The whole cycle count is also reset to zero. Such an event requires the complete recovery of the carrier measurement generation process. The WC and FR bits remain set until the lock is reestablished.
- The carrier measurement is unstable but still locked.

When both bits are asserted (Status = 3, Not ready), the carrier phase measurements are not usable. When both bits are clear (Status = 0, Ready), the whole cycle and fraction are declared to be reliable and accurate. When the WC bit is asserted (Status = 1), you can use the phase measurements but should expect a half cycle jump once the ambiguity is resolved. When only the FR bit is set (Status = 2, Phase unlock), use the measurement with care (Early Warning). Temporary Phase unlock is detected when the signal strength falls below a threshold for a short period of time. When this event happens, it is possible for the phase measurement to be affected since the signal input to the tracking loop has low power. For most applications, you should use measurements only when both bits WC and FR are clear.

Both status bits are latched over a 1 second period. However, the receiver is also maintaining a discontinuity counter (Cycle_Slip Counter) for each channel being tracked. A constant value over a period T indicates that carrier phase measurements have been continuous over that period. Therefore, when measurements are logged at a rate less than 1 Hz, use that counter to validate the measurement.

C.5 Coherence Between Pseudoranges and ICP

Unless you want to further smooth the pseudorange measurement with carrier phase, there is no need to obtain coherent measurements. When you need a coherent set of ICP and pseudoranges (that is pseudoranges and ICP exhibit the same slope), there is an additional manipulation that must be done either on the ICP or pseudoranges. Coherency is very often verified by examining the first difference of ICP and first difference of pseudorange measurements.

✉ In aligned mode, the first difference of ICP and pseudorange differs for the ionospheric differential that is causing an advance on the carrier and a delay on the code measurement.

C.5.1 Time Adjustment Method

The first method is to modify the pseudoranges measurement to include the frequency drift. This allows you to match the ICP that contains the clock drift.

The equations that are used are only **valid for sampling of one second**. The slew value is only applicable for the previous 1 second interval.

C.5.1.1 Adjusting the Measurement Period of the Pseudoranges

The sequence of predicted time that is obtained in *Message ID# 23* is modified using the relationship below. The process is initialized using $PTime_0$ = GPSMessage23. PredictedTime. The Slew value is the number of 175 ns corrections that were applied on the measurement mark to have a 1 second period.

$$PTime_{i+1} = PTime_i + 1.00000 + (SlewValue_{i+1} - 5.7142857) * 175e - 09$$

Equation 5

where 5.7142857 is the nominal Clock Drift expressed in 175 ns increments

For instance, if the clock drift is +1µs/1s, it compensates for the –1µs/1s nominal drift and no slew correction is applied. The measurement time is 1 s – 1 µs to account for the clock drift even though the real measurement time is 1 s.

The sequence of pseudorange measurements are computed:

$$\begin{aligned}
&\rho_i(m) = \left[PTime_i - Floor(PTime_i)\right] - (CodePhase_i / 2095104000) \\
&if\ \ \rho_i < 0 \\
&\qquad \rho_i += 1 \\
&\rho_i = \rho_i * C \\
&where\ C\ is\ the\ speed\ of\ light
\end{aligned}$$

Equation 6

These equations reconstruct a sequence of pseudoranges that contains both the user/satellite Doppler and TCXO drift.

C.5.1.2 Adjusting the Measurement Period of the Carrier Phases

Because the integration period is not fixed, the carrier phase must be compensated for the effect of the measurement period variation on the nominal cycles (which is 1/intermediate frequency). Therefore, the nominal cycles at the IF frequency must be precisely adjusted to meet the measurement period. The measurement generator assumes the measurement period to be 0.999999 s. Therefore two corrections must be applied on the output ICP. The first correction is to account for the truncated IF. The seconds correction is to account for the measurement period different than 0.999999 s. The Slew value is the number of 175 ns corrections that were applied on the measurements mark to have a 1 s period.

Correction to apply for the measurement period different than 0.999999 s

$$DriftCorrection = F_{IF} * 175ns * Slew = 0.245944444375 * Slew$$
$$where$$
$$F_{IF} = 1405396.825Hz$$

Equation 7

With the two corrections applied, the reconstruction of the ICP becomes:

$$ICP_k = RawICP_0 + \sum_{i=1}^{k} (\Delta ICP_i + 4.5803 - 0.245944444375 * SlewValue_i)$$
$$\Delta ICP = (RawICP_i - RawICP_{i-1})$$

Equation 8

The slew value is contained in *Message ID# 23*. By using these equations and by calculating the first difference of pseudoranges measurement and delta-ranges measured on the carrier, a match between ICP and pseudoranges is obtained.

C.5.2 Double Difference Technique

When using the carrier phase measurement with a double difference technique, the non-coherency constant is the same for all satellites and therefore drops out of the equation. You can use *Equation 2* on *Page 140* to unwrap the ICP measurement.

C.5.3 Matching the Carrier Phases and the Code Phases for 1 Second

The measurements have to be adjusted to account for the true measurement period. In Align Mode, the measurement period is 1 s.

The sequence of predicted time is taken directly from *Message ID# 23* without adjustments. With this time, the sequence of pseudorange measurements are computed to produce pseudorange measurements for the actual measurement period which is slightly different than 1 s.

$$\rho_i = [PredictedTime_i - Floor(PredictedTime_i)] - (CodePhase_i)/(CodePhaseUnitPeriod)$$

if $\rho_i < 0$

$$\rho_i += 1$$

$$\rho_i = \rho_i \times C$$

Equation 9

The carrier phase measurements must be modified to match the 1s code phase measurements as in *Equation 10.*

$$ICP_k(cycles) = RawICP_0 + \sum_{i=1}^{k} (\Delta ICP_i + TrunkCorrection - TimeCorrection_i - ClockDrift_i \times c/\lambda)$$

where

$$\Delta ICP = RawICP_i - RawICP_{i-1}$$

$$TimeCorrection_i = Slew_i * f_F * 175e-9$$

$$f_F = 1405396.825\text{Hz}$$

$$ClockDrift_i = 175e-9 * Slew_i - NominalDrift - (PredictedTime_i - PredictedTime_{i-1} - 1.0)$$

$$NominalDrift = 1e-6$$

Equation 10

The TimeCorrection element adjusts the ICP to the effective measurement period. It is used to remove the nominal cycles for the period going from 0.999999 to the actual measurement period. The clock drift is removed from the ICP because the clock drift is absent on the pseudorange.

This method for carrier and code phase matching works for time measurements only. It is only applicable for 1 Hz measurements as the slew is required. The slew is output once a second.

✉ The slew is used to remove the clock drift element. The clock drift can be computed externally and then removed, allowing you to work with any rate of measurements.

Appendix D SBAS Positioning

D.1 Overview

A Satellite-Based Augmentation System (SBAS) is a type of geo-stationary satellite system that improves the accuracy, integrity, and availability of the basic GPS signals. Accuracy is enhanced through the use of wide area corrections for GPS satellite orbits and ionospheric errors. Integrity is enhanced by the SBAS network quickly detecting satellite signal errors and sending alerts to receivers to not use the failed satellite. Availability is improved by providing an additional ranging signal to each SBAS geostationary satellite.

SBAS includes the Wide-Area Augmentation System (WAAS), the European Geo-Stationary Navigation System (EGNOS), and the MTSAT Satellite-Based Augmentation System (MSAS). At the time of publication, there are two WAAS satellites over the western Atlantic Ocean and the Pacific (PRN 122 and PRN 134 respectively) and one EGNOS satellite over the eastern Atlantic Ocean (PRN 120). SBAS data is available from any of these satellites and more satellites will be available in the future.

The primary functions of SBAS include:

- data collection
- determining ionospheric corrections
- determining satellite orbits
- determining satellite clock corrections
- determining satellite integrity
- independent data verification
- SBAS message broadcast and ranging
- system operations & maintenance

The SBAS is made up of a series of Reference Stations, Master Stations, Ground Uplink Stations and Geostationary Satellites (GEOs). The Reference Stations, which are geographically distributed, pick up GPS satellite data and route it to the Master Stations where wide area corrections are generated. These corrections are sent to the Ground Uplink Stations which up-link them to the GEOs for re-transmission on the GPS L1 frequency. These GEOs transmit signals which carry accuracy and integrity messages, and which also provide additional ranging signals for added availability, continuity and accuracy. These GEO signals are available over a wide area and can be received and processed by SUPERSTAR II receivers with appropriate firmware. GPS user receivers are thus able to receive SBAS data in-band and use not only differential corrections, but also integrity, residual errors and ionospheric information for each monitored satellite.

The signal broadcast through the SBAS GEOs to the SBAS users is designed to minimize modifications to standard GPS receivers. As such, the GPS L1 frequency (1575.42 MHz) is used, together with GPS-type modulation, for example, a Coarse/Acquisition (C/A) pseudorandom (PRN) code. In addition, the code phase timing is maintained close to GPS time to provide a ranging capability.

Refer also to the *GPS+ Reference Manual* available on our website at http://www.novatel.com/Downloads/docupdates.html.

D.2 SBAS Receiver

SUPERSTAR II-based models may have an SBAS capability option. These models are able to simultaneously track two SBAS satellites and incorporate the SBAS corrections into the position. See also *Appendix A, SUPERSTAR II Card Models* on *Page 133.*

SUPERSTAR II products can output the SBAS data in log format (see *Message ID# 67, SBAS Data* on *Page 105*), and can incorporate these corrections to generate differential-quality position solutions. Standard SBAS data messages are analyzed based on RTCA standard DO-229C Change 1 Minimum Operational Performance Standards for GPS/WAAS airborne equipment.

A SBAS-capable receiver permits anyone within the area of coverage to take advantage of its benefits. To enable SBAS on a clean receiver, set the DGPS mode to SBAS or Automatic, see *Message ID# 83, Set DGPS Configuration* on *Page 44*.

D.2.1 SBAS Messages

The command *Message ID# 95*, *Track SV*, enables the use of particular SBAS corrections in the position filter. Two SBAS-specific messages are also available:

Message ID# 67, SBAS Data

Message ID# 68, SBAS Status

In order to use these messages, first ensure that your receiver is capable of receiving SBAS corrections.

StarView allows you to deselect GPS and SBAS system satellites. Select *Tool Settings | Deselect | SVs* from the main menu. To track one SBAS satellite in particular, do the following:

1. Select the *SBAS SVs* radio button
2. Click on the Deselect ALL button
3. Uncheck the satellite that you wish. This ensures that the receiver searches for a satellites that is known to be operating and thus a quick acquisition/reacquisition of the active SBAS satellite.
4. By default, if you select *SBAS SVs* alone, the unit is only searching for satellite PRNs 120, 122 and 134.
5. Select *Status | SBAS Status* from the *Window* menu to see the number of valid SBAS messages that are being decoded for a specific SV number since the last power-up. When the Valid Messages count is not incrementing, it means that either the receiver is not tracking any SBAS satellites, or it is unable to demodulate the SBAS bit stream.

See also *Message ID#*s *67* and *68* starting on *Page 35* for more details on individual SBAS messages that use SBAS corrections.

Appendix E Waypoint Navigation

The purpose of this appendix is to familiarize you with the Waypoint Navigation feature on your SUPERSTAR II receiver (whether stand-alone, in a FlexPak enclosure or in a SMART Antenna).

Waypoint Navigation requires the use of the NMEA protocol. An explanation of the supported NMEA protocol and field definitions is provided in *Appendix F, NMEA Format Data Messages* on *Page 150*. Individual NMEA commands and logs can be found in *Chapter 2* and *Chapter 3* of this manual respectively.

For further details on the NMEA message structure and formats, please refer to the NMEA 0183 specification.

E.1 Start-up in NMEA Protocol Mode

Switch the protocol for the receiver from Binary to NMEA by using *Configure COM1 Port Mode ID# 110* on *Page 58*. See also *$PMCAG, 000 Configure COM1 Port Command* on *Page 60* for more details on the NMEA equivalent command.

E.2 Waypoints

The SUPERSTAR II can perform simple navigation calculations through the serial communications port.

A database containing a maximum of 50 waypoints can be maintained within the receiver. Waypoint entry, retrieval and editing is accomplished using defined input/output messages. Waypoint positions are in the Military Grid Reference System (MGRS) co-ordinate system format. A waypoint is defined by an identifier number and an 8 character name.

E.3 Navigation Procedure

1. **Route Planning**

   Set up a navigation plan by defining a number of waypoints on your route. Load the plan into the receiver by sending a series of "*Define Waypoint*" messages (NMEA ID# 009, see *Page 68*). In *StarView*, select Tool Setting | Define Waypoint. Each ID# 009 NMEA message defines the exact location of a waypoint in MGRS format.

2. **Navigation Solution**

   Request a navigation solution by sending a "*Select Active Waypoint"* message (NMEA ID# 010, see *Page 70*). In *StarView*, select Tool Setting | Select Active Waypoint. The receiver replies, typically within 3 seconds, with a navigation solution from the local position to that waypoint using the currently selected datum.

   This message (NMEA ID# 906) contains bearing (in degrees true north), range (in meters), and delta elevation (in meters) information. In *StarView*, select Window | To Waypoint.

3. **Current Status**

   The receiver transmits navigation status and the current user position in both UTM and MGRS formats. These messages are defined by NMEA message ID#s 900 (*Page 116*) and 907 (*Page 119*). In *StarView*, select Window | Navigation Status and Window | User Position respectively.

Appendix F Message Formats

The chapter discusses the industry-standard message formats that can be used with your SUPERSTAR II receiver, including RTCM and NMEA. See also the RTCM and NMEA references on *Page 12,* for more information on using these message formats.

F.1 RTCM-Format Messages

The Radio Technical Commission for Maritime Services (RTCM) was established to facilitate the establishment of various radio navigation standards, including recommended GPS differential 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 receiver. Because the receiver 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. Refer to the *Standards/References* section of the *GPS+ Reference Manual* available on our website at http://www.novatel.com/Downloads/docupdates.html for reference information.

Message ID# 83, DGPS Configuration contains one or part of a RTCM message. The message type selected in the Set DGPS Configuration message (Message ID# 83, bytes 9 to 16) is retransmitted through this message. Message length is variable and a message can be transmitted up to once every 100 ms. A RTCM message always starts as the first byte of a message and always ends as the last byte of a message. Thus, a RTCM message can be output in one or many messages but a message block cannot contain more than one RTCM message. The control byte is used to determine the start and the end of a RTCM message. The sequence number of the control byte can be used to detect the loss of a message block on the transmitter side. It starts at 0 and increments by one for each consecutive message block (0,1,2,3,0,1,2,3,0,1,...). See also *Page 44* of this manual for details on this message.

All receiver messages adhere to the structure recommended by RTCM SC-104. Thus, all RTCM messages 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	8
	–	Frame/message type ID	6
	–	Base station ID	10
	–	Parity	6
Word 2	–	Modified z-count (time tag)	13
	–	Sequence number	3
	–	Length of message frame	5
	–	Base health	3
	–	Parity	6

The remainder of this section will provide further information concerning receiver RTCM data formats.

F.1.1 RTCM1 Differential GPS Corrections (Fixed)

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

Type 1 messages contain the following information for each satellite in view at the base station:

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

When operating as a base station, the receiver's position must be set using *Message ID# 80, Set User's Position/Operating Mode*. When operating as a rover station, the receiver COM port receiving the RTCM data must be set to Rover mode using command Message ID# 80. See also Reference [6] on *Page 12*, for more details on this input message.

F.1.2 RTCM2 Delta Differential GPS Corrections (Fixed)

Quite often a base station may have new ephemeris data before rover 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 base station will transmit this Type 2 bridge data concurrently with Type 1's for a few minutes following receipt of a new ephemeris. The rover 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 rover receiver has collected its own updated ephemeris, it will no longer utilize the Type 2 messages.

The GPS Card will accept and decode RTCM Standard Type 2 messages, when available and if required.

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

F.1.3 RTCM9 Partial Satellite Set Differential Corrections

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

Type 9 messages should give better performance with slow or noisy data links.

✉ The base station transmitting the Type 9 corrections must be operating with a high-stability clock to prevent degradation of navigation accuracy due to the unmodeled clock drift that can occur between Type 9 messages. For this reason, only receivers with an external oscillator can generate Type 9 messages. SUPERSTAR II receivers can accept Type 9 messages.

NovAtel recommends a high-stability clock such as the PIEZO Model 2900082 whose 2-sample (Allan) variance meets the following stability requirements:

3.24×10^{-24} s^2/s^2 between 0.5 - 2.0 seconds, and

1.69×10^{-22} T s^2/s^2 between 2.0 - 100.0 seconds

An external clock, such as an OCXO, requires approximately 10 minutes to warm up and become fully stabilized after power is applied; do not broadcast RTCM Type 9 corrections during this warm-up period.

Type 9 messages contain the following information for a group of three satellites in view at the base station:

- Scale factor
- User Differential Range Error
- Satellite ID
- Pseudorange correction
- Range-rate correction
- Issue of Data (IOD)

F.2 NMEA Format Data Messages

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 the *Standards/References* section of the *GPS+ Reference Manual* available on our website at http://www.novatel.com/Downloads/docupdates.html. The following table contains excerpts from Table 6 of the NMEA Standard which defines the variables for the NMEA messages. 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 Clear V = 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 Fields		
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	hh___	Fixed length HEX numbers only, MSB on the left
Information Fields		
Variable text	c--c	Variable length valid character field.
Fixed alpha	aa___	Fixed length field of uppercase or lowercase alpha characters
Fixed number	xx___	Fixed length field of numeric characters
Fixed text	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.

F.2.1 NMEA Checksum

The checksum field delimiter and checksum are optional on input.

The checksum is an 8-bit exclusive OR of all characters in the sequence, including "," delimiters, between but not including the "$" and the "*" delimiters.

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